'SMART CITY' MODEL FOR DESCENTRALIZATION OF PERUVIAN SUSTAINABLE DEVELOPMENT

ABSTRACT

The paper aims to analyze the adequacy of a smart city prototype to promote decentralized innovation in public services in Peru. The research is meant to become a reference guideline to establish Information and Communication Technologies' (ICT) solutions criteria to provide urban public services in Peruvian emerging cities. So the study is related to the country's national development politics stated in the Bicentenary Plan "Peru towards 2021". To follow these trends, regional and municipal strategic plans include policies which require a coordinated and cross sectoral perspective in order to achieve development and competitiveness goals in regional and national level.

The methodology of this paper is divided in two parts. The first part is focused on the analysis of the demand to provide five types of local public services: health, education, transportation, public safety and urban solid waste (USW) management. The second part is centered on the adaptation of the minimum telecommunications infrastructure requirements, to assume ICT solutions with a more efficient management of local resources to attend those public services. In addition an approach to an economic analysis of the proposed technical solution is done with focus on sustainable development. The main secondary source used in this study was the database of the municipality which was analyzed to obtain the demand of attention in the mentioned public services. This is the basis for the evaluation of the transmission capacity requirements for the local optical fiber network, whose access point has just been installed in this important emergent city located between the highland and rainforest area of Peru.

Based on the municipality of Huanuco database, the requirements were assessed considering the attention to 1 regional hospital, 1 health post, 7 health centers without internment, 241 municipal schools, 6 technical productive centers, 5 superior nonuniversity college, 85 urban public transportation routes, 160 security cameras, 2 video surveillance control centers, 62 mobile cameras, a total of 120 tons of USW daily and just 1 USW treatment center. The results defined that the use of ICT is needed to improve the necessary capacity for the transmission of information that enables effective local management. The implementation includes 1 Operations and Control Center supplied with 30 servers and 8 cores at a processing speed of 2.1 GHz, a central switch and 6 distribution nodes interconnected by 30 Km of optical fiber within the urban perimeter. Furthermore, the requirements for the implementation of the Big Data Analytics are analyzed and management software is needed for the collection, interoperability, processing and dissemination of the information obtained. In addition, to be effective, these telecommunication infrastructure requirements must be complemented with the development of institutional and personal capacities of the people related to these services.

Although the requirements for the implementation of the optical fiber dorsal and regional network have been previously estimated, this research is the first attempt to provide information regarding the need for urban telecommunications infrastructure for cities of the Peruvian highland and rainforest regions. As a result of this study, it was found that a municipal investment of around 5 million dollars is required to be able to improve the attention to 80% of the population of Huánuco. Thus, this project has an effectivity cost of 52 dollars per person for its implementation plus 20 dollars annually for operation and maintenance.

Key words: Smart City, Innovation, Sustainability, Telecommunication Infrastructure, TIC, Public services

INTRODUCTION

Government's purpose is to deliver public services that respond citizen's needs and promote sustainable development in their territories. In Latin America, this kind of development focus on set up local conditions that allow overcoming social and economic gaps and minimizes environmental impacts. In order to ensure local sustainable development is require that public service provided must be decentralized and delivered by subnational governments, because they are close to citizens and are capable to identify extended needs

In the last years, international trends show that subnational governments has dedicated on developing smart cities in which public services are delivered using ICT under a sustainable development focus that are adequate to citizen, business and private and public organization needs. In Peru, smart cities implementation is stated in the Bicentenary Plan "Peru towards 2021". This plan defines six core strategies which respond to the challenges and opportunities of the world mega trends: Globalization, global democracy, mass use of informatics and telecommunications, megacities growth, climate change, concern for the environment and preference for natural products, biotechnology and nanotechnology, among others. To follow these trends, regional and municipal strategic plans include policies which require a coordinated and cross sectorial perspective in order to achieve development and competitiveness goals in regional and national level.

It is important to note that the research is focused on the attention of five types of local public services: health, education, transportation, citizen security and management of USW which are of municipal responsibility. Neither the provision of services pertaining to other levels of public management, nor the provision of other local services related to water and drainage management, electric energy, public lighting and urban signposting among others, have not been included in this study. Likewise, this work has been developed on the basis of average demands for each type of service. Later on, the specific needs of infrastructure and the development of institutional capacities and human capital must be deepened for each case (school, hospital, etc.).

The paper's structure is divided in four sections; the first one is literature review that explains subnational government, decentralization process, sustainable

development and smart cities concepts and how they are related. In the second part the context and public services in Huanuco are described. After this, it is analyzed Huanuco city's telecommunication infrastructure requirements to develop a smart city in which public services, the five selected before, can be delivered effectively to citizens. Finally, some conclusions are presented, for example processing speed needed to implement ITC and investment require developing a smart city in Huanuco.

METHODOLOGY

To know the reality of the city of Huánuco in depth, interviews have been conducted with members of the Regional Government, Municipality, businessmen, members of professional associations and research centers, which are then contrasted and combined with documents published on Internet sites and local documentation of each entity. We mainly concentrate on.

A) Citizens, who are users of public administration, municipalities, universities and research centers.
B) Businessmen and merchants associations.

C) The organizational model of the institutions.

D) The types of services offered by the institutions and the main objectives of these services, in addition to those services provided through open and public Wi-Fi wireless connectivity, which allows access to all types of relevant information, such as tourism, economy, transportation, energy, safety, education, health and environmental care.

E) The technology used to provide public services, through the use of ICTs for an efficient and effective management of public administration, which results in a positive social impact. Citizens can receive services in digital format, thus reducing environmental pollution.

F) The business model allows the identification of new forms of services, free or paid, through the use of free and open Internet and other forms of paid services, which allows the growth of commercial activities, such as the development of software and multimedia applications necessary for the operation of the services.

G) The deployment of free and public Wi-Fi hotspots in the city allows the digital divide to be reduced so that the population with fewer resources has access to educational content through the use of the Internet.

H) The network infrastructure can generate collaborative work among citizens to create new services and better management of existing ones. It facilitates the exchange of information between different social subjects to improve aspects such as citizen security and care for the environment, through the creation of civic or municipal networks.

LITERATURE REVIEW

Following is a review of the literature that supports the relevance of the role of subnational governments in the promotion of sustainable development. This approach helps to understand the concept of smart cities in terms of commitment to the provision of efficient public services that promote effectiveness, in the attention of the citizens' needs, without endangering the future generation needs.

Subnational governments in the promotion of sustainable development

In the seventies, during the 1972 Stockholm Conference, the United Nations proposed that development should focus on improving "the quality of human life without exceeding the load capacity of the ecosystems that support it" (FAO, 2016, pág. 2). It is important to recall that it was not until 1987 that the World Environment Commission added the concept of sustainability to that of development, meaning to look for a balance between "environment quality and human activities" (Brundtland, 1987). Since then, many experiences have been recorded where governments have sought to incorporate the sustainable development approach in their plans, programs and actions in order to ensure welfare and living standards to society (FAO, 2016). A first stage for the definition of the scope of sustainable development approach, focused on understanding the limitations of economic growth, as well as reducing environmental impacts produced by human activity. Both focuses are necessarily important to be considered in the framework of the dimensions of socioeconomic development (Naciones Unidas, 2017; Gudynas, 2010).

For each dimensions analyzed, from the economic point of view, the need to understand the composition of the market in which you want to be present as well as the existence of conditions and opportunities for wealth generation, has to be considered. At this point, the State has an important role as the one who provides the conditions for creation of sustainable organizations and who becomes responsible for facing market imperfections to promote liberties which facilitate the emergence of the necessary capabilities to attain sustainable development (Artaraz, 2002; Sen, 1986).

The social dimension is specified as the one that seeks equity through "intragenerational solidarity" which ensures equity and development for the more vulnerable groups. This should take into account "intergeneracional solidarity" which requires that current economic or human activities do not affect the satisfaction of the needs of future generations. It is also necessary to consider "geopolitical solidarity" which analyzes, from the territorial point of view} the power relationship between different development levels (Xercavins, Cayuela, Cervantes , & Sabater, 2005; Artaraz, 2002).

Finally, the environmental or so called ecological dimension emphasizes that natural resources are not inexhaustible or completely renewable. Thus, the global economic base must prioritize new paradigms and focus on the most efficient use of resources. The emergence of more intelligent ways of development is expected and a more relevant investment in knowledge management to make the attention to social requirements more effective is

needed. This new ways demand more connectivity. For this purpose it is necessary to generate value in a cleaner, renewable and sustainable way. In this context, innovation becomes a key process, where the role of the State is to promote the sustainable development approach as a consistency axis between the science and technology systems and the innovation system (Vega Centeno, 2014).

Likewise, sustainable development trends can be broken down in "weak", "strong" and "super-strong", depending on the degree of value given to its dimensions. However, most countries, especially the most developed ones can aim to promote a strong type of development, which is characterized by recognizing the shortage of natural resources. This development proposes a change in the society's consumption habits with the purpose of producing less environmental impacts and generate opportunities for the development of entrepreneurships (Gudynas, 2010) . In developing countries, the low level of institutionalization does not allow direct impact at various levels of organizational policies, which may have implications in a weak framework for the generation of the necessary conditions for adoption of the sustainable approach.

In these countries, the State assumes an important role to ensure that sustainable development approach is implemented and that a better balance between the social, economic and environmental dimensions is generated. In that way, it provides public goods and services that respond to or are aligned with this point of view (Sen, 1986). To understand this perspective, the following section explains what is understood as public service, its characteristics, how it relates to sustainable development and how it is provided under a decentralized scheme.

Public services and decentralization process

In this section the provision of public services under a decentralized scheme is analyzed to explain their contribution to sustainable development. In a general framework, public services are considered as the intentions of the State, so to be identified and characterized, they must be understood from the specificity of each public administration (Ariño, 2004).

In addition, from the traditional concept, public services are conceived as a declaration of activity act from the government and therefore, are incorporated to the responsibilities of the State (Ochoa, 2013). These services are intended to satisfy the general needs or interests of the society, such as maintenance of public order, health and education, among others, and for which the citizen pays a monetary contribution or demands higher levers of equity (Reyna & Ventura, 2008). These services are managed by public, decentralized or centralized organizations, although their execution may be entrusted to private entities (Ochoa, 2013), this will depend on the financial and human capabilities with which they count as well as on the subsidiarity principle.

In this context, a government which is closer to the population and that presents the capacities to provide this type of service is required. For this reason the

responsibility for the provision of this services is given to subnational governments (Dromi, 1996) with the purpose of an effective provision of public services which are appropriate to the particular needs of the society and thus minimize inequalities (Winchester, 2006). Likewise, decentralization in the provision of services contributes to generate a more cooperative government scheme where management is done in accordance with the interests of citizens (Jorquera, 2011; Arguedas, 2008).

The generation of a favorable environment for local sustainable development is expected with the provision of these services in a decentralized way. For this, subnational governments should assume a leadership role and be able to direct the interests of society, to fulfill the productive promoter role and to strengthen local competitiveness (Silva, 2005). However, effectiveness of public services, both centralized and decentralized, is still incipient in Latin-American countries. This is due to the fact that social demands have been inadequately channelized and thus it is necessary to evaluate the performance of the provision of these services. In this sense, to optimize the management of public services it is necessary to measure both the demand, related to how much and in what way citizens expect to receive the service, and the level of offer, meaning how much of and in what way the service should be intelligently provided (Guzmán, 2005).

In order to achieve sustainable development at local level, the efforts of subnational governments in the provision of public services should be based on citizenship demands, should be aligned to create economic opportunities that have minimal or no environmental impact and that do not threaten the development of present and future generations. With these considerations, the concept of Smart Cities and its connection with the provision of public services at subnational level, including the sustainable development approach, will be explained.

Smart cities in developing countries

Cities are articulating nodes of social, economic and territorial or environmental aspects because they concentrate production, distribution and information exchange processes (Caravaca, González, Mendoza, & Silva, 2008). However, throughout history, cities have been implemented more to meet economic requirements and private displacement, than for public purposes (Aguilera, 2013).

Faced with this situation, new trends appear that seek to introduce the sustainable development approach in the conception, formation and construction of more humanized cities, among which are the strategies related to smart cities (Aguilera, 2013). These types of cities are characterized as places that should allow for the development of citizens with an efficient balance between the social, economic and environmental aspects. In this process, innovation and technology play an important role. This places use electronic means and information and communication technologies (ICT) for the provision of public

services and to give information about their availability and status (Mitchell, 2007).

In this innovation process, companies, public organizations and civil society participate collectively to meet the needs of public interest and the particular needs of each individual, which become public and private services or goods respectively (Caravaca, González, Mendoza, & Silva, 2008). The objective of these cities is to improve the relationship and the services between the stakeholders that interact in the city, in order to promote sustainable local development and to provide better life quality. In addition, this process is measured by the level of access and the quality of public services provided, such as health, education, public transportation, garbage collection, citizen safety and telecommunications (Claudel, Birolo, & Ratti, 2015; Vivas, Britos, García-Martínez, & Cambarieri, 2013).

In consequence, to implement a smart city, the decentralized provision of services is required. Subnational governments must lead the negotiation process and foster the generation of a future strategic vision that directs the needs of public interest with less negative externalities in the natural resources, that minimizes the economic, social and cultural gap (Villamil, 2014; Aguilera, 2013). In this manner, the smart city operates as a network where society, government and companies are convinced and willing to face relevant changes. In this context, the best ally is the use of new technologies in the provision of different services. Highly technological environments that decrease the use of resources, are created to guarantee the sustainability of the urban system as well as the reduction of poverty and the creation of environments suitable for living (Villamil, 2014; Mancheno & Terán, 2013).

It is important to highlight the fact that in developing countries, subnational governments play a more relevant leader role, directing the needs of public interest that help guarantee the provision of quality public services. It is assumed that this service can be optimized through the use of ICT. Thus, in countries with high environmental and cultural diversity, conditions are created to reduce social and economic gaps. Also, to obtain alternatives that reduces negative environmental impacts and enhances positive externalities. With this theoretical framework, the following section will describe the context of Huánuco district where this research is carried out.


PUBLIC SERVICES IN HUÁNUCO

The socio-economic description of Huánuco is analyzed in order to make easier the look at the demand for public services prioritized in this study (health, education, transportation, security and USW). Likewise, the current telecommunications infrastructure is analyzed to establish an estimation basis for the new requirements to generate more efficiency in the provision of public services in this city. Huánuco district is located in the central part of the homonymous region, whose geography mixes parts of the highland and the

jungle area of Perú which accounts for a high diversity and fertility of its lands for agricultural activities. Likewise, this type of geography, both uneven and combined with forests and thick jungle, originates challenges and opportunities to provide quality public services, especially in transportation (Banco Central de Reserva del Perú [BCRP], 2015).

Socio-economic description of Huánuco

In the first place, the main economic activities that are developed in Huánuco region, are analyzed. Later on the main social indicators, such as monetary poverty, literacy level and coverage of basic needs will be characterized. Huánuco district is located in the central area of the homonymous province and region, has an area of 96.55 Km² and an estimated population of 88 031 people (Instituto Nacional de Estadísticas e Informática [INEI], 2017; INEI, 2009). With regard to the economic activities developed in the Huánuco region and province, highlights are the agricultural activity and fishing (22%) and commerce (13%) as well as other activities such as tourism which is shown in the following graph (BCRP, 2015).

Figure 1. Perú and Huánuco: Production Structure, 2014
(In percentage of NPV)
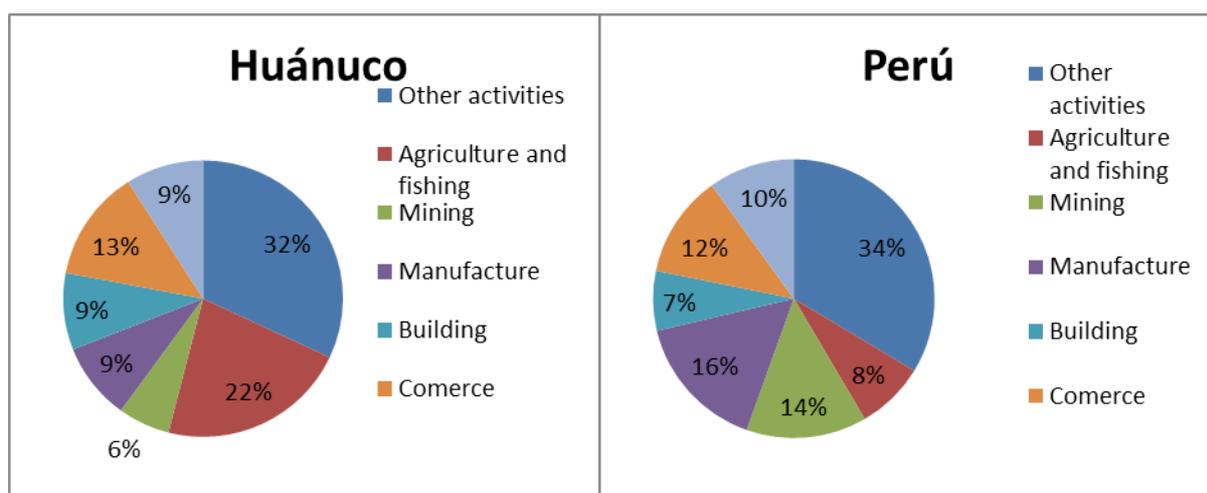
Source: Banco Central de Reserva del Perú (BCRP, 2015)

The mineral richness and diversity of the soils in the Huánuco region accounts for a varied offer of agricultural products and constitutes a potential for growth (BCRP, 2015). Among them are green beans, olluco, potato and tea, which has a soil yield much higher than the national average; cocoa, coffee, coconut, starchy corn, banana and wheat have relatively lower yields (INEI, 2012). Complementarily, Huánuco region exports have had a sustained increase since 2010, especially due to the increase in the production and exportation of minerals (Dirección Regional de la Producción - Huánuco, 2016).

The case of Huánuco district is similar because its main economic activities are those of extractive type, such as mining and agriculture. On the other hand, 43% of the economically active population turns to self-employment through the creation of micro-enterprises (Sayhuite, 2017; Banco Central de Reserva del Perú

[BCRP], 2015). With regard to social indicators, in 2014 this district had between 20% and 23% of the population in the condition of poverty or extreme poverty (Banco Central de Reserva del Perú [BCRP], 2015) and more than 20% of the households had at least one unsatisfied basic need, such as access to drinking water, electricity, among others (Sayhuite, 2017). Furthermore, more than 5% of the population is illiterate and 80% of this group is constituted by women. Finally, more than half of the population does not have any type of social security, be it private or public, which risks the attention and health of the citizens (Sayhuite, 2017).

Due to this serious condition, the effective provision of public services by the local government is necessary to reduce the social and economic gaps that affect the inhabitants of Huánuco district. To overcome this risky situation, the current state in the provision of services and the real demand have to be analyzed in order to detect the gap between what is provided and what the citizen receives. This analysis will enable the proposal of appropriate strategies that respond to reduce the gap.

Public services in Huánuco

This article focuses on five public services: health, education, transportation, public safety and urban waste management. This section will describe the provision of these services in Huánuco district. In the first place, with regard to the **health** service, the district has 60 types of units that provide this service including hospitals, health posts and ambulatory care centers, among others. However, only 9 of them are of public administration and their management is in charge of national (2) or regional (7) level organizations as can be appreciated in Table 1 (Superintendencia Nacional de Salud [SUSALUD], 2017):

Table 1. Huánuco District: Active medical centers under public administration, 2017

Name	Managing institution	Level	Classification
System of attention of urgencies-SAMU	Regional Government of Huánuco	Regional	Support health service
Regional laboratory	Regional Government of Huánuco	Regional	Health establishment without internment
Regional Hospital Hermilio Valdizán	Regional Government of Huánuco	Regional	Health establishment with internment
Las Moras	Regional Government of Huánuco	Regional	Health establishment without internment
Aparicio Pomares	Regional Government of Huánuco	Regional	Health establishment without internment
Nauyan Rondos	Regional Government of	Regional	Health establishment without internment

Name	Managing institution	Level	Classification
	Huánuco		
Colpa Baja	Regional Government of Huánuco	Regional	Health establishment without internment
Center of primary attention III-Metropolitano	EsSalud (Ministry of Labor and Employment Promotion)	National	Health establishment without internment
Health Región PNP – Huánuco	Sanity of the national police of Perú	National	Health establishment without internment

Source: Superintendencia Nacional de Salud [SUSALUD], 2017.

As it can be appreciated, the supply of health services is insufficient because its population is over 88 thousand inhabitants and more than half does not have any type of health insurance. With regard to the public service of **education**, the district has 252 educational institutions including initial, primary, secondary, alternative education, special education, technical productive and higher artistic, pedagogical and technological (MINEDU, 2017). The number of educational institutions, students and teachers is presented in Table 2 where the presence of other types of organizations is appreciated together with the greater participation of primary and secondary institutions.

Table 2. Huánuco District: Educational institutions by type, number of students and teachers, 2017

Type	Number of institutions	Number of students	Number of teachers
Initial-Nursery-Kindergarten	128	5 877	305
Primary	65	14 044	706
Special Education	2	70	15
Secondary (high school)	35	12 649	761
Alternative	11	1 237	58
Technical productive	6	1 696	60
Higher not university	5	2 122	83
Total	252	37 695	1 988

Source: Ministerio de Educación del Perú (MINEDU, 2017).

About educational quality, the results of the Student Evaluation Census –ECE- are not so encouraging because more than half of the students evaluated from 2nd and 4th grade of primary and 2nd grade of secondary showed performances below the satisfactory level (MINEDU, 2017). This points out that there are deficiencies in the provision of a quality public education service because the educational contents are scarcely contextualized or do not incorporate elements of the

cultural identity of the students, which hinders the teaching-learning process (Aramburú & Cajavilca, 2017).

In the case of the urban **transport** system, the Huánuco district has 62.75 kilomenters of road network but only 22% is paved and in good condition. Local, provincial and regional governments are facing this situation through the rehabilitation and maintenance of public roads (Municipalidad Provincial de Huánuco, 2015). Likewise, the district is considered in the construction plans of the Amazonas Hub of the Initiative for the South American Regional Integration – IRSA (Ministerio de Transporte y Comunitaciones del Perú [MTC], 2013). On the other hand, five authorized ground transportation terminals for people, both interprovincial and interregional, are located in this district.   It also has 85 authorized routes to provide these services (INEI, 2016). This situation merits the coordination of the national and subnational governments to provide a transportation service that reduces the threats of traffic flow. Thus, reduces the risks of traffic accidents caused by roads in poor condition or considered dangerous and improves the economic dynamics of agricultural products export to other districts and regions.

The fourth type of public service to analyze is **urban safety**. For the study case, Huánuco city has 2 Video Surveillance Control centers with 160 video surveillance cameras located at strategic places in the city. In addition there are 32 new "witness" mini cameras located on the windshields of the mobile units and 30 hands free cameras for motorized watchmen. Work is coordinated with the police stations of Huánuco city and with the special offices of the National Police.

With regard to the **management of solid waste**, the types of waste in charge of municipal management are those of domestic, commercial and urban cleaning origin (Organismo de Evaluación y Fiscalización Ambiental [OEFA], 2015). After the evaluation carried out by OEFA in 2015 about the compliance level of the management of solid waste indicators, it was evident that in the region's capital there is much to work on. Huánuco province obtained a score of 8 out of 20 points because the capital of the region still has inadequate management of municipal solid waste (40/100) and has few plans for solid waste management (20/30) (OEFA, 2016).

According to information from the District Municipality of Huánuco, the solid waste collection area covers the whole city from Monday to Friday. It has 82 solid waste compaction vehicles, 49 pickup trucks with handrails, 71 tricycles for collection services, 19 dump trucks, 18 solid waste compactors and 23 mini loaders for sanitary landfills. In total, 120 tons daily are collected and taken to the Chilipampa deposit, near the city. However only a small percentage of it is recycled or reused (Municipalidad Distrital de Huánuco, 2017).

Current telecommunications Infrastructure

A diagnosis will be made of the optic fiber core networks and the wireless access networks existing in Huánuco city. The National Optic Fiber Dorsal Network is

one of the most important telecommunications projects in Peruvian history with an investment of S/ 999 million. It consists in the laying of 13 500 km of optic fiber throughout the country which will allow that 92% of the 196 provincial capitals of Perú will have access to high speed Internet by the first semester of 2016. This will improve life quality of Peruvians and will make possible the implementation of initiatives such as tele-education, telehealth and e-government.

In Huánuco, the National Optic Fiber Dorsal Network started operations on February 2016 and has lain 664 km with an investment of US $ 15,4 million, which allows interconnection of all the 11 provincial capitals with a project that will directly benefit 201 000 people. In addition, the Optic Fiber Regional Network will connect 69 district capitals of Huánuco with optical nodes of the National Optic Fiber Dorsal Network (RDNFO) which is currently operating.

Huanuco metropolitan network infrastructure

The infrastructure of the Metropolitan Area Network in the city of Huánuco has the implementation of IP video surveillance cameras, Wi-Fi hotspots (Access Point), connected by passive optical fiber with GPON technology (Gigabit Passive Optical Network), through a network own of poles, which allows monitoring and management in real time from the Network Operations Center, located in an ad hoc location near the Municipality. The NOC has five work stations for the monitoring of IP cameras and access points, a video wall made up of 10 televisions (arrangement of 2 rows by 5 columns). The NOC has two 42RU cabinets, one for the stabilized power system and the other for the management servers and telecommunications equipment as a central switch (core switch) and equipment for GPON as the OLT (Optical Line Termination). Additionally it has cooling systems, technical floor, ground connection system, intrusion system, access control and internal video system.

Passive optical fiber connectivity system

The Passive Optical Network (PON) technology is a suitable solution for the point-to-multipoint network infrastructure of a smart city, since it allows optimization in the use of optical transmission systems, through the use of fiber optics from the NOC to the IP and Acces Point cameras, distributed throughout the city of Huánuco, without the need for active electrical equipment that consumes energy between the central equipment (OLT) and the extreme terminal equipment (ONT: Optical Network Termination), where the IP cameras and Access Point are connected.

This type of network consists of dividing the optical signal between 64 terminals through a completely passive network. This division is made through a passive component called Splitter, or passive optical splitter. Each splitter divides the signal into a single fiber for 2, 4, 8, 16, 32 or 64 fiber optic wires. The fiber optic cables for the network are of loose structure for the totally dielectric overhead installations, they are called ADSS and the number of wires is 24 and 48.

TELECOMMUNICATIONS INFRASTRUCTURE REQUIREMENTS

The document "Technical Report on Stakeholder for Smart Sustainable Cities – WG4 FG SSC-0113" produced by the Theme Group about Smart and Sustainable Cities (FG-SSC) of the International Telecommunications Union (ITU) indicates that the state, through the Housing, Construction and Sanitation Ministry (Ministerio de Vivienda, Construcción y Saneamiento [MVCS]) and the Transportation and Communications Ministry (Ministerio de Transporte y Comunicaciones [MTC]), is the main actor in charge of the formulation, execution and supervision of the compliance of the urban and sanitary, transportation and telecommunications policies respectively. These policies are essential for the development of smart cities. The next step is that local governments must incorporate and adapt these policies in their Concerted Development Plans (PEDC) and in their Institutional Strategic Plans (PEI). Likewise, there are other ministries, such as the Health, Education, Energy, Culture Ministry, among others, whose functions are to establish policies related to the provision of public services. As counterpart in the private sector, there are private companies committed with the implementation, operation and maintenance of the urban infrastructure and equipment.

Telecommunications infrastructure and ICT

For the provision of urban services, it is necessary to have telecommunication infrastructure that enables digital connectivity between the different sectors of the city and its population. Based on this connectivity, from a control and remote monitor center, the sensors and actuators implemented as part of the ICT solutions to be developed are managed. It is also important to have a market penetration of electronic communication devices (smartphones, tablets, laptops or others) above population average in order to have an active interaction of Internet added value OTT (Over The Top) services such as YouTube and Netflix. Thus, regardless of the applications or ICT solutions to be implemented in a city, the following components should be available:

Urban connectivity.- Optic fiber core networks within Huánuco city should be implemented with available interconnection points in different sectors of the city. They can interconnect distribution and access networks of different Operators or deploy new networks to extend connectivity throughout the city. This would guarantee digital connectivity within the city and innovative and integral ITC solutions could be implemented to manage urban public services. The digital bandwidths of the core networks must be at least 10 GBps due to the large traffic capacity that will be generated. Likewise, the network must be scalable so that its capacity can grow to admit new services without degrading quality and performance. They should allow the access to broadband Internet, both fixed and mobile, to receive and send data.

Web interfaces for user communication.- This includes web services, mobile applications to send and receive information from the population, government

entities, private companies, associated with open data platforms and electronic government.

System of sensors and actuators.- They enable the capture of different signals from the environment and their transmission through telecommunications networks to city control, management and operation centers. They integrate different urban public service networks such as traffic management, urban safety, emergency situations monitoring and natural disaster alert, educational and health platforms, among others.

Figure 2: Infrastructure of a smart city
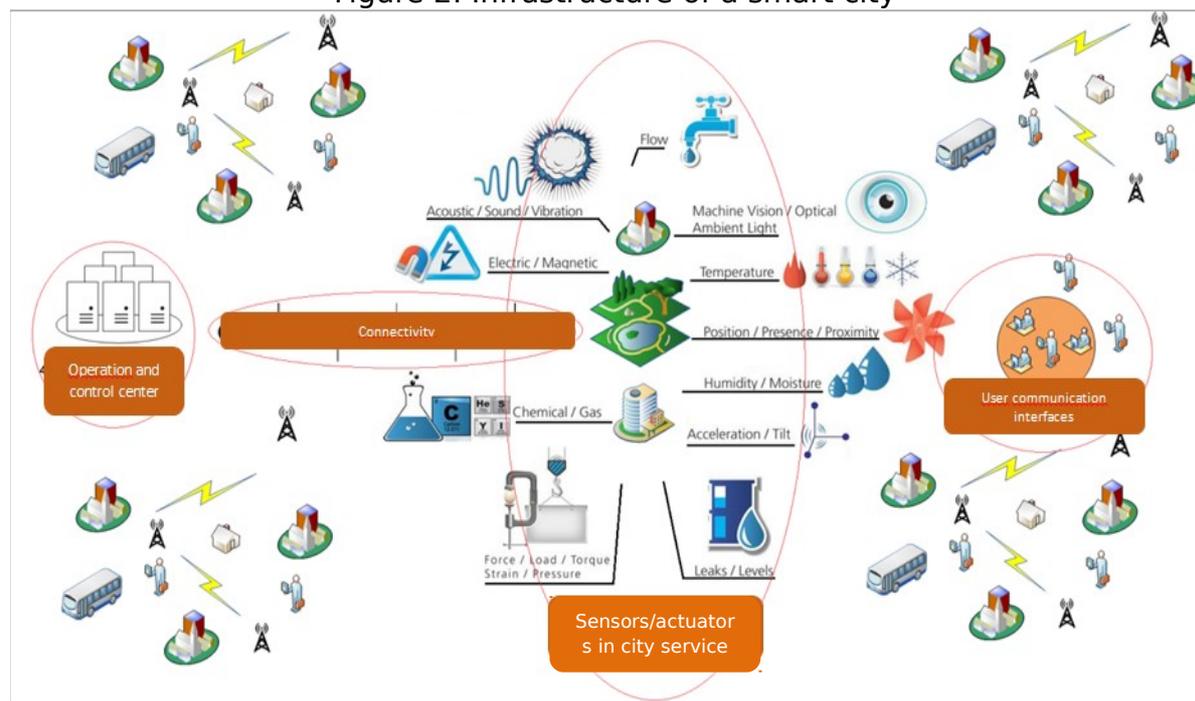
Source: Mercado (2017)

Operation and control center.- For the management and monitoring of urban public services the operations and control center must allow integration and management of the different physical and virtual telecommunications networks. It should be available to the various traditional urban public services that are provided in a city, as well as for new technological platforms for the provision of digital multiservices. Therefore, it is necessary that the following elements are available at the operation and control center: data center, which enables the storage and processing of information that is generated in the telecommunications network operation as well as in the offered services; management and monitoring center, which enables the remote management and monitoring of the elements of the transportation, distribution and access network as well as to obtain statistical information from the digital ecosystem of users that interact with the services offered by the telecommunications network; and Operations Support Systems (OSS) which allows to manage all the components of the telecommunications network, to manage the platforms of telecommunications services and digital services and to ensure the quality of the service.
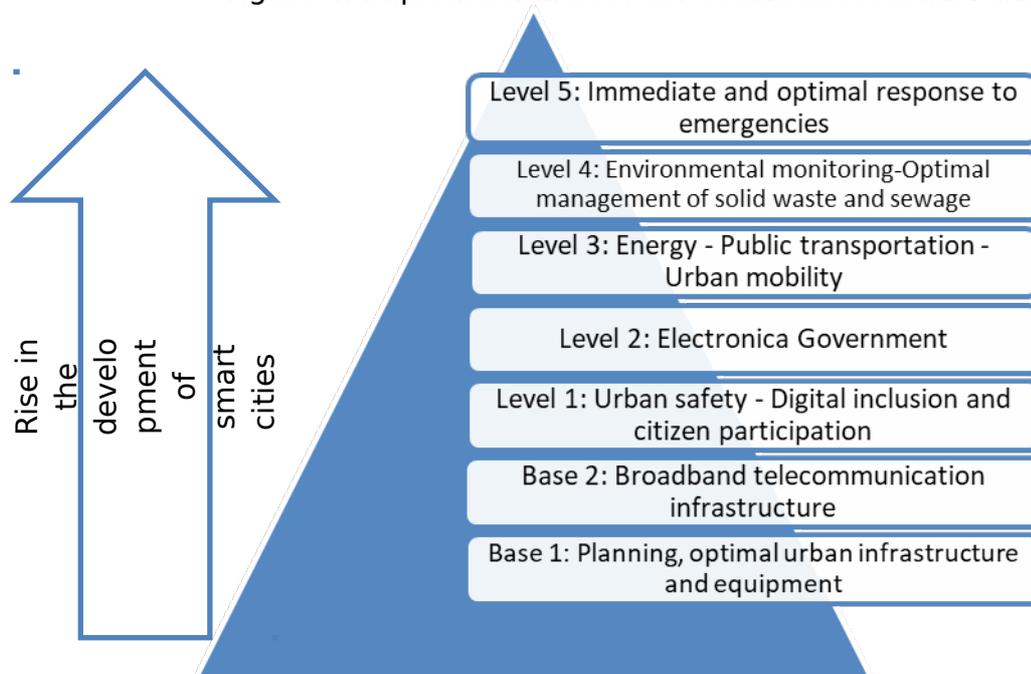
Figure 3: Data Center and Management and Monitoring Center

Data Center   Management and monitoring

Source: Mercado (2017)

ICT services and solutions that will be implemented in Huánuco city look for the improvement of management tools. Figure 4 shows the fundamental basis needed for ICT solutions to rise and strengthen at different relevant environments of the urban management of Huánuco city.

Figure 4: Implementation of ICT solutions for smart cities

Rise in the development of smart cities

Level 5: Immediate and optimal response to emergencies

Level 4: Environmental monitoring-Optimal management of solid waste and sewage

Level 3: Energy - Public transportation - Urban mobility

Level 2: Electronica Government

Level 1: Urban safety - Digital inclusion and citizen participation

Base 2: Broadband telecommunication infrastructure

Base 1: Planning, optimal urban infrastructure and equipment

Source: Mercado (2017)

ICT FOR THE DEVELOPMENT OF SMART CITY APPROACH FOR HUÁNUCO

To analyze the possible solutions, the requirements for the management of health services are set apart to implement the first management tools. In regard to the electronic government, the application of ICT's to the functions of the public sector is promoted with the purpose of increasing efficiency, transparency and citizen participation. Therefore, as part of the digital connectivity, public entities of Huánuco will be able to use the State Interoperability Platform (PIDE), created on October 18, 2011 by Supreme Decree N° 083-2011-PCM. This platform enables the implementation of online public services by electronic

means and the electronic data exchange between State entities through Internet, mobile telephony and other available technological means. In addition, this platform allows citizens to use government web services such as search of vehicle license plates and infringing drivers, location of police stations, medical units, inquiries of public service payments, of judicial background, of academic degrees among others as well as mobile applications from different government entities.

In relation to health services management, with the purpose of providing telemedicine service in Huánuco city, a broadband connection is implemented in health centers to connect with specialized centers and with telepresence modules. These are communication interfaces and portable medical health modules (high resolution portable ultrasound, cardiorespiratory equipment, electronic stethoscope, inspection and examination camera). For the operation of the telemedicine service, the telecommunications network must provide a virtual private network (VPN) for communication to all the city health centers. This will enable communication with each other and therefore, higher hierarchy health centers can meet the clinical requirements of lower hierarchy centers. In the event that clinical requirements cannot be attended locally, health facilities could connect through Internet telecommunications network with specialized centers in the country or in any other part of the world. Additionally, the clinical record of patients that are treated in public health facilities will be stored in electronic records that will comply with technical specifications provided by Ministerial Resolution N° 576-2011-MINSA. The records will be hosted on a server from the datacenter of the operation and control center for exclusive use of the telehealth service.

Among the proposed tele-education solutions are telepresence modules and interactive whiteboards. With digital connectivity, they will enable teachers to have up-to-date and innovative educational content that will capture and maintain the attention of students. This will make easier the creation of educational material and will promote education and learning based on visual elements. Also, a more amusing and interactive atmosphere will be generated. Urban safety management is understood as one of the main problems that is afflicting the population. For this reason, video surveillance of public areas service is proposed. The installation of security cameras interconnected by optic fiber with GPON technology to the monitoring and control center will enable public institutions responsible for dealing with emergencies, giving urban safety and keeping public order to converge (Firefighters, National Police, Municipal Police and "Serenazgo"). This way authorities would be alert to respond immediately when vandalism or emergency arises in the city that might put the citizens at risk.

To implement the proposed solution the recommendation is to install two (2) outdoor IP cameras together with the Hotspot infrastructure for WIFI, to use the same pole infrastructure for the transmission of the captured information. The cameras would be a fixed camera with vision to a specific point of the strategic area, complemented by a rotational camera that allows tracking an objective in

the visual scope. For this purpose it is important to analyze the following requirements:

1. Outdoor PTZ dome camera with infrared function. This type of camera is characterized by having rotational movement in the horizontal plane (panning) and in the vertical plane (till), and infrared function which enables the capture of images and/ or video at night.

2. Outdoor bullet camera with infrared function. Is characterized by having a fixed vision but a wider scope as compared to the PTZ.

3. Camera management software. Is used for video storage server, for 160 video surveillance cameras instead of having many Network Video Recorder (NVR) equipment.

In regard to the management of urban solid waste (RSU) and due to the high concentration of garbage in a single collection center, a first alternative of solution would be focused on the improvement of solid waste treatments. This includes both an aspect of change in citizen culture and another of management by the local government. The cultural change requires citizens to be aware of the correct separation of household wastes between organic and inorganic, among other classifications. For this, technology can be used as a dissemination media. In addition and related to local government management, positive incentives and penalties are required to attain the desired attitude. Consequently, the local government should work in coordination with national level organizations such as OEFA and the Environment Ministry. As well it should coordinate with the Regional and Provincial Government of Huánuco for the construction of solid waste treatment centers. In these centers household solid waste would be correctly segregated. If possible, part would be recycled. Organic residues would be treated to generate new products such as fertilizers.

CONCLUSION

An approach to an economic analysis of the proposed technical solution is done with focus on sustainable development. The requirements were assessed considering the attention to 1 regional hospital, 1 health post, 7 health centers without internment, 241 municipal schools, 6 technical productive centers, 5 superior nonuniversity college, 85 urban public transportation routes, 160 security cameras, 2 video surveillance control centers, 62 mobile cameras, a total of 120 tons of USW daily and only 1 USW treatment center. The results defined that the use of ICT is needed to improve the necessary capacity for the transmission of information that enables effective local management. The implementation includes 1 Operations and Control Center supplied with 30 servers and 8 cores at a processing speed of 2.1 GHz, a central switch and 6 distribution nodes interconnected by 30 Km of optical fiber within the urban perimeter. Furthermore, the requirements for the implementation of the Big Data Analytics are analyzed and management software is needed for the collection, interoperability, processing and dissemination of the information obtained. In addition, to be effective, these telecommunication infrastructure requirements

must be complemented with the development of institutional and personal capacities of the people related to these services.

Although the requirements for the implementation of the optical fiber dorsal and regional network have been previously estimated, this research is the first attempt to provide information regarding the need for urban telecommunications infrastructure for cities of the Peruvian highland and rainforest regions. As a result of this study, it was found that a municipal investment of around 5 million dollars is required to be able to improve the attention to 80% of the population of Huánuco. Thus, this project has an affectivity cost of 52 dollars per person for its implementation plus 20 dollars annually for operation and maintenance.

The local Huánuco government understands that the provision of quality public services to its citizens is a great challenge, thus the transition to a smart city management model would be convenient to ensure the welfare of its citizens. For this purpose, qualified personnel and a minimum of infrastructure is needed to achieve the transition to take advantage of the connectivity opportunities in the optic fiber network. In this aspect, Huánuco society has to be empowered so as to be active stakeholders in the transition process where agreement is required between the civil society, government and companies. Likewise, the transition to a smart city model in Huánuco would enable public administration to have real time information about the conditions of the city and the quality in the provision of public services. This will allow replacing some deficiencies in the coverage of the public services analyzed in this study, where improvement opportunities are appreciated to have more effective management of quality services with the promotion of sustainable development.

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