Bibliographic Review: GIS Sciences and Informal Settlements

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Abstract

The objective of this research is to present a condensed bibliographic review of published papers linking Geographic Information Systems Sciences and related sciences and technologies to informal settlements. GIS Sciences constitute an important tool in places were conventional maps do not exist such as informal settlements. For this study, a total of more than 100 published papers, from 1995 to 2014, related to this particular topic are classified in thematicareas. Thereafter, a total of 75 similar articles from the year 2015 are also classified and referenced in this research. A few specific comments, selected from the extensive list of publications in 2015, are herewith summarily present. The results of these studies demonstrate the importance of GIS sciencesin helping to improve informal settlements. It concludes about the challenging future of GIS sciences and its current limitations.

Keywords: Informal Settlements, GIS, GIS Sciences, Remote Sensing, Bibliography Review

Introduction

According to United Nation's estimates more than one billion people currently live in slums worldwide, it is projected that by 2030, the urban population of developing countries will double, while the area covered by cites could triple[1]. This tendency ought to be an important concern to all professionals working in areas potentially related to these types of settlements. Many of these particular areas are usually called shantytowns, unauthorized settlements, or informal settlements; in other languages: *barrio, barriada, favela,* and *bidonville*are the terms usually employed. In this study, the term "informal settlements" will be used to refer to these areas. Informal settlements are not synonymous with "slums", but most of them fulfill at least one of the UN-Habitat's conditions for slums. According to the UN-Habitat definition, a slum dweller fulfills at least one of five conditions: lack of tenure, lack of access to safe water, lack of access to improved sanitation, non-durable housing and overcrowding.

Due to financial restrictions, people living in informal settlementsareas tend to invade unoccupied land and build shacks, with the intention of improving it over time if some favorable conditions are met. Informal urban settlements appear in cities of developing countries, as manifestations of both traditional squatting and a kind of "pirate urbanism", enabled by bribes possible within populist governments. In the case of some Asian countries, these are the resultof property speculation and rental-oriented development targeted towards the urban poor, with hope for eventual regularization and compensation for their investment,[2]. When a community has established itself, it is difficult for the government to 'bulldoze' the place that has now been occupied by the settlers in question. The security of tenure is also a challenge. Many international agencies such as the World Bank, believe it is a measure to limit the eviction and demolition threat in slums, [3]. After years of improvement, some informal settlements will be successful, while others

will not. The approach favored today is on-site upgrading and improvement, with the goal of integrating low-income communities into their larger urban context. [2]. Due to their location's vulnerability to natural hazards, several settlements present a sturdy challenge to the concerned authorities and agencies. Many informal settlements share in common the lack of formal addresses, many of them are not in the city maps.

Theoretical Background

The existence of informal settlements has been study by many scientists including geographers. A number of social scientists have directed attention to various economic and social aspects of life in squatter settlements. The nature of their formation makes traditional representation difficult in the city maps. If those areas are not recognized as part of the urban grid, the concerned government agencies will not be able to improve them using the advantages of relatively new techniques. The ability to represent informal settlements spatially using GIS technologies is already recognized as an important component of the upgrading process. GIS Sciences, i.e. the visual representation of spatial and attribute data provides the technology for informal settlement upgrading, while geospatial information management provides the framework for wider upgrading methods[4]. Addressing the problems of informal settlements requires comprehensive geographical analysis. As informal settlements manifest as a consequence of poverty, consistent information on their idiosyncrasies is fundamental for planning and implementing urban poverty alleviation programs and informal settlement upgrading. The systematic quantification of informal settlements requires their spatial identification in order to support geographical targeting in slum intervention programs, [5]. There are many ways GIS Sciences can help describe better parameters and indicators of informal settlements. Earlier studies have demonstrated the ability of data from GIS and related sciences to directly or indirectly extract socio-economic attributes that can be useful to researchers in the area, [6]. However, there is a current lack of articles of bibliography reviews on the relation between GIS Sciences and informal settlements, therefore, the necessity for the study presented herewith.

Research Methodology

The completion of this manuscript has required a bibliography review related to GIS Sciencesand informal settlements, conducted by the author. The bibliography has been obtained from several resources here explained. Scholarly articles from online resources (Mendeley, Google Scholar) are the primary data providers for this study, library repository and online subscriptions through Nova University of Lisbon and Florida Atlantic University compliment the bibliographical sources. Viewed in this light, geospatial information technologies have the potential to completely transform the way in which informal settlements are developed. There are two bibliography classifications presented:

Published articles from 1995 to 2015. The author selected more than one hundred articles from 1995 to 2014 in order to classify the main research theme of each one. All the articles have been classified in a matrix reflected the title, author and main research topic.Articles were selected according to the following criteria: - Number of article citations- Innovation promise of the study area according to the author'sempirical selection process- Assessment of new, less widely cited publications' potential contribution to the improvement of informal settlements, according to the author opinion.

Published articles in 2015. The author included here all 75 published articles funded in 2015 in the described online resources. Keyword used for the online research included:shantytowns, unauthorized settlements, non-formal settlements or informal settlements; together with GIS, remote sensing, satellite. In order to find more articles, keywords were also writtenin French, Spanish, and Portuguese including the

terms such as *barrio, favela,* and *bidonville.* Articles related to this research from the year 2015 were included independently of the number of citations. Without doubt, some important articles are not included because the limitations of the number of research keywords used in the research engines and papers repositories. As this is a pilot study, the selection is an attempt to represent some of the most relevant articles, but not all of them. Articles related to health sciences and GIS Sciencesin informal settlements, but with a clear objective focus in health improvement were considered in this research only if GIS Scienceswas the main objective. But investigations about heath as a primarily objective have not been considered

Results and Discussion

Classification of the primary research areas from 1995 to 2014.

After reviewing the selected papers, they were pre-classified into several groups or classes.The author noticed that one of the original classes of this grouping (remote sensing and satellite imagery) was part of more than 60% of the consulted papers. Therefore, remote sensing and informal settlements are not a specific category as intended at the beginning of the study. This area was divided among other GIS Sciences classifications. In order to create the statistical groups was considered a matrix with the main objective of each article consulted for this research as the only classificatory parameter. Results of this experimental research are presented in Figure 1.
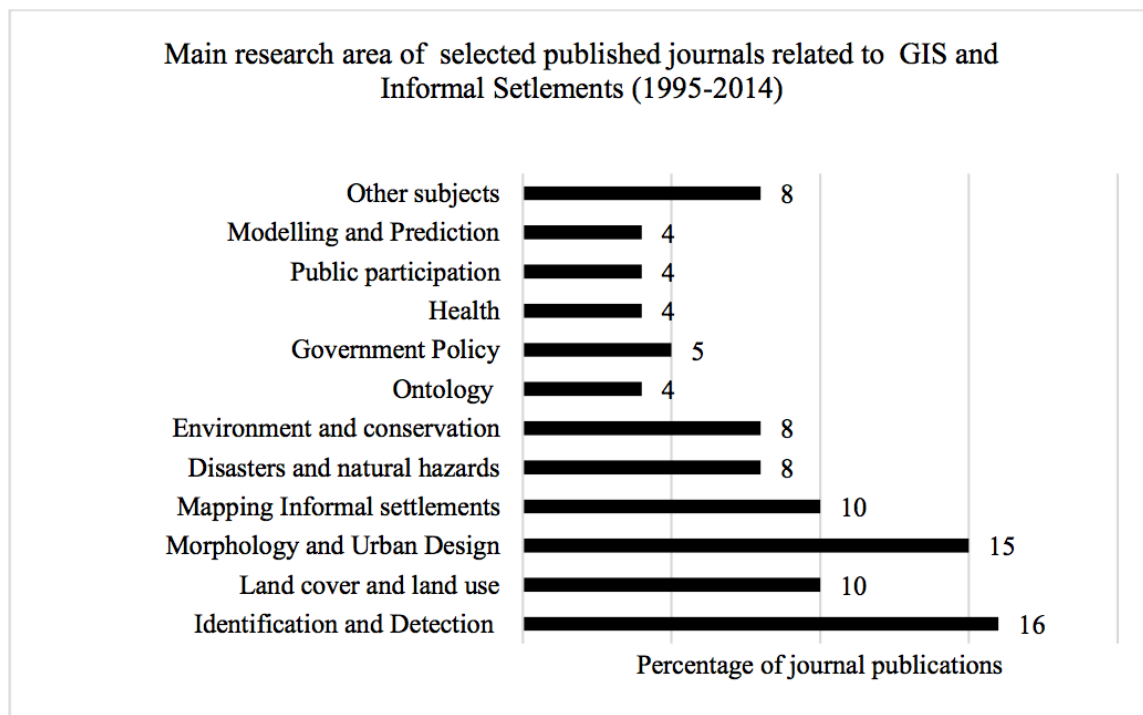

Figure 1. Classification of selected journals 1995-2014

It is worth noting that a high percentage of the papers for this first classification from 1995 to 2014 are related to identification and detection. There is also a considerable number of papers related to general descriptions of informal settlements in the area of urban planning and urban design using GIS Sciences. Also,a considerable number related to environment and natural hazards. Finally, there are some papers related to informal settlements and other themes like "ontology", "public participation" and "spatial analysis". A short review of some of the articles related toGIS Sciences shows some of the themes: Hasan

(2006)[7],Nobregaet al,(2006) [8].Baud et al (2010) worked in infrastructure and remote sensing,[9]. Urban morphology papers are especially popular in comparison to the next classification in 2015, including aspects such as metrics, growth patterns and others, [10] [11] [12] [13].

Classification of the primary research areas in 2015

In a similar way, a review of 75 papers related to GIS Sciencesand informal settlements published in 2015 were reviewed and classified. The results are presented in Figure 2.
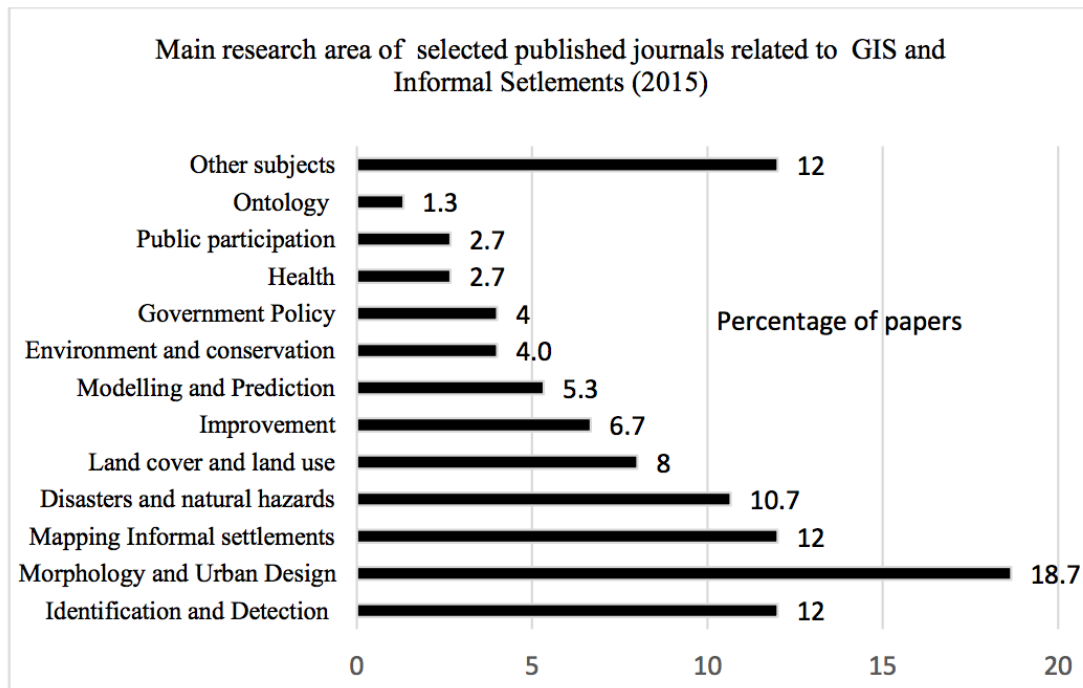

Fig. 2. Classification of selected journals 2015

As a comparison, in the year 2015, there are a smaller percentage of papers related to use of GIS Sciences for detection and identification of informal settlements and less papers in ontology compared to the past. The most popular themes are related to urban design.

Morphology and Urban Design

As a substantial part of the scholars dedicated to the study of informal settlements include urban planners, urban scientists and architects, it is not surprising that 18.7% of the analyzed papers published in 2015 are related to this area. Morphology has been analyzed by Sharma (2016)[14], Brelsford (2015)[15], transformation and planning by Mabaso (2015)[16], Andersen(2015)[17], Ahmed (2015)[18]. Urban growth was analyzed by Tsumida et al(2015)[19],Poyil et al(2015)[20],Harshwardhan (2015)[21]. The subject of urban structure by Heinzel et al (2015)[22], digital modelling by Elhag(2015) [23]. Others authors are: Pravitasari (2015)[24], Machakaire (2015)[25], Imwati et al (2015)[26], and also by Musakwa et al (2015)[27].

Mapping Informal settlements

Apart from land cover and land use, adequate mapping of informal settlements is fundamental for governments and related agencies. Ten different publications from the selected papers are part of this category, Ribeiro (2015)[28], Suman (2015)[29],Pedro et al (2015)[30], Kruk (2015)[31], Jabaren (2015)[32]. There are also works in mapping from Teunusien et al (2015)[33], Vatsavai (2015)[34], Engstrong et al (2015)[35], Marcos (2015)[36], Song (2015)[37]. Most mapping articles were concentrated in Latin America and Africa.

Identification and detection of informal settlements

As explained, most of the articles are related to remote sensing and the use of satellite data in the study of informal settlements. Among the papers revised there is a natural tendency of articles in the areas of detection, identification and monitoring of informal settlements, Kleynhans(2015) [38], Silva(2015)[39], Rodriguez (2015)[40], Sethi et al(2015)[41], Huang and Hui(2015)[42], are among the authors. As explained, due to the lack of representation of informal settlements in most city maps and urban plans, as well as the advantages offered by remote sensing techniques to identify and detect these, this category is the well represented, 12% of the papers analyzed herewith.More authors working in this area are: Kufferet al (2015)[43],Husmann (2015)[44]. Detection of slums using satellite imaging as an important tool is quite common.

Disasters and natural hazards

There is a strong interest in determining how GIS Sciences and related technologies can contribute to the understanding of natural hazard-related challenges to informal settlements. According to Srinivas (2008)[45], some of the most important challenges include sewage overflow hazardous debris, ground and surface water contamination, and unsafe water supplies. Among the articles there are the following authors, Setyawan et al. (2015)[46],Heimbuber (2015)[47],Rumbach (2015)[48], and Masuya et al (2015)[49]. Others authors include: Claghorn et al (2015)[50], Castro et al (2015)[51], Chingombe (2015)[52], Zubair et al (2015)[53]. **Land cover and land use**

A total of eight articles from the analyzed group are part of this category. The use of remote satellite imagery is again fundamental for this type of research. Duque (2015)[54],Olajuyigbe et al. (2015)[55], Temba (2015)[56], Yehia (2015)[57]. GIS Sciences are very useful for working with large scale maps that have not been monitored due to rapid change of land use, as is the case in many growing megacities of the developing world. The following published articles were also among the selected area: Rauntenbach (2015)[58],Marghany (2015)[59].

Improving Informal Settlements

This subject is one of the most important in social sciences related to informal settlements. ArticlesusingGIS Sciencesin the area of housing improvement in 2015 includes the following authors: Koc et al (2015)[60], Jordhus et al (2015)[61], Collin et al (2015)[62], and Lufulele et al (2015)[63].

Modelling and Prediction

GIS Sciences and related technologies have the possibility to predict the urban growth and urban patterns of informal settlements with several limitations as explained byEffat and Shobaki (2015)[64], Hoffmann et al (2015)[65]. However, modeling is an increasingly important subject tool for improving and predicting the future of such settlements.

Environment and conservation

For this study, the authors in this area are: Biggs et al (2015)[66],Fan et al (2015)[67], Islam et al (2015)[68].

Police Government Policies

The urban poor admirably self-improve settlements and dwellings unable to fulfill legal permit requirements, laws and urban plans instituted by the local or federal government. Corruption as well as an attitude of "laisser faire" are typical of many politicians and functionaries in charge (and with the means) of improving the life standards of the settlers. However, many of them are willing to help the poor; the objective of analyzing certain publications is to help this tremendously challenging task. Among the papers there are: Badaway et al (2015)[70], Bagarinao (2015)[71], Beane (2015)[72], and Christinidis (2015)[73].

Health

For this study, only the publications related to the general improvement of health were analyzed, however there are many publications that are directly related to specific health problem that are not included because are mostly art of medical studies. Among the publications selected there are Adams et al., (2015)[74], Badaru et al (2015)[75].

Public participation

As previously discussed, informal settlements can be successful when self-improvement is promoted internally, by their respective inhabitants. General public participation is very important. Speiski (2015)[76], and Mohamed et al (2015)[77], published in this area.

Other subjects related to GIS Sciences and informal settlements:

Different papers herewith discussed constitute either part of subjects not categorized here, or a mix of the above classifications proposed by the author, the following are included among others, Zhang et al, (2015)[78], Wei et al. (2015)[79],Criqui, (2015)[80], Schlesinger(2015)[81], Shaw (2015)[82], and Zubair et al (2015)[83]. Finally, this category also includes: Ravshty et al (2015)[84], Junior et al (2015)[85]and Oyeniyi et al (2015)[86], Herrera, 2015 [87],Hlatywayoand Masvosve, 2015 [88]Olthuis, 2015[89].

The analysis here presented include the 75 publications the authors was able to find for 2015 using several keywords, future work will include the updating of this bibliography and the analysis of all the selected publications.

Conclusion

This is a pilot research that only explores the surface of the important contribution of GIS Sciences in the past years. This article concentrated mostly in publication of the year 2015 and the classification of the papers has been done using empirical methods. Future work will be conducted in order to analyze more publications and formulate a more systematic methodology to select the papers. There is no doubt that GISS

ciences are an effective tool for mapping and analyzing urban sprawl and providing valuable information necessary for planning and development. It is a very helpful tool for researchers, governmental institutions and agencies in charge improve urban living standards. GIS Sciences are especially relevant in the case of urban centers in developing countries, which are facing the challenges of rapid growth associated to informal settlements. As explained, those areas are not reported in many traditional city maps and plans.

While GISrelated software is widely available, access to adequate data and skilled users is considerably limited in developing countries. In the case of researchers, GIS Sciences and related techniques pose limitations. For example, satellite imagery presents resolution constraints and software are not yet able to classify land use than human observations. However, GIS Sciences and related technologies are sometimes the only way to perform a rapid assessment of big areas, including informal settlements. Knowing the current urbanization situation of informal settlements will help decision makers monitor these areas, protect agricultural and forest lands and hopefully achieve - at least - a partial sustainable development of informal settlements in the future. In the future, GIS Sciences can also be used as a tool to measure and negotiate many other predicaments. Undertaking this study has driven an impetus to pursue the identification and monitoring of potential improvements in informal settlements with the help of GIS Sciences. In the future, the author intends to use this pilot study to create a more detailed and complete bibliography which can contribute to this topic.

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