The Role of People and Sensors in the Development of Smart Cities: A Systematic Literature Review

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***Abstract*—Over the last few years, with rapid population growth in the biggest cities of the world, issues like air pollution, water scarcity, and intense traffic conditions, have become more evident. Trying to mitigate them, the concept of Smart City was presented, which uses technology and human resources to manage urban resources in a sustainable manner. As new scientific researches about this phenomenon are being carried out, the importance of both human and technological resources remain implicit in the development of Smart Cities. But, it is not clear what role is occupied in the different stages of evolution, which leads a city to be considered Smart. Given this context, in this paper we used the SLR method to analyze scientific publications, and thus to determine what is the role of the human factor, represented by people, and technological, represented by sensors, in the development of smart cities. We also created the overview of the scientific research, and can identify the most and least studied areas among those addressed in this study.**

Keywords–Smart City; Sensors; IoT; People; Open Innovation.

I. INTRODUCTION

In the last century, the number of cities in the world with more than 1 million inhabitants jumped from 20 to 450. In 2007, the number of people living in urban centers exceeded 50% of the world population and it is estimated that this number will reach 70% by the year 2050 [1]. The fast growth of the population in urban centers makes us face problems like the deterioration of public transportation services, decrease of air quality and increase of unemployment, etc. [2]. When dealing with these issues, it is necessary to use creativity, human resources, and cooperation between the different areas of the society and good ideas [3].

Technology is a way to solve the problems caused by the population growth in urban centers. Some, such as the IoT (Internet of Things), are used in the context of Smart cities due to their potential to improve the life quality of the population [4]. Not only investments in technology should be taken into account when thinking about sustaining Smart Cities, but human and social capital must be used as a fuel for economic growth and high quality of life by using the natural resources in an intelligent way, through government policies that involve the society [3].

In the current scenario, every initiative is important if it helps understand the growth of great urban centers and how it occurs, as well as what measures should be adopted to extinguish the problems caused by it, from a scientific and economic point of view. Through a Systematic Literature Review (SLR), a panorama of the current scientific research will be presented, dealing with the relationship between people and sensors with the development of modern cities, which are Smart Cities.

The problem considered in this work may be described the following way: There is a large number of works approaching the participation of people and the use of sensors in Smart Cities. There is a need to visualize the current panorama of this research line in a broad way in order to identify open issues, as well as identifying researches to be used for accelerating the studies of this field.

In this work, we intend to provide the current panorama of the scientific researches made in the field of Smart Cities that talk about their development based on the participation of people and the use of sensors, based on the Systematic Review methodology, according to what Kitchenham [5] proposed.

In this work, the term ”development” is used to identify the initiatives of creation of new Smart Cities, as well as the improvement of those that already possess management of natural resources and monitoring of basic services and wish to improve them. Also, the term ”sensors” includes sensors that receive information on the environment, actors that execute actions and transform the environment they live in and other technologies related.

This work is organized as follows: Section II presents the necessary concepts to understand the rest of the research; Section III presents the methodology used; Section IV presents the research protocol used; Section V exposes the results obtained from the execution phase of the protocol and presents the analysis of the results and finally, Section VI exposes the conclusions, suggestions for future researches and the final considerations.

II. SMART CITY

The term Smart City has been used for 20 years and it has evolved due to concerns about the service supply and resource consumption [6], which are increasing with the growth of urban centers. According to Nam et al. [2], the term Smart City can be approached according to three perspectives: (1) Technological Elements: Hardware and software infrastructure; (2) Human Elements: creativity, diversity and education; (3) Institutional Elements: governance and politics. A city may be considered as a smart one when investments in social and human capital and Information Technologies infrastructure transform environmental growth and improve quality of life through participative governance [3].

The use of the word smart as a label for future cities is not by chance. In marketing words, smartness focuses on the

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perspective of the user [7], and it is related to a fast mind, with efficient answers. Smart Cities need to adapt themselves rapidly to the needs of their citizens and provide customized interfaces [2]. Technology is a way to reach it. In this context, Smart Cities can be defined, according to Kehua et al. [8], as the use of information and technologies of communication to measure, analyze and integrate the information of the main services of a city. This way, Smart Cities may respond intelligently to different types of need, including daily maintenance, environmental protection, public safety and commercial activities.

A. IoT

At the same time the access to the Internet becomes easier, computer devices are getting smaller and more popular through mobile devices with the evolution of the industry over the years. IoT can be defined as a global network infrastructure with the ability to self-set itself based on interoperable communication patterns and protocols, through physical and virtual things have an identity, physical attributes and smart virtual interfaces integrated through an information network [9].

Smart Things networks promise to revolutionize the monitoring of environments in a great variety of application domains due to their reliability, efficiency, flexibility, low cost and easy installation [10].

B. Smart City and People

The concept of Smart Cities only makes sense when we talk about the presence of people as target audience of the benefits achieved through the use of technology and other ways to improve quality of life. According to Washburn et al. [11], what makes a city smart is the use of technology to provide basic services for the citizens in an efficient way.

Smart Cities are human cities with multiple opportunities to explore the human potential and turn life into a more productive life [2]. Technological issue, very present in the current conception of smart cities, becomes secondary in the views centered in the social and human part.

III. Methodology

In this section, we present the methodology used.

SLR is, almost always, the initial phase of any research [12]. The purpose is to accumulate more knowledge about the subject the research is about. SLR goes beyond a simple literary review because it uses scientific methodology and provides a way to integrate studies, creating generalizations about the subject.

This modality of study is a way to identify, evaluate and interpret a relevant part of the research about a specific matter of the research, area or phenomena of interest [5].

According to Petersen et al. [13], the need to carry out systematic reviews is that as a specific area matures, a lot of research is made, which generates a great number of primary works that need to be summarized.

Systematic review uses the review protocol as its main tool, which defines a series of steps that must be followed in order to get to a conclusion [12]. These steps must be very well defined so other people can reproduce the same process to validate the study.

The systematic review model used in this work, is based on the proposal of Kitchenham [5] and performed by Oliveira et al. [14], Budgen et al. [15] and Ribeiro et al. [16]. Biolchini et al. [12] proposed a model used on the protocol.

The model is based on three main phases: (1) Planning: the research objectives and the research question are defined; (2) Execution: primary studies are identified, selected and evaluated according to the criteria of inclusion and exclusion defined during the Planning phase; (3) Presentation of Results: presentation of the report with the information obtained during the previous phase.

Described phases may seem sequential, however, many tasks performed in each one of the phases can be started in the Planning phase and concluded only during the Execution phase.

Biolchini et al. [12] describe the three phases through a chart, as seen in Figure 1.

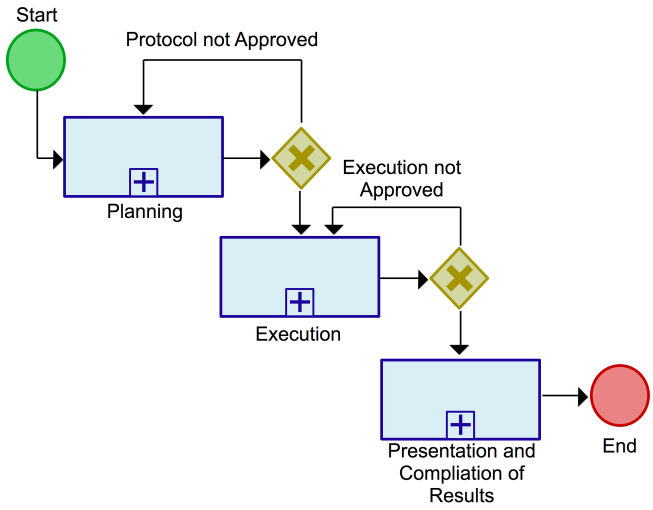

Figure 1. Three stages SLR process.

According to them [12], the process of systematic review can be divided into five steps:

- Problem formulation. Aims to define what kind of evidences will be included in the review. On this step, the criteria that will help the researcher define which studies are relevant for his research should be set;
- Data collection. The objective is to define which will be the sources to acquire evidence;
- Data evaluation. Aims to define which information will be used in the research. Quality criteria must be applied in order to distinguish the valid studies;
- Analysis and interpretation. Synthesizing data is the main goal to create generalization about the researched subject in order to determine if it can be solved or not;
- Conclusion and presentation of the results. The objective is to decide which information will be presented in the final report, since not all the information obtained in the data analysis are relevant for the research.

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IV. Protocol Definition

Protocol definition is the first step of the research development. Using the problem related in the Introduction of this work, a research question was elaborated with the objective of conducing the research procedures. We may define this question as: **Q01** (Question 01) What is the role of people and sensors in the development of Smart Cities?

Novais et al. [17] suggests the division of the research question into sub-questions in order to provide greater coverage. Thus, Q01 was subdivided: **Q1.1**. What is the influence of the participation of people or use of sensors in the study?; **Q1.2**. What is the level of previous infrastructure so the study proposal is viable?; **Q1.3**. What stage of social organization the city needs to be in so the study is viable?; **Q1.4**. What is the contribution of the study for the scientific community?; **Q1.5**. How was the study validated?; **Q.1.6**. What was the main feature of the city affected by the study?.

After defining what will be observed, the next step is selecting the research bases of the research, which were:

- Compendex (CPE);
- IEEExplore (EXP);
- Science Direct (SDI);
- Scopus (SCO).

Besides the chosen research bases, a manual research through the references of the publications was made, based on the initial researches, restricted to articles, thesis and dissertations in English.

A research expression was defined to be used in the consultations in each one of the research bases, using the research question as a guide. The expression used was: **EX01** - (((digital OR smart) AND (city)) AND (development OR creation OR expansion)) AND (iot OR ict) AND (people OR citizen)).

After researching in the chosen bases, the results obtained were exported and stored.

The approach to select the primary studies follows the guidelines of Barcellos et al. [18], which suggest only the need to define exclusion criterion in order to select relevant studies. This way, four steps were defined and for two of them, exclusion criterion were defined as well. Details are presented in Table I. The stages can be described as follows:

- **ST01**. The search must be done in the selected bases SCO, EXP, SDI and CPE using the search expression EX01. Results obtained must be stored to facilitate future consultation;
- **ST02**. This stage eliminates primary studies that do not attend the purposes of this study;
- **ST03**. Publications not excluded on the previous step will be re-evaluated based on their title, abstract or full text;
- **ST04**. Search for referenced of the remaining publications must be made.

Data extraction consists in taking relevant information that may help solving the research question through the reading of the text and the metadata.

A test before the final protocol execution must be conducted to assure it is correct, in order to identify possible failures introduced during their definition. The test must be carried out in a reduced portion of the total bases to be used in the conduction of the research [18].

TABLE I. Exclusion Criteria.

Step	Criteria Code	Description
ST02	EC01	Repeated publications.
	EC02	Publications of the same author presenting similar content.
	EC03	Studies which text cannot be obtained.
ST03	EC04	The title indicates the study deals with a different subject from this work.
	EC05	The abstract indicates the study deals with a different subject from this work.
	EC06	The text indicates the study deals with a different subject from this work.

A protocol test was conducted using the CPE and SDI bases with this purpose. Results obtained in the execution of the test were left out; however, they were satisfactory and enabled the protocol execution to be conducted without any changes.

A. Quality Assessment

According to Kitchenham [5], quality criterion can be used to help analyzing and resuming the data obtained, identifying subgroups among the selected studies. This way, a checklist was set with some items that must be applied to the selected studies after executing the ST03 stage.

Quality assessment will help determine if the quality of the analyzed studies influences on the results of the publications. The assessment can be made in parallel to the activity of reading publications.

Issues related to evaluating the quality of the studies are presented in Table II.

TABLE II. Quality Criteria.

ID	Question	Answer
QC01	Are the objectives clear?	Yes/No/NA
QC02	Was there a validation of the proposal?	Yes/No/NA
QC03	Was data collection correctly made?	Yes/No/NA
QC04	Is the purpose of the analysis clear?	Yes/No/NA
QC05	Were the questions asked in the study answered?	Yes/No/NA
QC06	Were the results reported negative?	Yes/No/NA
QC07	Does the study explicitly explore the research question?	Yes/No/NA

To ensure that the selection of publications is performed correctly, each of which must be evaluated by more than one researcher.

V. Results

After the protocol approval, the other stages were executed. The result can be seen in Table III. In this table we can notice that, in the first stage ST01 the number of publications is rather high, a total of 1121 publications, which were evaluated in the following steps according to the selection criteria. In the stage ST02, 61 publications were excluded and , in the stage ST03, the number of excluded publications was 1030.

After applying the exclusion criterion, the manual search for references of the selected publications was made and the general results can be seen in Table IV, as well as the manual search. This table presents a summary of the selection of publications result. The publications included in the stage ST01 were found, so as the publications included

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in the stage ST04, matching with the manual search. The exclusions realized in the stages ST02 and ST03 are also detailed, classified according to the search tool that have been used.

45 publications were obtained after executing all the steps. Table V shows all the obtained publications. In this table, each publication is identified by a code. The code of the search tool used to find the publication, the stage in which the publications are and the year of the publication is also showed.

TABLE III. PROTOCOL EXECUTION RESULTS OF THE FIRST THREE STAGES.

Step	Criteria	SCO	EXP	SDI	CPE
ST01		349	648	78	46
		EXC	EXC	EXC	EXC
ST02	CR01	1	38	1	2
	CR02	0	0	0	0
	CR03	4	12	2	1
ST03	CR04	297	531	69	38
	CR05	22	46	5	3
	CR06	5	14	0	0
Total Exclusion		329	641	77	44
Total Remaining		20	7	1	2

TABLE IV. TOTAL PUBLICATIONS BY DATABASE AND MANUAL SEARCH.

	SCO	EXP	SDI	CPE	MSC	Total
Included	349	648	78	46	15	1136
Excluded	329	641	77	44	0	1091
Total	20	7	1	2	15	45

Results of the evaluation of the publications in each one of the sub-questions were compared with the other results. Therefore, deep analysis of the obtained data could be made, once the isolated observation of the results is not enough for the research question to be cleared.

Crossings between the research sub-questions are numbered in Table VI.

A. Question Q1.1 Analysis

During these two phases of development of the Smart Cities, the Sensor element stands out in the Chaotic and Managed levels of organization.

In the initial level of organization, the People element is the one with more highlight. This happens due to the approach of human resource in many publications as a collaborator in data production, along with the sensors.

Last two levels of technological organization, Integrated and Optimized, were the less approached levels among the analyzed publications. A small amount of cities around the world with characteristics that put them in these two last levels is what partly explains this fact.

The first level of social organization, the Chaotic, was the one that obtained the highest number of publications, which is explained by crowdsensing and other data collection techniques. In the last two levels, the People element obtained a higher number of publications.

The result of this research points out that when a society is not organized to sustain initiatives to create a Smart City, Technology is the most expressive element to start the process,

TABLE V. SELECTED PUBLICATIONS.

Code	Engine	Step	Pub. Year	Pub.
PB10	CPE	ST03	2013	[19]
PB13	CPE	ST03	2014	[20]
PB52	SDI	ST03	2014	[21]
PB136	SCO	ST03	2015	[22]
PB144	SCO	ST03	2014	[23]
PB159	SCO	ST03	2014	[24]
PB165	SCO	ST03	2014	[25]
PB170	SCO	ST03	2014	[26]
PB171	SCO	ST03	2014	[27]
PB192	SCO	ST03	2014	[28]
PB195	SCO	ST03	2014	[29]
PB210	SCO	ST03	2014	[30]
PB323	SCO	ST03	2013	[31]
PB334	SCO	ST03	2013	[32]
PB341	SCO	ST03	2013	[33]
PB375	SCO	ST03	2012	[34]
PB389	SCO	ST03	2012	[35]
PB410	SCO	ST03	2012	[36]
PB430	SCO	ST03	2011	[37]
PB436	SCO	ST03	2011	[38]
PB438	SCO	ST03	2011	[39]
PB453	SCO	ST03	2010	[40]
PB467	SCO	ST03	2010	[41]
PB504	EXP	ST03	2013	[42]
PB518	EXP	ST03	2010	[43]
PB638	EXP	ST03	2012	[44]
PB708	EXP	ST03	2014	[45]
PB1024	EXP	ST03	2010	[46]
PB1042	EXP	ST03	2013	[47]
PB1050	EXP	ST04	2011	[48]
PB1127	MSC	ST04	2011	[49]
PB1134	MSC	ST04	2010	[50]
PB1135	MSC	ST04	2011	[2]
PB1139	MSC	ST04	2011	[51]
PB1141	MSC	ST04	2011	[52]
PB1146	MSC	ST04	2011	[53]
PB1148	MSC	ST04	2012	[54]
PB1149	MSC	ST04	2011	[55]
PB1150	MSC	ST04	2013	[56]
PB1151	MSC	ST04	2011	[57]
PB1152	MSC	ST04	2013	[58]
PB1157	MSC	ST04	2011	[59]
PB1158	MSC	ST04	2013	[60]
PB1159	MSC	ST04	2013	[61]
PB1160	MSC	ST04	2011	[62]

TABLE VI. COMPARISON BETWEEN RESEARCH QUESTIONS.

Sub-Question	Compared Sub-Question
Q1.1	1.2, Q1.3, Q1.4, Q1.5, Q1.6
Q1.4	Q1.5
Q1.6	Q1.2, Q1.3, Q1.4

generating more engagement of the population in the subsequent levels, when there is already a favorable environment.

Thus, the result obtained through the analysis of the charts in Figures 2 and 3 indicate that in cities with no infrastructure and control of their resources nor promote participation of the population in the decision-making processes,the administration of the city prefer to invest their efforts to acquire technologies that allow us to go forward towards a Smart City. Then, technology is an enabler of future innovation in the field of the city.

When there are available infrastructure and the engagement of the population in the city affairs, even if it is in a precarious way, it is possible to notice that human resource is the most discussed issue, indicating the influence it may have on the development of the city.

Figure 4 presents the chart generated by the results of the

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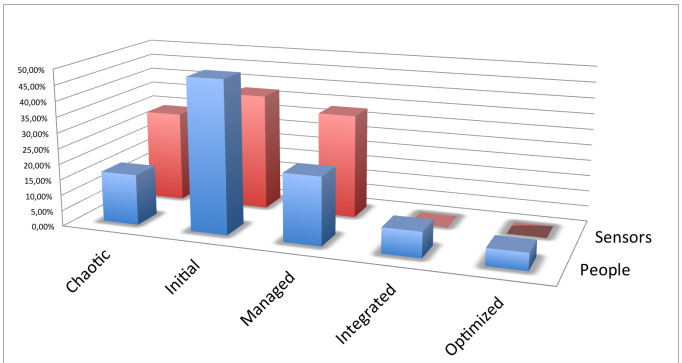
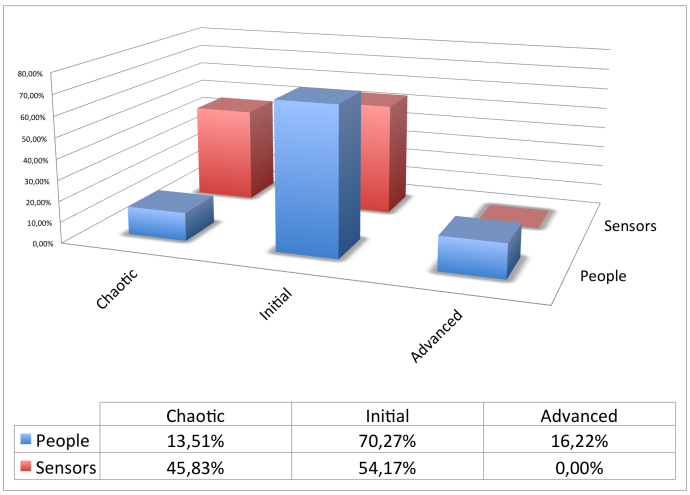


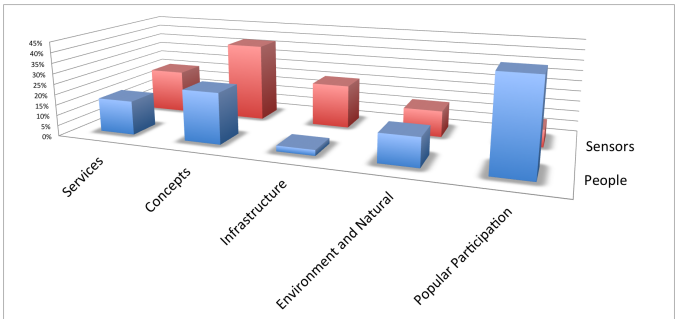
	Chaotic	Initial	Managed	Integrated	Optimized
People	16,21%	48,64%	21,62%	8,10%	5,40%
Sensors	29,16%	37,50%	33,33%	0%	0%

Figure 2. Result of questions Q1.1 and Q1.2.



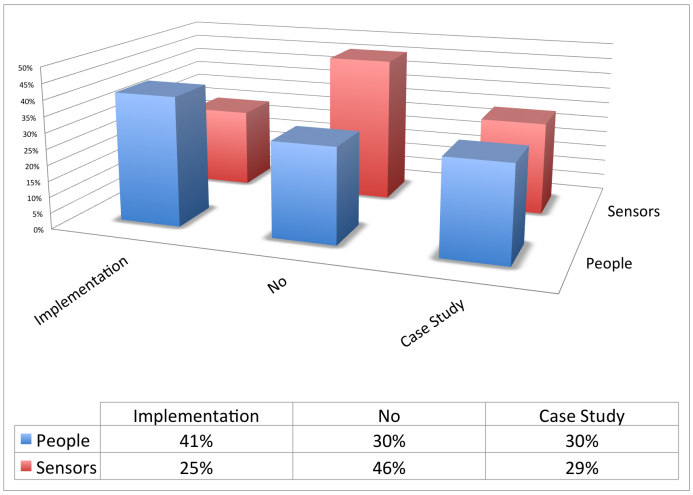
	Chaotic	Initial	Advanced
People	13,51%	70,27%	16,22%
Sensors	45,83%	54,17%	0,00%

Figure 3. Result of questions Q1.1 and Q1.3.



	Services	Concepts	Infrastructure	Environment and Natural Resources	Popular Participation
People	16%	24%	3%	14%	43%
Sensors	21%	38%	21%	13%	8%

Figure 4. Result of questions Q1.1 and Q1.4.



	Implementation	No	Case Study
People	41%	30%	30%
Sensors	25%	46%	29%

Figure 5. Result of questions Q1.1 and Q1.5.

sub-questions Q1.1 and Q1.4. We can see the elements People and Sensors in it, distributed according to the scientific contributions made. Generally speaking, the technological issue was the most influent in all categories, except the last two, Environment and Natural Resources and Popular Participation.

The result presented reinforces the statement of Chourabi et al. [63] that the study of people and communities is critical in the context of Smart Cities, however, it is being neglected.

The element People presented a small advantage in the category Environment and Human Resources, demonstrating the human perception of the environment is being explored in the monitoring of natural resources and urban environment, being as important as the sensors in the information acquisition. The same element was the most influential in the category Popular Participation, an awaited result due to its direct relationship between people and concepts, such as crowdsensing, open innovation, crowdsourcing and open participation.

Figure 5 represents the chart from crossing the results of the sub-questions Q1.1 and Q1.5. We can see the elements People and Sensors in it, distributed according to the types of validation of each publication.

The element People was the one with greater highlight in the publications that adopted Implementation and Case Study as a way of validation, obtaining only 1% (one percentage point) more than Sensors in the Case Study way. This lower number of the element Sensors related to human perspective is because many publications about the technological perspective maintained themselves in more theoretical subjects, with no need of validation that would fit one of the two validation categories defined in this work.

Figure 6 presents the chart from crossing the results of the sub-questions Q1.1 and Q1.6. We can see the elements People and Sensors distributed according to the areas of the Smart Cities of the analyzed publications.

Data presented followed a trend. In the first four areas (Economy, Environment, Mobility, Governance), sensors were the most influent, while in the areas of Housing and People it was the element People the most influent. Generally speaking, results of the analysis of the combination of these two sub-questions may indicate there should have more balance when approaching both elements in every area. The least influenced

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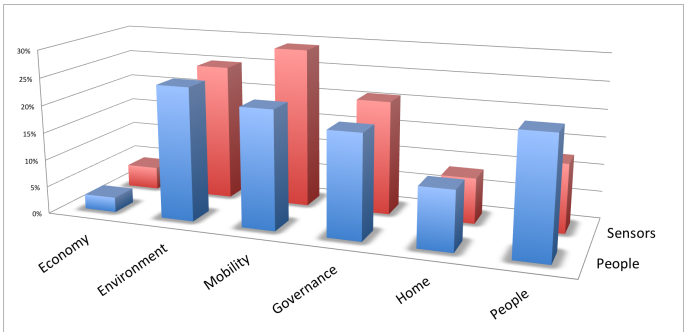
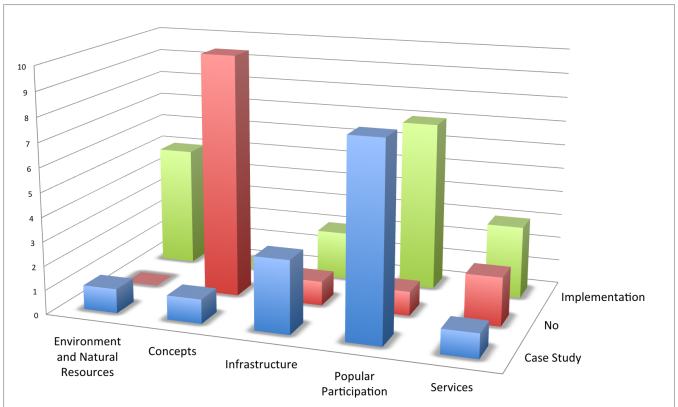


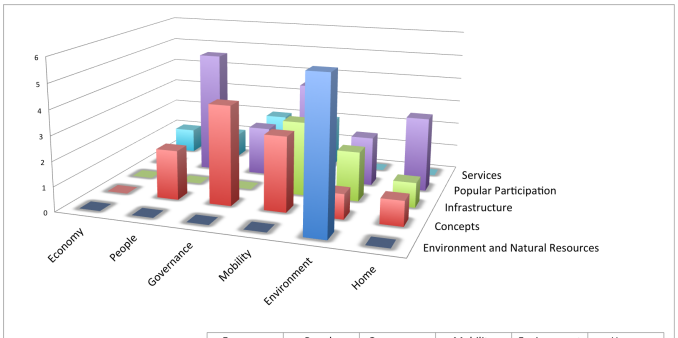
	Economy	Environment	Mobility	Governance	Home	People
People	3%	24%	22%	19%	11%	22%
Sensors	4%	25%	29%	21%	8%	13%

Figure 6. Result of questions Q1.1 and Q1.6.



	Environment and Natural Resources	Concepts	Infrastructure	Popular Participation	Services
Case Study	1	1	3	8	1
No	0	10	1	1	2
Implementation	5	0	2	7	3

Figure 7. Result of questions Q1.4 and Q1.5.



	Economy	People	Governance	Mobility	Environment	Home
Environment and Natural Resources	0	0	0	0	6	0
Concepts	0	2	4	3	1	1
Infrastructure	0	0	0	3	2	1
Popular Participation	0	5	2	4	2	3
Services	1	1	2	2	0	0

Figure 8. Result of questions Q1.4 and Q1.6.

area was Economy, while Mobility was the most. It can be explained by the low event of publications about economical matters, while there were many talking about technological issues.

B. *Question Q1.4 Analysis*

Analyzing the chart of Figure 7 that presents the results of the sub-questions Q1.4 and Q1.5 together, it is expected to be able to determine which are the most used ways of validation in each research area. Firstly, the greatest part of the non-validated publications talked about the theme of this research in a theoretical way or those about works in progress. Popular Participation was the area with more validated publications through implementation and case studies.

In a general way, Implementation was the most used way to validate the efforts, which made it a little ahead the Case Study. It may indicate that Implementation is the most used way of validation because there are not many options to test the previously available proposals, which made the researchers responsible for developing their own tools to validate their proposals. Testbeds and Living Labs are initiatives that may help.

Analyzing the chart of Figure 8 presenting the results of the sub-questions Q1.4 and Q1.6 together, the intention is to identify the most researched areas of the Smart Cities and those that need more attention, taking into account the defined research areas.

Initially, it is possible to notice the concepts of the economic elements were not explored. The research area of Infrastructure did not emphasize technological elements of the areas of Governance, People and Economy and there were also no researches about services in the areas of Housing and Environment. Those numbers suggest more research should be developed in these areas.

Second, the result presents coherent numbers between the two analyzed dimensions, like the cases of the areas of Environment and Natural Resources and the area of Environment, between the areas of Infrastructure and Mobility and between the areas of Popular Participation and People.

As for the rest of the results, it is possible to observe that concepts about all areas of Smart Cities were researched and Popular Participation was also in their agendas. Economy was the only exception in both cases, when it was not mentioned.

In a general way, it is possible to conclude that more researches about the economic features of Smart Cities are necessary.

C. *Question Q1.6 Analysis*

Due to the cross-analysis of the result of sub-question Q1.6 with sub-questions Q1.3 and Q1.3, it is expected to determine which areas of the Smart Cities are more researched during the phases of technological and social evolution.

Result of crossing sub-questions Q1.2 and Q1.6 is shown in the chart of Figure 9. Governance was the area that received more attention, followed by People, Mobility and environment, as observed in the chart. Housing and Economy were not mentioned. This result may point to a city in the Chaotic level as Governance as the area that should get more attention, since it deals with the decision making about the future of the city.

Only Governance was not mentioned in an initial level, while Environment was the most discussed area followed by

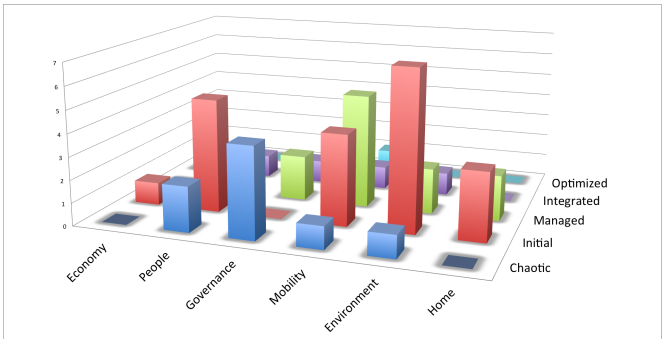
People, Mobility, Housing and Economy. This result may indicate that, in an initial level, Environment is the level that should get more attention.

Mobility was the area that received more attention in a Managed level, indicating that when there is infrastructure, the trend is to try improving it.

Integrated and Managed levels were the least explored among all the evaluated publications. For this reason, it is not possible to conclude anything from the presented chart.

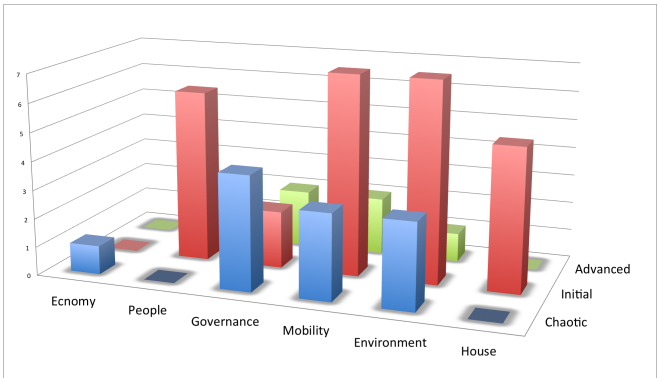
Figure 10 shows a chart that presents the result of the crossing between sub-questions Q1.3 and Q1.6.

Through the chart is possible to notice that in the Chaotic organization level there is more concern with the areas of Governance, Mobility and Environment. However, the number of studies about the People area in this level was zero. According to its definition, in this stage the level of social organization is zero, which demonstrates the evaluated studies talk about an environment where the Popular Participation is already in a more elevated level.



	Economy	People	Governance	Mobility	Environment	Home
Chaotic	0	2	4	1	1	0
Initial	1	5	0	4	7	3
Managed	0	0	2	5	2	2
Integrated	0	1	1	1	1	0
Optimized	0	0	1	1	0	0

Figure 9. Result of questions Q1.2 and Q1.6.



	Ecnomy	People	Governance	Mobility	Environment	House
Chaotic	1	0	4	3	3	0
Initial	0	6	2	7	7	5
Advanced	0	2	2	2	1	0

Figure 10. Result of questions Q1.3 and Q1.6.

The initial level concentrates a bigger number of publications. In this level, Economy was the only area not explored due to the low incidence of publications about this area. Most explored areas in this level were Mobility and Environment, indicating that caring for the environment and technology used in the city are considered more important in this level.

D. Quality Analysis

As defined in the revision protocol, a qualitative evaluation of the 45 selected publications was made in order to avoid biases in the selected publications. Results of this analysis are shown in Table VI.

TABLE VII. RESUME OF QUALITY ANALYSIS RESULTS.

Criteria	Yes	Not	Not Applicable
CQ01	100%	0%	0%
CQ02	71,11%	0%	28,80%
CQ03	71,11%	0%	28,88%
CQ04	71,11%	0%	28,88%
CQ05	100%	0%	0%
CQ06	2,22%	97,77%	0%
CQ07	24,44%	97,77%	0%

Through the results analyzed it was possible to notice that the quality of the selected publications was not good, which did not influence negatively on the analysis of the publications.

VI. Conclusion and Future Work

SLR was the method used in this work, to create a panorama of the scientific research about the participation of people and use of sensors to develop Smart Cities. Based on the work of Kitchenham [5], a revision protocol was developed so the SLR could be executed.

Results obtained during the protocol test show it could be used in a consistent way to reach the objectives of this study. Through the research sub-questions, defined during the elaboration of the revision protocol, it was possible to direct the analysis of the publications to reach the general and specific objectives defined for this study.

The general objective was to provide the current panorama of the scientific research made in the area of the Smart Cities that explore their development based on the participation of people and use of sensors. We reached it by making a bi-dimensional analysis of the research sub-questions results. We could notice that people and sensors have great importance when developing Smart Cities. Their importance changes according to the level of technological and social development each city is in, as well as the needs each city defines as priority.

It was also possible to classify the studies based on different technical and scientific criteria, as well as identifying many areas that need more attention of the scientific area when it comes to popular participation and use of sensors in the development of Smart Cities. Results obtained can show a direction for future researches in most needed areas.

The economic aspect was showed pretty deficient, from almost all analyzed points of view. So, this theme needs to be deeply analyzed, in order to understand better the relationship with the cities technological and social elements.

This research was realized considering just a period of five years of study. A new protocol execution can be made, with a bigger range, in order to analyze the evolution of

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the researched aspects with the development of new scientific studies about Smart Cities, making it possible to enhance the knowledge about how people and sensors influence the Smart Cities development, drawing an evolutionary profile.

REFERENCES

[1] C. E. A. Mulligan and M. Olsson, "Architectural Implications of Smart City Business Models : An Evolutionary Perspective," IEEE Communications Magazine, vol. 51, no. 6, Jun. 2013, pp. 80–85.

[2] T. Nam and T. A. Pardo, "Conceptualizing smart city with dimensions of technology, people, and institutions," in Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times - dg.o '11. New York, New York, USA: ACM Press, 2011, pp. 282–291.

[3] A. Caragliu, C. Del Bo, and P. Nijkamp, "Smart cities in Europe," Journal of Urban Technology, vol. 18, no. 2, Apr. 2011, pp. 65–82.

[4] T. Yashiro, S. Kobayashi, N. Koshizuka, and K. Sakamura, "An Internet of Things (IoT) architecture for embedded appliances," in 2013 IEEE Region 10 Humanitarian Technology Conference. IEEE, Aug. 2013, pp. 314–319.

[5] B. A. Kitchenham, "Guidelines for performing Systematic Literature Reviews in Software Engineering," Keele University, Keele, Tech. Rep., 2007.

[6] A. Bartoli, J. Hernández-Serrano, M. Soriano, M. Dohler, and A. Kountouris, "Security and Privacy in your Smart City," in Proceedings of Barcelona Smart Cities Congress 2011, 2011, pp. 1–6.

[7] C. Klein and G. Kaefer, "From Smart Homes to Smart Cities: Opportunities and Challenges from an Industrial Perspective," in Next Generation Teletraffic and Wired/Wireless Advanced Networking, ser. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer Berlin Heidelberg, 2008, vol. 5174, pp. 260–260.

[8] K. Su, J. Li, and H. Fu, "Smart city and the applications," in 2011 International Conference on Electronics, Communications and Control (ICECC). IEEE, Sep. 2011, pp. 1028–1031.

[9] H. Sundmaeker, P. Guillemin, P. Friess, and S. Woelfflé, Vision and challenges for realising the Internet of Things, 1st ed., H. Sundmaeker, P. Guillemin, P. Friess, and S. Woelfflé, Eds. Luxemburgo: Publications Office of the European Union, 2010, no. 1.

[10] S. Tilak, N. B. Abu-Ghazaleh, and W. Heinzelman, "A taxonomy of wireless micro-sensor network models," ACM SIGMOBILE Mobile Computing and Communications Review, vol. 6, no. 2, 2002, pp. 28–36.

[11] D. Washburn et al., "Helping CIOs Understand Smart City Initiatives," Cambridge University, Tech. Rep., 2010.

[12] J. Biolchini, P. G. Mian, A. Candida, and C. Natali, "Systematic Review in Software Engineering," Universidade Federal do Rio de Janeiro, Rio de Janeiro, Tech. Rep. May, 2005.

[13] K. Petersen, R. Feldt, S. Mujtaba, and M. Mattsson, "Systematic Mapping Studies in Software Engineering," in 12th International Conference on Evaluation and Assessment in Software Engineering, 2008, pp. 71–80.

[14] L. B. R. Oliveira, F. S. Osório, and E. Y. Nakagawa, "A Systematic Review on Service-Oriented Robotic Systems Development," ICMC/Univ. of So Paulo, Tech. Rep., 2012.

[15] D. Budgen, M. Turner, P. Brereton, and B. Kitchenham, "Using Mapping Studies in Software Engineering," PPIG'08: 20th Annual Meeting of the Psichology of Programming Interest Group, vol. 2, 2007, pp. 195–204.

[16] F. Ribeiro, F. S. Ferraz, M. Carolina, G. Henrique, and S. Alexandre, "Big Data Solutions For Urban Environments A Systematic Review," ALLDATA 2015, The First International Conference on Big Data, Small Data, Linked Data and Open Data, 2015, pp. 22–28.

[17] R. L. Novais, A. Torres, T. S. Mendes, M. Mendonça, and N. Zazworka, "Software evolution visualization: A systematic mapping study," Information and Software Technology, vol. 55, no. 11, Nov. 2013, pp. 1860–1883.

[18] M. P. Barcellos, R. Falbo, and R. Rocha, "A Strategy for Measurement of Software and Evaluation of Bases of Measures for Statistical Control of Processes of Software at High Maturity Organizations," Ph.D Thesis, Federal Univ. of Rio de Janeiro, 2009.

[19] D. López-de Ipiña, S. Vanhecke, O. Peña, T. De Nies, and E. Mannens, "Citizen-Centric Linked Data Apps for Smart Cities," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2013, vol. 8276 LNCS, pp. 70–77.

[20] L. Roo et al., "Mobile Crowdsourcing Older People s Opinions to Enhance Liveability in Regional City Centres," no. April, 2014, pp. 21–24.

[21] L. Atzori, D. Carboni, and A. Iera, "Smart things in the social loop: Paradigms, technologies, and potentials," Ad Hoc Networks, vol. 18, 2014, pp. 121–132.

[22] C. Klonner, C. Barron, P. Neis, and B. Höfle, "Updating digital elevation models via change detection and fusion of human and remote sensor data in urban environments," International Journal of Digital Earth, vol. 8, no. 2, Feb. 2015, pp. 153–171.

[23] D. S. Gallo, C. Cardonha, P. Avegliano, and T. C. Carvalho, "Taxonomy of Citizen Sensing for Intelligent Urban Infrastructures," IEEE Sensors Journal, vol. 14, no. 12, Dec. 2014, pp. 4154–4164.

[24] A. Cenedese, A. Zanella, L. Vangelista, and M. Zorzi, "Padova Smart City: An urban Internet of Things experimentation," in Proceeding of IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks 2014. IEEE, Jun. 2014, pp. 1–6.

[25] S. Fang, L. D. Xu, Y. Zhu, J. Ahati, H. Pei, J. Yan, and Z. Liu, "An Integrated System for Regional Environmental Monitoring and Management Based on Internet of Things," IEEE Transactions on Industrial Informatics, vol. 10, no. 2, May 2014, pp. 1596–1605.

[26] E. Theodoridis, G. Mylonas, V. Gutiérrez, and L. Muñoz, "Large-Scale Participatory Sensing Experimentation Using Smartphones within a Smart City," in Proceedings of the 11th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services. ICST, 2014, pp. 178–187.

[27] J. Paradells, C. Gomez, I. Demirkol, J. Oller, and M. Catalan, "Infrastructureless smart cities. Use cases and performance," in 2014 International Conference on Smart Communications in Network Technologies (SaCoNeT). IEEE, Jun. 2014, pp. 1–6.

[28] H. Sun, "Research of an intelligent street-lamp monitoring system based on the Internet of things," L. Zhang, L. Yu, and Y. Zhao, Eds., Mar. 2014, pp. 681–686.

[29] M. Granath and K. Axelsson, "Stakeholders' Views On ICT And Sustainable Development In An Urban Development Project," European Conference on Information Systems (ECIS), 2014, pp. 0–14.

[30] C. Shiyao, W. Ming, L. Chen, and R. Na, "The Research and Implement of the Intelligent Parking Reservation Management System Based on ZigBee Technology," in 2014 Sixth International Conference on Measuring Technology and Mechatronics Automation, no. 1. IEEE, Jan. 2014, pp. 741–744.

[31] E. Massung, D. Coyle, K. F. Cater, M. Jay, and C. Preist, "Using crowdsourcing to support pro-environmental community activism," in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13. New York, New York, USA: ACM Press, 2013, p. 371.

[32] V. Gutiérrez et al., "SmartSantander: Internet of Things Research and Innovation through Citizen Participation," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2013, vol. 7858 LNCS, pp. 173–186.

[33] D. Doran, S. Gokhale, and A. Dagnino, "Human sensing for smart cities," in Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining - ASONAM '13. New York, New York, USA: ACM Press, Aug. 2013, pp. 1323–1330.

[34] P. Marchetta et al., "S2-MOVE: Smart and Social Move," in 2012 Global Information Infrastructure and Networking Symposium (GIIS). IEEE, Dec. 2012, pp. 1–6.

[35] S. Roche and A. Rajabifard, "Sensing places' life to make city smarter," in Proceedings of the ACM SIGKDD International Workshop on Urban Computing - UrbComp '12. New York, New York, USA: ACM Press, Aug. 2012, p. 41.

[36] P. Mechant, I. Stevens, T. Evens, and P. Verdegem, "E-deliberation 2.0 for smart cities: a critical assessment of two 'idea generation' cases," International Journal of Electronic Governance, vol. 5, no. 1, 2012, p. 82.

 ISBN: 978-1-61208-438-1

[37] H.-N. Hsieh, C.-Y. Chou, C.-C. Chen, and Y.-Y. Chen, "The evaluating indices and promoting strategies of intelligent city in Taiwan," in 2011 International Conference on Multimedia Technology. IEEE, Jul. 2011, pp. 6704–6709.

[38] F. Gil-Castineira et al., "Experiences inside the Ubiquitous Oulu Smart City," Computer, vol. 44, no. 6, Jun. 2011, pp. 48–55.

[39] D. Havlik et al., "From Sensor to Observation Web with Environmental Enablers in the Future Internet," Sensors, vol. 11, no. 12, Mar. 2011, pp. 3874–3907.

[40] A. Botero and J. Saad-Sulonen, "Enhancing citizenship," in Proceedings of the 11th Biennial Participatory Design Conference on - PDC '10. New York, New York, USA: ACM Press, 2010, p. 81.

[41] J. Corchado, J. Bajo, D. Tapia, and A. Abraham, "Using Heterogeneous Wireless Sensor Networks in a Telemonitoring System for Healthcare," IEEE Transactions on Information Technology in Biomedicine, vol. 14, no. 2, Mar. 2010, pp. 234–240.

[42] K. Benouaret, R. Valliyur-Ramalingam, and F. Charoy, "CrowdSC: Building Smart Cities with Large-Scale Citizen Participation," IEEE Internet Computing, vol. 17, no. 6, Nov. 2013, pp. 57–63.

[43] N. Lane, E. Miluzzo, H. Lu, D. Peebles, T. Choudhury, and A. Campbell, "A survey of mobile phone sensing," IEEE Communications Magazine, vol. 48, no. 9, Sep. 2010, pp. 140–150.

[44] A. S. Pentland, "Society's Nervous System: Building Effective Government, Energy, and Public Health Systems," Computer, vol. 45, no. 1, Jan. 2012, pp. 31–38.

[45] S. E. Middleton, L. Middleton, and S. Modafferi, "Real-Time Crisis Mapping of Natural Disasters Using Social Media," IEEE Intelligent Systems, vol. 29, no. 2, Mar. 2014, pp. 9–17.

[46] D. L. Estrin, "Participatory sensing," in Proceedings of the 8th international conference on Mobile systems, applications, and services - MobiSys '10. New York, New York, USA: ACM Press, 2010, pp. 3–4.

[47] G. Cardone et al., "Fostering participaction in smart cities: a geo-social crowdsensing platform," IEEE Communications Magazine, vol. 51, no. 6, Jun. 2013, pp. 112–119.

[48] R. Ganti, F. Ye, and H. Lei, "Mobile crowdsensing: current state and future challenges," IEEE Communications Magazine, vol. 49, no. 11, Nov. 2011, pp. 32–39.

[49] M. C. Domingo, "An overview of the Internet of Things for people with disabilities," Journal of Network and Computer Applications, vol. 35, no. 2, Mar. 2012, pp. 584–596.

[50] M. F. Goodchild, "Citizens as sensors: The world of volunteered geography," GeoJournal, vol. 69, no. 4, 2007, pp. 211–221.

[51] M. N. Kamel Boulos et al., "Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples," International Journal of Health Geographics, vol. 10, no. 1, 2011, p. 67.

[52] S. F. King and P. Brown, "Fix my street or else," in Proceedings of the 1st international conference on Theory and practice of electronic governance - ICEGOV '07. New York, New York, USA: ACM Press, 2007, p. 72.

[53] P. Meier, "New information technologies and their impact on the humanitarian sector," International Review of the Red Cross, vol. 93, no. 884, Dec. 2011, pp. 1239–1263.

[54] D. Hasenfratz, O. Saukh, S. Sturzenegger, and L. Thiele, "Participatory Air Pollution Monitoring Using Smartphones," Mobile Sensing: From Smartphones and Wearables to Big Data, 2012, pp. 1–5.

[55] E. DHondt, M. Stevens, and A. Jacobs, "Participatory noise mapping works! An evaluation of participatory sensing as an alternative to standard techniques for environmental monitoring," Pervasive and Mobile Computing, vol. 9, no. 5, Oct. 2013, pp. 681–694.

[56] D. Richter, M. Vasardani, and L. Stirlng, Progress in Location-Based Services, ser. Lecture Notes in Geoinformation and Cartography, J. M. Krisp, Ed. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.

[57] H. Achrekar, A. Gandhe, R. Lazarus, Ssu-Hsin Yu, and B. Liu, "Predicting Flu Trends using Twitter data," in 2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS). IEEE, Apr. 2011, pp. 702–707.

[58] S. Devarakonda et al., "Real-time air quality monitoring through mobile sensing in metropolitan areas," in Proceedings of the 2nd ACM SIGKDD International Workshop on Urban Computing - UrbComp '13. New York, New York, USA: ACM Press, 2013, p. 1.

[59] M. Faulkner et al., "Demo abstract, the next big one: Detecting earthquakes and other rare events from community-based sensors," in Proceedings of the 10th ACM/IEEE International Conference on Information Processing in Sensor Networks. Chicago: IEEE, 2011, pp. 13–24.

[60] G. Hancke, B. Silva, and G. Hancke, Jr., "The Role of Advanced Sensing in Smart Cities," Sensors, vol. 13, no. 1, Dec. 2012, pp. 393–425.

[61] T. Sakaki, M. Okazaki, and Y. Matsuo, "Tweet Analysis for Real-Time Event Detection and Earthquake Reporting System Development," IEEE Transactions on Knowledge and Data Engineering, vol. 25, no. 4, Apr. 2013, pp. 919–931.

[62] E. Aramaki, S. Maskawa, and M. Morita, "Twitter Catches The Flu : Detecting Influenza Epidemics using Twitter The University of Tokyo," in Proceedings of the 2011 Conference on Emperical Methods in Natural Language Processing, Stroudsburg, 2011, pp. 1568–1576.

[63] H. Chourabi et al., "Understanding Smart Cities: An Integrative Framework," 2012 45th Hawaii International Conference on System Sciences, Jan. 2012, pp. 2289–2297.

 ISBN: 978-1-61208-438-1