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Development of Smart Rural Village Indicators in Line With Industry 4.0

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ABSTRACT In 1950, approximately 1.8 billion lived in rural areas and subsequently, rural population growth averaged 1.0 per cent per year, with the result that the rural population nearly doubled, reaching 3.4 billion in 2018 and is expected to peak in 2021 at just over 3.4 billion. Rural villages are lacking behind urban areas when it come to the stages of industrial revolutions and societal development with respect to technological advancement. Today, the world is faced with the new wave of advanced technological revolution called Industry 4.0. Despite the impressive work being implemented successfully to create smart cities and smart villages in various countries, there are still no developed standard indicators that can be used to define smart rural village concept. The objective of the study is to develop indicators for smart rural villages aligned with Industry 4.0 technologies using systematic literature review, the 2030 agenda for sustainable development, as well as the ISO 37122, smart cities indicator's standard. The translation method developed prioritized indicators according to sustainability, smartness and connectivity from the Information and Communication Technology. The main contribution is the method and indicators developed over 2-year period for smart rural villages. The resulting indicators makes it possible to answer what a smart rural village is: village that has access to affordable energy, adequate housing, safe drinking water, an inquisitive rural culture, early warning systems against adverse weather conditions, against drinking water pollution as well as the predictable schedule for local doctor, taxi/bus.

INDEX TERMS Indicators, industry 4.0, smart city, smart rural village.

I. INTRODUCTION AND BACKGROUND

Today, the world is faced with the new wave of advanced technological revolution called Industry 4.0. In other circles this is what is referred to as the fourth industrial revolution or 4IR. Industry 4.0, like so many new technologies in the 21st Century, is not a new concept; it is more a rebirth of an older concept that is utilizing newly developed technologies [1]. The concept features as a container carrying a plethora of meanings [2] and promises hope to both urban & rural communities across the globe. Even though several authors have tried to define the term Industry 4.0, to date there is still no unanimously adopted definition of the concept [3]. However, Industry 4.0 is defined as ''real-time capable, intelligent, horizontal, and vertical connection of people, machines, objects, and ICT systems to dynamically manage complex systems'' [4]. Accordingly, the concept of smart cities is born, which is not novel, but in the recent years it has taken on a new dimension of using ICTs to build and integrate critical infrastructures and services of a city [5]. It is important to note that the concept for urban smart communities is already very well established—e.g., Smart Cities, but less so for rural communities as the concept Smart Village has only recently gained momentum; for example, in the EU, the Smart Village Initiative was launched by the European Parliament in 2017, and the EU Action for Smart Villages document was published by the European Commission together with the European Parliament [6]. Smart network technologies with variable quality of service demand are thus crucial also to enable 4IR in emerging economies [7].

Despite the impressive work being done to create smart villages in various countries, there are still no developed standard indicators that can be used to define what a smart rural village is. Existing studies are mainly biased towards developed countries as well as urban areas with limited studies available focusing on rural communities [8]. There is no

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work being done to define what a smart rural village is in terms of smart indicator standard for smart rural villages. It is however, noted that the challenges faced by a rural area elsewhere, even though at times similar, are however context specific and can never be the same from country to country. Rural areas or villages also deserve meaningful growth that brings development that improves people's lives. This is because rural development is essential to accelerate overall development of any country [9].Thus, in terms of the conceptual aspects and in terms of potential indicators and measures of smart growth and its determinants, there is a need for studies that analyses each of the factors that can influence the growth potential in a diverse set of rural regions [10].

Rural Villages

In 1950, seven out of ten people on earth lived in rural areas, and in 2018, the rural population growth nearly doubled, reaching 3.4 billion from 1.8 billion people, with the population growth expected to peak in the year 2021 [11]. However, for the rural people, conditions for them are worse than for their urban counterparts when measured by almost any development indicator, from extreme poverty, to child mortality and access to electricity and sanitation [12]. Today, society live in a world where resources are becoming scarce while human needs continue to increase [13].

People, in the remote villages, still have not seen the wonders of electricity, still cook using dry animal dung fuel and completely depend on nature to suit their needs [14]. The people in such villages depend on water from wells or tube wells for drinking, household, and agricultural purposes [9]. Before defining a rural area, it is worth noting that there is no unanimous agreement on a distinctive classification of a rural community [15]. However, even when a formal definition of rurality cannot be used, the following possible characteristics may alert the reader to the 'depth' or context of the situation: (i) population size; (ii) availability of basic amenities; (iii) main economic activity in the area; and (iv) common public health problems [16].

Rurality further mean areas where most households may still be using traditional fuels for cooking such as coal and wood [17], with limited or no access to basic facilities like water supply, electricity, schools, hospitals and toilets [9]. Furthermore, Statistics SA asserted in 2003 that a rural area is a village or settlement without a local authority, which is not situated within a tribal area and with formal and semi-formal dwellings such as mud houses and/or huts [18]. They are constrained by a lack of productive employment opportunities, poor education and infrastructure, and limited access to markets and services, despite half a century of rural development theories and approaches [12].

Fourth Industrial Revolution

The term 'industrial revolution' refers to the change of the technological economic and social systems in industry [19]. To date the world has witnessed four stages of the industrial revolution. First industrial revolution is attributable to the first mechanical loom from 1764, which brought the mechanization of the textile industry [20], in the 1780s with steam power, making humans more productive [13]. Then in the 1870s the second industrial revolution emerged with the development of mass production and electrical energy [13], the revolution was associated with the Ford assembly belt from 1913 [20].

The third revolution started in about 1968, it was about digitization and internet connectivity of the production environment, the introduction of the first Programmable Logic Controller (PLC), usage of Information Technology (IT) systems, automation using computerized systems, and the use of electronic based systems which enabled more efficient production [20] [21]. The main flagship for the 3rd revolution is that machines are affordable, and digital manufacturing tools that are connected to the Internet and the energy sources are renewables [22]. In the year 2000's the global community faced the new wave. First popularized by the World Economic Forum (WEF) in 2015, 'Industry 4.0' has become a catch-all term to describe imminent changes to global business, labor and education models stemming from the advent of 'cyber-physical systems' [7].

It involves computer generated products, such as 3D printing technology, intelligent agents, biotechnologies, and nano materials [23], it is about exploiting and the extensive use of the internet. This is to say the revolution based on cyber physical systems. This is a new phase where the fusion of several technologies is not only automating production, but also, knowledge [21]. Figure 1 below depicts the stages of industrial revolutions discussed above.

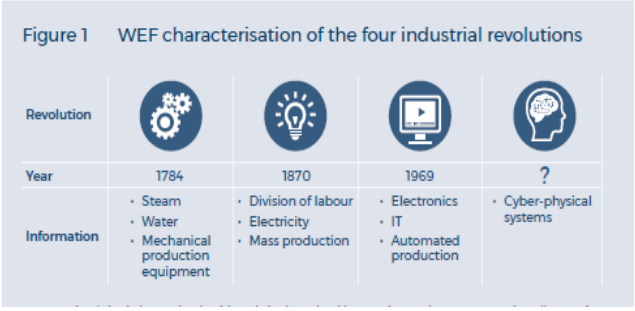

FIGURE 1. WEF characterization of the four industrial revolutions [7].

As can be shown on the figure 1 above, all stages have been a continuation from one stage of technological advancement to the next. Accordingly, the World Economic Forum (WEF) reports that, there are emerging technologies that came about as a result of Industry 4.0 which are: Virtual/Augmented Reality; Block Chain; Autonomous cars/intelligent machines; 3D Printing/ Custom/ Additive manufacturing; Artificial Intelligence (AI); Robotics; Digital traceability; Internet of Things (IoT); machine learning; bioscience technologies cyber physical systems and Connected Devices [20], [21]. These advancements may appear less immediately relevant to emerging economies that are still grappling with the challenges of the second and third industrial revolutions however adopting new technologies

will prove crucial for rapid and sustained productivity and economic growth [7].

This purpose of this article is to develop indicators for smart rural villages aligned with Industry 4.0. This is done so as to define what a smart rural village is, based on the characteristics that emerge out of the indicators. The trigger point is the non-availability of smart village indicator's standard like smart city indicator's (ISO 37122) already developed for urban areas aligned with the sustainable development goals. This is mainly because, the Sustainable Development Goals (SDGs) have identified digital connectivity as a basic human right [7] which the study believes has potential to make rural villages smart, sustainable, and connected. The study is neither geared towards converting rural villages into smart cities, nor to recreate the smart city concept in rural villages.

The article is structured as follows: Section 2, discusses the method used to derive the indicators as well as the work rule. Section 3 gives a snapshot of conducted literature review covering main concepts such as smart city, smart village, sustainable development, as well as sustainable development goals. Section 4 discusses the translation in a step by step manner for development of indicators, while section 5 discusses the characteristics of a smart rural village. Section 6 concludes the paper with the prioritized indicators.

II. METHOD

This section introduces the methodology followed in this study. The method followed is described graphically on figure 2. As can be seen on figure 2, the first step covers literature review which defines critical concepts for the study. Among the concepts discussed on the systematic literature review is smart city, smart village, sustainable development, sustainable development goals as well as the indicators and how they get developed from previous studies.

The second step identifies the SDGs applicable to smart rural/village development. The intention of identifying these goals is so that they can be mapped and utilized in developing the smart rural village indicators in an effort to ensure rural communities of the world are not left behind when coming to the stages of industrial revolutions. On the third step, the smart cities main metrics applicable to smart rural development are identified with an intent to utilize them for the rural setting. The fourth step maps the SDGs objectives to Smart Cities objectives. The objectives are more about: what needs to be measured. The last step is concerned with the full translation to check if the purpose in the rural village would be for sustainability, smartness or connecting the rural village to the outside world using ICT infrastructure. While these indicators are similar in spirit to those appearing in ISO 37122 standard on smart cities, they are however meant to be part of an international standard for smart rural villages. To derive performance indicators, a consideration should be given to different typologies of indicators like scenario indicators, input indicators, activity indicators, output, and outcome indicators (see e.g. Chiara Mio (2013)). For the current study focus is on output indicators to address the identified objective to make rural villages sustainable, smart, and connected. At the end, the derived smart rural village indicators are tabulated. The method is explained in detail below starting with the graphical representation.

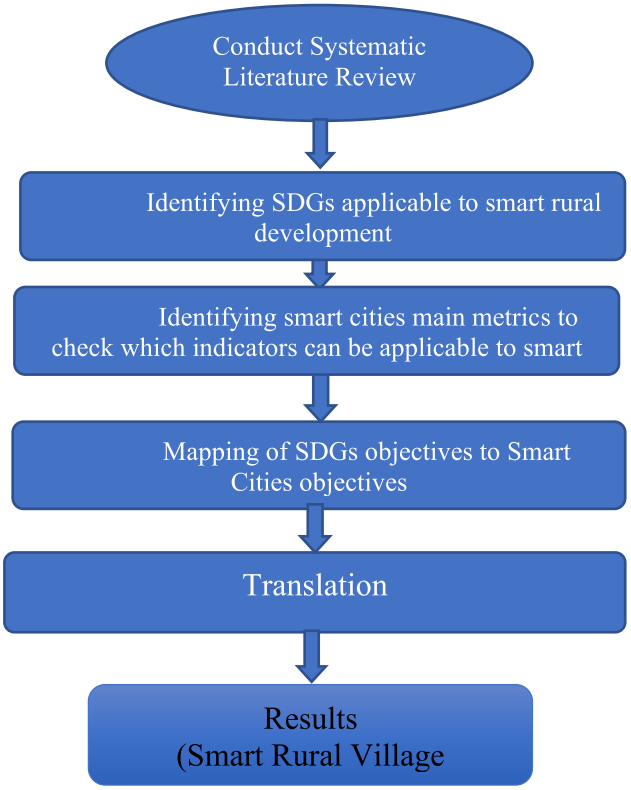

FIGURE 2. Research Method followed to derive Indicators.

A. SYSTEMATIC LITERATURE REVIEW

The methodological approach followed in this study was to first do the systematic literature review. Data collection was through the following reputable journals: IEEE, Ebscohost, Google Scholar, ScienceDirect, UJ Digital library. Systematic review could be used to see the previous concepts regarding the topic being researched [24]. The previous concepts identified are smart, smart city, rural village, smart village, indicators, smart cities indicators. Hence the combination's search used is: Smart + Rural + Village + Indicators; Smart + ISO Standard + Indicators; Sustainable + Development + Rural + Indicators; Smart + Development + Standards + Indicators.

B. IDENTIFYING SDGs APPLICABLE TO SMART RURAL DEVELOPMENT

Secondly, identification of the sustainable development goals that can be used in the development of smart village indicators. This was achieved by looking at the 2030 agenda for sustainable development vision and objectives as articulated further by the 17 sustainable development goals. The 17 Sustainable Development Goals (SDGs) are closely linked to addressing the new challenges for rural areas,

such as demographic pressure, ecological side-effects and climate change, and poor governance, along with negative consequences imposed by lagging rural areas such as polarized regional development and rural migration into urban slums [12].

The SDGs are used in this study as the objectives that get mapped to the smart cities metrices or objectives.

C. IDENTIFYING SMART CITIES MAIN METRICS TO CHECK WHICH INDICATORS CAN BE APPLICABLE TO SMART RURAL DEVELOPMENT

The third step is to look at the smart cities' main metrics from the ISO standard (ISO/CD 37122) on sustainable development in communities – indicators for smart cities. The point is to select the indicators that would be applicable to the current cause. Applicability would mean the indicators that would help rural villages to be sustainable, smart, and connected without compromising the rural fiber, nor converting the village to a smart city. The reason here is to somehow maintain the ''equilibrium'' between the urban and rural areas, the smart development of both must be parallel and simultaneous [10]. The International Standard is meant to help cities to implement smart city policies to: provide better services for citizens; provide a better life environment where smart policies, practices and technology are put to the service of citizens; achieve their sustainability and environmental goals in a more innovative way; identify the need for smart infrastructure; facilitate innovation and growth; and build a dynamic and innovative economy ready for the challenges of tomorrow [25]. In this instance, the smart rural village indicator standard once finalized would help villages to implement smart rural village policies which would improve rural life, offer better life for the rural communities, sustain the rural environment for future generations, identify the need for smart rural ICT infrastructure; facilitate innovation and growth for the rural setup; and build a dynamic and innovative rural and attractive economy ready for the challenges of tomorrow.

D. MAPPING OF SDGs OBJECTIVES TO SMART CITIES OBJECTIVES

The fourth step is the mapping of the smart cities' metrics with the sustainable development goals. The mapping in this instance look at the objectives of the smart city indicators' standard applicability to the rural area. The objectives give guidance of what is being measured and the output expected over which period. This is because the ISO 37122 standard is urban focused and move from that premise that the infrastructure that supports sustainability, smartness and connectivity already exists. Table 1 below shows the mapping of the smart cities' objectives to the sustainable development goals. Accordingly, the following questions are asked: *Which Metric from ISO 37122 aligns with the SDG's? Are the Metrics meant for sustainability, smartness, or connectivity in rural village?*

To answer the above questions, table 1 is showing all the smart cities indicators standard main metrics (headings) listed against the sustainable development goals. As can be seen on table 1 below, column 3 classifies the intent of each metric to be an indicator for sustainability, smartness, and connectivity (i.e. need for ICT infrastructure) purposes when applied in a rural setup. The intent of the study is not to be prescriptive even on the selection of the ICT infrastructure, but safe to say, it should be easy to maintain, easy to install and fall into the category of plug and play principle.

TABLE 1. Smart Cities Metric mapped against SDG's.

Metric (Smart Cities)	Metric (SDG)-Objectives	Objective aligned
Housing	Making human settlements more inclusive and sustainable	Sustain & Smart
Environment and Climate Change	Taking actions to combat climate change, protecting ecosystems	Sustain & Smart
Healthcare	Wellbeing	Smart & Sustain
Education	(inclusive and equitable quality) education	Smart & Sustain
Culture	Fostering innovation	Smart, Sustain and Connect
Energy	Accessibility of sustainable energy	Smart & Sustain
Economy	Sustainable economic growth and decent work	Smart & Sustain
Governance	Empowerment of women and girls	Smart & Sustain
Telecommunication	Technology (ICT)	Connect, Smart & Sustain
Finance		Smart & Sustain, Connect
Transportation		Smart & Sustain
Urban/local Agriculture and food security	Rural/Local Agricultural and food security	Smart & Sustain, Connect
Urban planning		N
Wastewater		N
Water	Management of water resources	Smart & Sustain
Reporting & record keeping		N
	Reducing inequality	Smart & Sustain, Connect
	Building resilient infrastructures	Smart & Sustain, Connect

N.B. Color coding purely used for match making, Blue to Blue & Yellow to Yellow

From the table above, it can be noted that transportation is color coded/matched (yellow to yellow) with building resilient infrastructure. This is because in rural areas needs enabling infrastructure like road networks, railway network. This would go a long way in reducing the isolation gap as it connects the rural villages to the cities or even towns which in a way would act as an enabler to the economy. To reduce inequality in rural areas, access to finance becomes critical component of the rural live, hence it is color coded/matched (blue to blue) with reducing inequality. However, what is known is that competitive advantage is increasingly determined by connected, knowledge-intensive economies with high digital skill levels [7]. The mobile finance options utilized in various rural setup goes a long way to improve the financial mobility, digital money, or online money transfer

etc. Hence the next section takes each objective, attach indicators, and translates to show which ones are for smartness, sustainability, and connectedness.

E. TRANSLATION

This last step takes the main metric objective, break it down into the things that will need to be measured, monitored or checked to achieve the objectives, and then categorize those measured variables into sustainability, smartness and connectivity/ICT. The measured variables are what is termed indicators. The following questions are asked:

Will the indicator support sustainability of rural villages? Will it be for supporting smartness? Would the indicator require some form of ICT infrastructure for it to be realized?

Using the Boolean logic, the following conditions needs to be satisfied:

Any two conditions should be true to make the indicator to be accepted as applicable to smart rural village. It should be however be indicated that conditions take a que from sustainability. Because we have three variables, we shall indicate this on the truth table.

TABLE 2. Conditional criterion for Smart rural village indicators.

Sustainable	Smart	Connect	Applicable/ Not Applicable
0	0	0	Not Applicable
0	0	1	Not Applicable
0	1	0	Not Applicable
0	1	1	Partially Applicable with full explanation
1	0	0	Not Applicable
1	0	1	Applicable
1	1	0	Applicable
1	1	1	Applicable

Sustainability in this study shall mean a village with a safe environment that would bring long term view for future generation's benefits. Smartness is the village's ability to learn, extract and disseminate data or information to build a culture of inquisitive and/or knowledge hunger traits. ICT/Connectivity which is Information and Communication Technology, is the village's need or capacity to get an infrastructure that will cause the removal of isolation gap/digital divide and connecting the rural people to the outside world beyond their rural borders.

III. LITERATURE REVIEW

This section covers the snapshot of the study's literature review. This literature study was done through books, journals, and University of Johannesburg online library to access previous studies that deal with the concept of smart cities, smart village, smart rural village, sustainable development, sustainable development goals as well as the smart cities indicator standard. The first section will define the meaning of smart city concept, followed by smart village concept. The third section will introduce sustainable development and sustainable development goals concepts. The last section concludes with the discussion on indicators.

A. SMART CITY

Even though there is an increase in frequency of use of the phrase "smart city", there is still not a clear and consistent understanding of the concept among practitioners and academia [26]. However, an in-depth analysis of the literature revealed that the meaning of a smart city is multifaceted [27]. As a starting point, a smart city is defined as a city "connecting the physical infrastructure, the information-technology infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" [13]. However, smart city is seen comprehensively as an ecosystem that offers variety of services to citizens and ensures that there is information exchange between subsystems so as to enable the analysis of that information, creation of statistics that will help in resource's mobilization and optimization [28]. The important point to make here is that the city uses ICT's to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects [28]. This concept is about an urban system that uses ICT to make both its infrastructure and its public services more interactive, more accessible, and more efficient [29]. Hence it is noted that one important aspect of smart approaches is related to the fact that nearly all discussed concepts are targeting urban conditions thereby neglecting rural environments [30].

B. SMART VILLAGES

Poggie *et al.* (2017) points out that there can be no smart cities without smart rural [31]. Visvizi, Lytras and Mudri (2019) begin their book on smart villages in the EU and beyond with the following questions about the smart villages: "Is it life, water, energy, community, or food? Is it the technology, the ways and means, or the status? What do villages, or rural areas in the concept actually stand for?" [32]. To answer the questions above, a smart village concept is firstly defined as an approach to rural local development which exemplifies current dynamic and direction of the development processes and civilizational challenges [33]. Like smart city concept, smart village is an ecosystem consisting of various elements to improve the quality of community life and village environment, involving various stakeholders such as government, private, academics and elements of village communities [34]. This mean the smart village concept is an innovation of sustainable planning approach at the village level that promotes knowledge-based development through the continuous learning of human resources as an integrative part of village resource development, especially in encouraging rural areas development as a part of regional system in the context of national development planning system [35]. The notion of Smart Villages is built around advancing economic and

social development and the provision of sustainable energy, healthcare, education, water and sanitation infrastructures as the key catalysts for ensuring improved livelihoods, increased incomes, human security, gender equality and democratic engagement [36].

C. SUSTAINABLE DEVELOPMENT AND SDGs

The Brundtland Commission's brief definition of sustainable development as the ''ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs'' is surely the standard definition when judged by its widespread use and frequency of citation [37]. Sustainable development has become a widely recognized goal for human society ever since deteriorating environmental conditions in many parts of the world indicate that its sustainability may be at stake [38]. It is important to note that sustainability demands an understanding of the world's problems as systemically interconnected and interdependent [39]. Hence, the Johannesburg Declaration on sustainable development created ''a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development—economic development, social development and environmental protection—at local, national, regional and global levels.'' [40] Accordingly, the notion of sustainable development goals came from the millennium objectives experience, after which, the UN has launched the continuity of the development program. This was done through the sustainable development goals (SDG), which have the purpose of giving support to local and regional governments for the 2030 agenda in local sphere [41]. These Sustainable Development Goals (SDGs) are closely linked to addressing the new challenges for rural areas, such as demographic pressure, ecological side-effects and climate change, and poor governance, along with negative consequences imposed by lagging rural areas such as polarized regional development and rural migration into urban slums [42]. Despite phenomenal advances in science, technology, medicine and agricultural production, the promise that 'development' would eradicate world poverty remains unfulfilled in several parts of the globe, especially in the third world [43].

D. INDICATORS

The world leaders have declared, during the Johannesburg sustainable development summit declaration that, they commit themselves to monitor progress at regular intervals towards the achievement of our sustainable development goals and objectives [40]. Indicator development remains valuable as a way of clarifying what is important (thereby also contributing to objective setting) [44]. The three main functions of indicators are quantification, simplification, and communication [45]. As a result, social indicators are an important tool for evaluating a country's level of social development and for assessing the impact of policy [46]. The smart cities indicators standard as an example, intends to help countries implement policies aimed at the development of smart cities, and for this purpose it offers: Better services for citizens; Provide a better living environment in which smart policies, practices and technologies are put at the service of citizens; Achieve their environmental and sustainability goals in a more innovative way; Identify the need for intelligent infrastructure; Facilitate innovation and growth; Build a dynamic and innovative economy ready for future challenges [47]. No set of indicators can be exhaustive, hence a selection has therefore to be made [45].

IV. RESULTS

This section presents the results achieved from the using the methodology discussed in section 2 above and graphically shown on figure 2 in deriving the smart rural village indicators. The detailed energy metric, objective, indicators, and translation will be done in a step by step manner to demonstrate the above sequence in this result section. While the indicators are not necessarily arranged in order of importance, it is critical to note that for industry 4.0 technologies to be implemented, energy becomes a primary requirement hence it is the number 1 indicator discussed here.

A. SYSTEMATIC LITERATURE REVIEW

Energy is a basic element that must be met first before the use of any technology because without energy, there is no internet and ICT [24]. A key premise of the Smart Villages Initiative1 is that the required acceleration must be founded on a more integrated approach to rural energy access in which increased emphasis is placed on the use of renewable energy and modern information communication technologies (ICT) to enable productive enterprises and the provision of key services [48].

B. IDENTIFYING SDGs APPLICABLE TO SMART RURAL DEVELOPMENT

The task taken on this step was to first search on the 17 SDG's to check which goal will be closely linked to the energy metric, which would be beneficial to the rural villages in a quest to make them sustainable, smart and connected in line with industry 4.0. The search result: SD Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.

Identifying smart cities main metrics to check which indicators can be applicable to smart rural development. To respond to the energy needs of the rural villages, a *cross reference to the smart cities indicators is made to develop the objectives for rural villages*

C. MAPPING SDG (Energy) TO SMART CITY ENERGY OBJECTIVE

From Table 1, the energy metric is mapped with the accessibility of sustainable energy. This is sustainable development goal 7 which calls for access to affordable, reliable, sustainable, and modern energy for all [12]. The objectives of smart city energy metric are shown in Table 3, column 2 followed by the indicators in column 3. It is noted that in smart cities

TABLE 3. Indicators for smart cities energy.

Metric	Smart City Objective	Indicator
Energy	Evaluating capability and intention to recognize the potential of wastewater as a sustainable energy source and utilize it in their energy source mix.	Electrical and thermal energy (KWh) produced from wastewater treatment per capita per year
	Evaluate the city's capability to seize an opportunity to recover energy, using new and possibly cleaner technologies.	Electrical and thermal energy (KWh) produced from solid waste treatment per capita per year
	To assess a potential to utilize renewable energy sources and expands access to clean energy services using decentralized system	% of the city's energy that is produced using decentralized energy production systems
	To evaluate capability to balance the supply and demand for energy in a region and to ensure that the frequency of energy shortages/ interruptions is reduced.	Storage capacity of the city's energy grid per capita (KWh)
	Evaluating capability to account for the energy use of public street lighting and effectively managing public street lighting energy to help cities realize energy savings, maintenance costs reductions and CO2 emissions reductions.	Energy consumption of public street lighting as a percentage of total annual municipal energy consumption
	Evaluating commitment to improve energy efficiency of the street lighting system.	% of street lighting that has been refurbished

indicator's standard, the availability of the grid and access is a non-issue as can be seen on what is being measured.

Contrary to the cities, rural villages have no access to the grid, due to lack of infrastructure and remoteness of the villages. To derive objectives and indicators, the following questions were raised:

Does the village have stable energy source? Is the village connected to the national grid? Does the village have alternative and affordable energy source in the form of renewables? What is the percentage number of people still using the inferior fuels for heating and cooking? Does the municipality know and measure storage capacity for the village?

Table 4 below lists the mapped objectives of smart rural energy indicators.

D. TRANSLATION

This section shows how the smart rural energy table is developed. A conversion column is added on table 5, to determine if the objective will be to achieve sustainability, smartness, or connectivity. Even though the key could be broken further down in terms of sustainable energy source, recover energy, renewable energy, supply and demand balance, emission reduction, and efficiency, this is captured only in terms of objectives as opposed to second level stage. The main point

TABLE 4. Mapped Objectives.

Metric	Smart city energy objective	Smart rural energy objective
Energy	Evaluating capability and intention to recognize the potential of wastewater as a sustainable energy source and utilize it in their energy source mix.	Evaluation of the village capability to have a smart and reliable energy source from the national grid
	Evaluate the city's capability to seize an opportunity to recover energy, using new and possibly cleaner technologies.	Evaluation of the village's capability to have the reliable energy source from the renewables
	To assess a potential to utilize renewable energy sources and expands access to clean energy services using decentralized system	To assess a potential to utilize renewable energy sources and expands access to clean energy services using decentralized system
	To evaluate capability to balance the supply and demand for energy in a region and to ensure that the frequency of energy shortages/ interruptions is reduced.	To evaluate capability to balance the supply and demand for energy in a village and to ensure that the frequency of energy shortages/ interruptions is minimized.
	Evaluating capability to account for the energy use of public street lighting and effectively managing public street lighting energy to help cities realize energy savings, maintenance costs reductions and CO2 emissions reductions.	To evaluate how the village intent and capability to introduce alternative energy sources
	Evaluating commitment to improve energy efficiency of the street lighting system.	Evaluating the villages energy consuming infrastructure and its source

is on explaining the objective of the indicator as opposed to just showing the key headings.

Table 5 above gives a comprehensive view of the resulting indicators with smart rural village indicators in the last column. If the selected objective passes the condition of two ticks without compromising sustainability, it gets accepted as discussed on the methodology section. As can be seen on the table 5 above, a set of sustainable indicators, deeply rooted in the relevant scientific literature, easily measurable, and sufficiently flexible [49], get selectively included in each metric.

The second indicator following from the energy requirement in a rural area is the telecommunication infrastructure. One cause of low rural income can be blamed on "information poverty" – the lack of access to information and knowledge that could improve earnings potential [50]. The following section will only give a brief snapshot of the

TABLE 5. Indicators for smart rural energy.

Metric	Smart rural energy objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Energy	Evaluation of the village capability to have a smart and reliable energy source from the national grid	X	X		%No of people connected to the national grid.
				X	%No of households with smart prepaid meters
	Evaluation of the village's capability to have the reliable energy source from the renewables	X	X		% No of people involved in the village solid waste recycling initiatives
	To assess a potential to utilize renewable energy sources and expands access to clean energy services using decentralized system	X	X	X	% energy produced using centralized energy production system...e.g. solar home systems (controlled centrally)
	To evaluate capability to balance the supply and demand for energy in a village and to ensure that the frequency of energy shortages/ interruptions is minimized.	X	X	X	Storage capacity of the village energy grid (KWh) What energy capacity is available in a village?
	To evaluate how the village intent and capability to introduce alternative energy sources	X	X		No of houses in a village utilizing Solar panels, gas as their energy source.
	Evaluating the villages energy consuming infrastructure and its source	X	X		% No of installed street solar powered lights/electric powered

process and the results with the view that the energy metric has successfully demonstrated the methodology.

E. TELECOMMUNICATIONS

From literature it is noted that Information and Telecommunications infrastructure, particularly the telecommunications infrastructure, provides facilities for communications and saves time, energy, labor and capital by condensing the time and space required for production, consumption, market activities, government operation, educational and health services [51]. Telecommunications is mapped with SD Goal 9.c: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

The objectives after mapping is to provide access to information and communications technology. From the Smart Cities indicator standard, the objectives that aligns SDG 9c is: Telecommunication, and Culture as can be seen in table 6 and 8 below. However, the first metric looked at is telecommunications as shown on table 6.

TABLE 6. Indicators for smart cities Telecommunication [25].

Metric	Smart City Objective	Indicator
Telecommunication	Evaluating the city's population access to reliable electronic devices, to be able to search key databases such as jobs advertisements, government services	% of the city population with access to computers or other electronic devices with internet access in libraries and other public buildings
	Evaluating the individual's ability to exercise their right to freedom of opinion& expression, to promote the progress of society through wider access to information.	% of the city population with access to sufficient speed broadband
	Evaluating the societal access to telecommunication which implies an ability to communicate without barriers	% of city area under a white zone/dead spot/not covered by telecommunication connectivity
	Determining the ability of municipalities to passively track internet users for future planning purposes.	% of city area with publicly available internet connectivity

Accordingly, a cross reference with the smart city indicators objectives shows that most of the indicators are for technologically advanced urban areas, as per the table 6 above. To move from the smart indicators to smart rural village, the following questions are asked: *How can the rural villages areas access information and communications technology? How can municipalities help implement the ICT infrastructure projects for the benefits of rural villages?* Consequently table 7 below is populated to align smart city indicators against smart city objectives while at the same time checking which ones would make the village sustainable, smart and need ICT for connectivity.

From table 7, it is noted that telecommunications indicators for smart rural areas satisfies all three determining criterion because the ICT infrastructure not only support sustainability in terms of prosperity, but also smartness because this becomes an enabler to access to information as well as connectivity which ensures the rural village gets connected to the outside world.

F. CULTURE

Culture falls within this category. It is significantly increasing access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries. This is because, rural areas should also develop a culture of innovation, in a way develop-

TABLE 7. Indicators for smart rural telecommunication.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Telecommunication	Evaluating the village's population access to Information, to be able to search key databases such as jobs advertisements, government services	X	X	X	No of Cell phone Towers in a village
					No of Cellphone provider networks reachable in a village and their %.
	Evaluating the village's ability to exercise their right to freedom of opinion& expression, to promote the progress of society through wider access to information.	X	X	X	%population of people having 3G/voice access, broadband access in a village
					%No of households with internet access
	Evaluating the societal access to telecommunication which implies an ability to communicate without barriers	X	X	X	% village area with cellular Voice, data, and other reception
	Evaluating Municipalities capacity to roll out ICT infrastructure projects	X	X	X	No of ITC projects rolled out in the past 5 years for the rural villages

ing inquisitive minds and life-long learning. Number of book titles could unlock access to information and media, online databases and internet access from library would encourage information sharing which builds one's confidence and self-esteem [25]. This metric is mapped with SD Goal 9.c: Significantly increase access to information. Then, a cross reference check with smart cities objectives and indicators reveals that at least two of the indicators can be used as is. The smart city indicators on culture are shown on table 8.

While the other indicators support both smartness and sustainability, only internet access need ICT infrastructure as well as online database access, as a result the table 9 below shows that only 2 out of 4 indicators are marked for the ICT infrastructure.

A rural culture that is geared towards inquisitiveness, hunger for information search can support the sustainable environment which is the next indicator to look at.

G. ENVIRONMENT

This is mapped with SD Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse

TABLE 8. Indicators for smart city Culture [25].

Metric	Smart City Objective	Indicator
Culture	Provision of a basic condition for lifelong learning, independent decision-making, and cultural development	Number of library book titles per 100 000 population
	Enabling ease of information accessibility, allowing citizens to continue lifelong learning more conveniently, cultural development-through digitization	Number of library e-book titles per 100 000 population
	To measure the reach and effectiveness of local libraries providing "a basic condition for lifelong learning, independent decision-making, and cultural development	No of active library users as a percentage of total population

TABLE 9. Indicators for smart rural Culture.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Culture	Provision of a basic condition for lifelong learning, by providing access to information to enable freedom of press and media	X	X		Number of Library book titles per 10 K population
				X	Does the library have free internet access to public
	Enabling information accessibility, allowing citizens to more conveniently continue lifelong learning, cultural development within a 50km radius	X	X		Number of library hard copy-book titles per 10K population (A village is assumed to have a Library)
	To measure the reach and effectiveness of local libraries providing "a basic condition for lifelong learning, academic freedom and freedom of scientific research	X	X	X	No of online data bases available at village library

land degradation and halt biodiversity loss. The objectives are to provide means and ways to have an environment that is not harmful to village community's wellbeing, Provision of an environment that can be ecologically secure as well as an environment free of pollution and ecological degradation. A cross reference with ISO 37122 standard reveals that the smart city indicators also have Environment and Climate Change as the main metric with its objectives and indicators as shown in Table 10 below.

To develop the objective indicators the following questions are asked:

Does the village have capacity to have emergency plan and respond on time in case natural disasters happen? How can

TABLE 10. Indicators for smart city environment [25].

Metric	Smart City Objective	Indicator
Environment	Evaluating city's capacity to understand the evolution of the natural environment and to prevent undesirable outcomes.	% of ecosystems that are mapped by remote sensing monitoring
	evaluation of the contribution to the "preservation and improvement of environment"	Annual frequency of ecosystem remote sensing monitoring
	evaluation of the contribution to "responsible resource use" "attractiveness, and "well-being" purpose- Green Environment	% of buildings built or refurbished within the last 5 years in conformity with green building principles
	Capability to real-time observations, data processing, and analysis, giving people timely information on the safety of a city's air quality.	No of real-time ICT-based air quality monitoring stations per 100K population

the village preserve their own environment for sustainability? Does the village have early warning systems?

How can the village remain green initiatives? How does the village respond to challenge of livestock theft?

Table 11 below is showing how the metric is populated. As can be seen on the table, the indicators support or get ticked for all three criteria, that is, the indicators support sustainability, smartness, and connectivity as well. Technological connectivity in this instance supports the emergency response initiatives and animal welfare and care, wildfire detection etc.

Having looked at the rural culture, environment and safety, the rural village with the help of ICT infrastructure should be ready to unlock the rural economy which is the next metric looked at below.

H. ECONOMY

According to international labor organization (ILO), 'Common challenges to unleashing the potential of rural areas include low productivity; underinvestment in agriculture and non-farm rural employment; lack of adequate infrastructure; poor occupational safety and health and working conditions; and limited or no access to services, including financial services.' The common challenges mentioned here could be resolved if the rural economy thrive. This metric is mapped with SD Goal 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. A cross reference is made with the smart cities' indicator standard as shown on table 12.

From the smart cities indicators, it can be deduced that the economic activities in the village would have potential to bring sustainability, as well as smartness, if people in these areas can start engaging in STEM related jobs even if they must start at very basic levels. To populate the table for smart rural economy, the following questions were raised: *How best can the rural communities do business with the outside world? Are local business owners utilizing online payment methods? How can young people in villages be capacitated with ICT basic skill? How can the village keep its skilled persons in the village to avoid brain drain? Do the small business owners know about the power of social media when doing business?*

To answer the above questions the table 13 below is populated and the three main criteria ticked. Hence smartness

TABLE 11. Indicators for smart rural environment.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Environment &Safety	Evaluating village's capacity to understand and be aware on time, of the evolution of the natural environment, to prevent undesirable outcomes. (ecological security)	X	X	X	Availability of early warning systems in the village, accessible remotely like weather station
	Evaluation of the village capability to coordinate at a central location, data that would be used to asses risk and responds accordingly in case of emergency/natural disasters	X	X	X	Check emergency plan for natural disasters and % No of people trained in such a plan.
	Capacity of a village to deal with livestock theft	X	X	X	%No of domestic animals marked uniquely or having a tracking device
	Capacity to preserve grazing area against wildfires	X	X	X	Availability of Wildfire indicators and emergency response plan
	evaluation of the contribution to "responsible resource use" "attractiveness, and "well-being in safe and lively dwelling" purpose- safe and basic shelter	X	X	X	%No of buildings built to withstand harsh weather conditions (...Villages are green)
	Capability of a village to (preserve the environment) monitor basic conditions and quality of air and use that data for village's benefit.	X	X	X	%No of air quality measuring devices per village. monitored remotely?

TABLE 12. Indicators for Smart Cities Environment [25].

Metric	Smart City Objective	Indicator
Economy	To enable communities to search and find business data online beyond word of-mouth or contacting a business	% No of local businesses contracted to provide city services which have data communication openly available
	To evaluate the contribution of start-ups to employment creation in the innovative/technology focused areas of the economy to bring "attractiveness"	Annual number of new start-ups per 100 000 population
	evaluation of the contribution to "Social cohesion", "Well-being", "Attractiveness" and "Resilience". Bridging digital divide	% No of labor force employed in the (ICT) sector
	development of human capital, economic development, promoting innovative thought processes	% No of the labor force employed in the Education, R &D Sector

and sustainability are ticked. ICT would be the driver of the innovative indicators identified below to unlock the rural village economy. As can be seen on Table 13 below, for the villages to have smart economic activities, they would need connectivity as this would ensure they are connected to the entire global village and get to know in real time market activities as an example.

Once the rural economy is up and running, people can have access to basic services and at least also afford to pay for such services, ownership of property in the form of housing etc.

I. HOUSING

Accessing basic services for rural housing would go a long way in realizing the adequate housing rights and making the rural villages sustainable. From the sutainable development goals, the housing metric is mapped with SD Goal 1.4. According to the goal, by the year 2030, nations are to ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance. The main objective in this instance is to provide access to adequate housing. The question asked here is: which things will make housing adequate and basic? How can rural villages enjoy basic human rights like the urban nations? Can the governments/state provide safe shelter to rural communities? Table 14 below shows smart city standard's housing indicators. The smart city objectives move from the premise that the urban dwellers already have smart electricity and water meters.

Unfortunately for rural areas, access to piped clean water, reliable energy source etc remains a challenge. As the table 15 below shows, out of the four indicators identified on this metric, only two would require an ICT infrastructure.

TABLE 13. Indicators for smart rural economy.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Economy	Enabling communities to be able to search and find business data online beyond word of-mouth using data enabled platforms.	X	X	X	No of businesses that uses Social media platforms for advertising in a village
	Unlocking smart agricultural practices	X	X	X	% No of small farmers in a village having access to farming portals for advice, as well as access to advertising.
	To evaluate number of small businesses utilizing the ICT platforms to trade, creating jobs in an innovative and cost-effective manner	X	X	X	Annual number of new spaza shops/ start-ups per 10K population-using ICT platforms to sell their services
	Skills transfer and capacity building in line with Industry 4.0 skill set to bridge the digital divide.	X	X	X	% No of labor force employed in the (ICT) sector
	human capital, economic development, promoting innovative thought processes in the rural villages	X	X	X	% Labor force employed in Edu, R&D sector and still residing in the village.

TABLE 14. Indicators for Smart Cities Housing [25].

Metric	Smart City Objective	Indicator
Housing	Evaluate capability to measure and monitor electricity usage remotely in order to better plan and predict consumption rates.	%Households with smart electricity meters
	improving neighborhood, livability and sustainability by providing a higher density of varying uses in an area.	%Total land area that is a mixed-use zone
	Evaluate capability to measure and monitor water usage remotely in order to better plan and predict consumption rates	% Households with smart water meters

The other basic right that all persons should have once they have adequate housing is access to basic health care. The following section look at the heath care access as called upon by SDG 3.

TABLE 15. Indicators for smart rural housing.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Housing	Access & usage monitoring systems-responsible resource usage	X	X	X	% Households with pre-paid (smart) electricity meters in a village
	Access to Land/ rural planning	X	X		% Total Land area earmarked for development
	Access to proper structured Housing facilities	X	X		%No of state provided housing Houses in a village equipped with Solar heating
	Provision of clean pipe water as a necessity to a central accessible location	X	X	X	% Zones having access to clean municipal water with centralized area smart meter

J. HEALTH CARE, FOOD, WATER, AND SOCIAL SECURITY

This metric is mapped with SD Goal 3: Ensure healthy lives and promote well-being for all at all ages. The objectives from SDG 3 is the promotion of people's well-being, ensuring access to healthcare to ensure healthy lives. Accordingly, table 16 below shows the smart cities indicators extract taken from ISO 37122 standard on health metric.

TABLE 16. Indicators for Smart Cities Healthcare [25].

Metric	Smart City Objective	Indicator
Healthcare	Enabling care providers to care for patients from a holistic approach anywhere anytime accessing patients' information.	%City population with online unified health file accessible to health care providers
	To allow researchers and the city to have access to reliable and easily accessible EMF mapping data.	%City area covered by an electromagnetic-fields radiation mapping
	To provide a vital alternative to traditional walk-in appointments. Consideration includes aging populations, decreased mobility, or limited access to transportation.	Annual No of medical appointments conducted through telephone or online video service per 100K population
	To provide important information and advice to the public to minimize air pollutant exposure.	% City population registered with public alert systems for air and water quality advisories

While the smart cities standard differentiates between healthcare and recreation, for rural areas the need the two are combined. The point is that the health and recreation go hands in glove. For one to have a healthy lifestyle, recreation is necessary and therefore the need for such infrastructure arise. For the village indicators development, the following questions were raised to derive the smart rural village indicators:

Does the village have recreational area, what measures are in place for the village early warning systems related to healthcare? Can the village be warned on time in case the river stream is contaminated? How can the village know the general practitioner's scheduled time to come to the village clinic? Does the village have sporting facility or land earmarked for sporting/playing ground?

To answer the above questions, and cross checking with smart cities' indicator standard as well as deriving objectives, the indicator objectives are checked against sustainability, smartness and need for ICT for connectivity as shown on table 17 below. As the table shows, almost all the indicators would require the ICT infrastructure for connectivity. For sustainability and smartness all indicators are ticked beside the number of sporting facilities in the rural village because that requires at least access to land or infrastructure.

Rural communities need some form of education to participate in an economy, live in an equitable society with an inquisitive culture as well as participation and affordability of the heath-care system. Accordingly, the next section covers the smart rural education indicators.

K. EDUCATION

This metric is mapped with the SD Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

The following objectives are created from the SDG 4:

Provision of basic quality education,

Provision of secondary quality education, as well as

Provision of further education and training.

Table 18 below is an extract from the smart city indicator's standard on Education.

To derive indicators to tie in with main objectives on education for smart rural communities, the following questions are asked:

How can we measure provision of basic quality education for children of a schooling age in a village? How can we measure the provision of access to secondary quality education for the rural youth? How can we measure or monitor progression to further education and training for the rural youth?

Table 19 below gives the detailed objectives and indicators proposed for the smart rural village that would as well be important to sustain the village community. Smartness and connectivity for the smooth running of the education system in rural villages is also proving to be a necessity. Those implementing these standard indicators would have to adjust to their village setup as the education challenges differ from one village to the other.

Almost all indicators and objectives support the three criteria for sustainability, smartness and connectivity beside where the objective is to determine the distance travelled by learners to access the nearest school as well as the issue

TABLE 17. Indicators for smart rural Healthcare and recreation.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Healthcare & Recreation	Provision of access to basic medical care in a predictable and reliable timeframe.	X	X		Predictable and reliable GP's Schedule to visit the village clinic:
				X	No of mobile smart mobile clinics per 10K village population
	Assessing the villages knowledge about access to healthcare online platforms	X	X	X	%No of people aware of e-health services and registered in a village
	Availability of recreation facilities in a village	X	X		No of sporting facilities and %area land used for recreation
	Access to clean, healthy and sustainable air and safe drinking water.	X	X	X	%No of people having access to quality monitoring data for air and water.
	To inform people whether the quality of water is suitable for drinking or use for other activities.	X	X	X	Does the village have any form of alert system for water and air quality deviation levels?
	To check the number of people knowledgeable on precautionary measures to take in case water is not suitable for use.	X	X	X	%No of people boiling water (borehole and river) before usage as a result of monitoring results data

of children of a schooling age being able to access basic education from a young age.

L. FINANCE

The finance metric is mapped with the SD Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development. Following from the mapping, a cross reference is made against smart cities' indicators for finance. Without means of implementation, there would be no rural economy, nor economic activities in villages. Table 21 gives a list of objectives and smart cities finance.

TABLE 18. Indicators for smart cities Education [25].

Metric	Smart City Objective	Indicator
Education	To determine access to Online databases available through public libraries which allows access for public library users to informational materials that might otherwise be accessible only via academic collections.	No of online databases available through public libraries per 100K population
	To check the potential to increase the mobility, employability and personal development of people, as a result of well-educated and diverse population that can handle interactions that extend beyond national borders.	% of city population with professional proficiency in one or more foreign languages
	To evaluate accessibility of electronic devices for students, as well as the exposure to computers, laptops, tablets, or other digital learning devices, enhancement of computer literacy at primary school level	No of computers, laptops, tablets, or other digital learning devices available per 1K primary school students
	To evaluate accessibility of electronic devices for students, as well as the exposure to computers, laptops, tablets, or other digital learning devices, enhancement of computer literacy at the secondary school	No of computers, laptops, tablets, or other digital learning devices available per 1K secondary school students
	To determine the city's capacity to create critical thinkers, increase science literacy, and enable the next generation of innovators through STEM education.	No of Science, Technology, Engineering, & Mathematics (STEM) higher education degrees per 100K population

The following questions were asked to further break the objectives down into indicators: *How does the village money circulate? How is the municipality spending against infrastructure development? How is the notion of inclusive growth implemented?* Table 22 below shows the derived indicators. To categorize the indicators, a ticking exercise was done to check if they would satisfy the sustainability objective, smartness, and the need for ICT infrastructure.

M. ROAD/RAIL NETWORK AND TRANSPORTATION

In most villages, infrastructure remains a problem. Accordingly, the below indicators could be what is called enhancement effects, which mean that a rural area will be more attractive, efficient, and rural physical network (road, rail, water, energy, and irrigation) will be more adequate to ensure rural-urban connectivity [52]. Below section covers the road/rail and transport infrastructure. This metric is mapped with the SD Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

The questions to be answered on road and rail network are: *How does the village connect physically to outside world? How can small scale farmers and big farmers in rural areas transport their products to the main markets? How do people in the village access the towns and cities? What is the possibility of people sharing their private cars for transportation*

TABLE 19. Indicators for smart rural education.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Education	Provision of access to basic education for the children of a schooling age in a rural village	X	X		% No of School aged children attending primary School
					No of a public school accessible within 30min walk in a village
	Provision of access to information and online databases in a village school	X	X	X	No of e-book titles in a school Library
	To evaluate the exposure of rural students/leaners to electronic devices to enhance computer literacy at primary schools' level (foundation phase)	X	X	X	No of computers, laptops, tablets, or other digital interactive learning devices available village's per primary school grade/classroom
	To evaluate the exposure of rural students/leaners to electronic devices to enhance computer literacy at village's secondary schools' level	X	X	X	No of computers, laptops, tablets, or other digital interactive learning devices available per village secondary school grade/classroom
	To determine the village's capacity to create critical thinkers, increase science literacy, and enable the next generation of innovators through STEM education.	X	X	X	No of Science, Technology, Engineering, & Mathematics (STEM) education certificates per 10K village population

of persons and parcels? Table 20 below presents the list of infrastructure requirement's indicators necessary for rural villages.

TABLE 20. Indicators for smart cities finance [25].

Metric	Smart City Objective	Indicator
Finance	Measure the extent to which municipalities are spending on smart city innovations and initiatives which provides insight into the commitment cities have towards smart city models.	% of municipal budget spent on smart city innovations and initiatives per year
	Evaluate if the inclusion of this policy allows for taxation which supplements municipal capital budgets.	Annual amount of tax collected from the sharing economy as a percentage of total tax collected
	Cities that combine e-invoice and e-transfers with automatic accounting and control systems can experience a noticeable increase in productivity.	% of payments to the city that are paid electronically based on electronic invoices

TABLE 21. Indicators for smart rural village finance.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Finance	Measure the extent to which tribal authorities/municipalities are spend on rural development and ICT Infrastructure development	X	X	X	% Municipal budget spent on smart rural development per year for innovation programs
					% banking /financial infrastructure like mobile Banks (mobile ATM's) in the rural villages
	Evaluate the rural community's saving culture and use of technology to do those transactions	X	X	X	% No of people investing in Society groups using formal banking sector apps,
					%No of people using cellphone banking
	Evaluate the possibility of inclusive growth and convenience to access finance through mobile data apps.	X	X	X	% No of people having bank accounts in a village/ utilizing mobile or digital money

V. SMART VILLAGE CHARACTERISTICS

This section introduces the characteristics of the smart rural villages based on the indicators derived on the previous section. Out of all the metrices and indicators identified above, the following characteristics are coming out to define what a smart, sustainable, and connected rural village:

A village that embrace the culture of lifelong learning, adapt new cost effective and easy to maintain technologies and innovate using same (Culture and Education).

A village that has adequate housing that is equipped with basic amenities like safe drinking water or services to make the living conditions conducive for the dwellers (Housing)

A village that can provide safe drinking water, detect early the pollution into their river streams and wells, as well as providing predictable and stable scheduled basic health care to its people (Healthcare and safety).

A village that take care of its environment for current and future generation's sustainability in a smarter manner by having early warning systems, to detect adverse weather conditions, wildfires etc. (Environmental sustainability).

A village that understand dangers of natural disasters and capable of responding on time and in a systematic, safe and predictable manner (Safety and Environment).

TABLE 22. Indicators for Smart rural village road/rail network.

Metric	Objective	Conversion			Smart Village Indicator
		Smart	Sustain	ICT	
Road/Rail Network and Transportation	Does the village have a physical connection to outside worlds	X	X	X	Availability of main road connecting the village to the main road
					Availability of the railway line to connect the village to nearest port
	Availability of reliable people's transport in a village	X	X	X	Availability of strict public transport schedule known by the village
	Municipal Capacity to run Road and Rail Infrastructure projects	X	X		%Municipal budget allocated for roads
					%Municipal Budget allocated for rail network infrastructure
	People involved in sharing economy	X	X		No of individuals in a village transporting people and parcels
	Usage of social media for transportation of people	X		X	No of people tracking a taxi using a social media platform

A village that is proud of its cultural values and practices, encourages creativity, attracts tourism leveraging its rurality for sustainability and economic activities (Culture).

A village that is connected to outside world physically as well as using basic ICT infrastructure and smart technologies/instruments (Roads/Rail network, ICT/Telecommunications)

A village that has basic technical skill to maintain the ICT infrastructure and technologies (Education)

A village that has basic mobile finance infrastructure to allow smart circulation and use of money (Finance)

It is noted that not all smart city indicators and objectives are applicable to rural villages. As an example, the water and recreation metrices were incorporated into the heath metric because to the village, monitoring the stream/well's water is regarded as a health rights issue while in the city there is already an infrastructure that deals with water cleanliness, sewerage farms etc. Exercising is also seen as a health matter for the better wellbeing of villagers, as a result the call for the availability of recreational facilities gets incorporated into the healthcare and recreation metric. The Safety metric elements were also incorporated into the Environment and Safety Metric, because the safety concerns in the rural villages are more about the adverse weather conditions, livestock theft as well as the safety of the grazing areas as a result of uncontrolled wild fires. Solid waste metric from the smart cities' indicator standard was also incorporated into the energy metric of smart rural village's proposed indicators. Urban/local agricultural and food security did not make it to the rural indicators because to the villagers, this is the way of life, in that agricultural activities in rural villages, small scale farming as well as general population farming for subsistence is the order of the day. The urban planning, population and social condition as well as reporting and record maintenance metrics were left out because as we said in the introduction, the intention of the study is not to transform villages into urban areas and as a result this metrics and their indicators were seen in that light. There is no piped water in the most villages, no sewerage farms nor recirculation of bulk water, accordingly the metric on wastewater fell off. When coming to transportation metric, for the start, the village's roads are not tarred, no proper bus stops, no reliable bus schedules due to lack of proper road infrastructure. So, if any metric was to be incorporated here, road infrastructure as a metric was added as an enabler.

VI. CONCLUSION

This section details the conclusion made in this study. The contribution of the study is on the detailed method developed over a two-year period to derive smart rural village indicators, as well as the characteristics that can be used to define what a smart rural village is. This would help various policy makers to make decisions that would help nations when coming to smart rural development to improve quality of lives. If implemented, rural areas can overcome the challenges they face in relation to inadequate access to healthcare, education, recreation, financial service, water, poor infrastructure, poor economic conditions as well as inefficient postal services. Following from the diminishing of challenges, the educated persons leaving villages because of lack of employment opportunities and other amenities thereby causing the brain drain in rural villages can be retained.

While the indicators are not listed in order of importance, it should be noted that without affordable, sustainable and modern energy source, all other indicators would not be possible to implement because the ICT infrastructure requires energy to operate for connectivity or smartness. A smart village envisaged in this study is the one that enables its villagers to make use of the contemporary technological and social achievements that are brought about by Industry 4.0. Immediate readily available technologies like the early warning system for adverse weather conditions, wildfires detection systems, online GP's schedule for the village clinic, online bus schedule or taxi schedule, smart mobile clinics, power of social media, internet access through mobile cellular telephones as well as smart pre-paid metering for electricity, cheaper and renewable energy, solar powered routers to equip rural villages libraries/schools with internet connectivity etc., would go a long way in supporting the developed indicators.

This mean the that based on the proposed indicators and each metric, villages would have an ecosystem that enables a data acquisition(from smart instruments like those early warning systems) so that it can be monitored, analyzed and used for better decision making in a rural setup. The smart

rural village would be attractive to manufacturing firms that are likely to set up factories and unlock the rural economy. The conclusion is that a smart village should sustain itself, be smart and be able to connect to the outside world both in terms of ICT network and the physical road/rail infrastructure. Attached as an appendix, is the table showing a reconciled table which shows the full list of smart rural village indictors with their objectives listed as well, developed in this study. We agree that the indicators developed need to be implemented as a case study for validating, however this is currently beyond the scope of the article. Hence, we recommend that for future studies. This is to say longitudinal study be done to test the validity of the indicators proposed on this article. We further recommend that an ISO standard similar to the ISO standard on smart cities indicators be developed and the list of indicators shown on the appendix be used as initial input to developing such a standard for policy makers across the world.

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