GEO-ETHICS IN SLUM MAPPING

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ABSTRACT

Earth Observation (EO) to produce policy-driven information on slums has been receiving increasing attention amongst experts. However, the geo-ethical concerns associated with making slum information publicly available are commonly neglected among the EO community. This study analysed the geo-ethics in terms of technology, product, and application-level using topic-focused interviews in the Greater Accra Region, Ghana. We identified that potential users have little knowledge of machine learning-based slum mapping methods, which implies the need for technology and product documentation to improve the acceptability and usability of EO data. We observed an application mismatch among institutions. While NGOs and research institutions required data for pro-poor initiatives, most government institutions needed data for slum eradication. Such mismatches require a rethinking of how slum data should be made public. We present a guide to disseminate information to users in support of developing a global slum data repository.

Index Terms— slums, geo-ethics, urban remote sensing, machine learning

1. INTRODUCTION

Most low-and middle-income (LMICs) countries are rapidly urbanising and face an unprecedented growth of slum-like communities [1]. Many of these countries already have limited capacity to deal with urbanization problems, which have led to increasing socioeconomic disparities and the marginalization of unprecedented numbers of people [2]. It is currently estimated that nearly one billion people worldwide live in slum settlements [3]. Slum-dwellers are often characterised by socioeconomic vulnerability, including poverty, poor housing conditions, and unemployment, and are usually located in environmental risk areas such as flood zones, facing increasing impacts of climate change [3]. Unfortunately, there is insufficient up-to-date data to localise such areas, which is essential for understanding deprivation levels and supporting the development of pro-poor initiatives.

Earth observation (EO) data has proven to be useful and efficient in deriving timely spatial information and bridging data gaps [4], [5]. Satellite images (e.g.,[6]–[8]) have been used to identify poor urban communities based upon morphological characteristics of the urban structure. Although EO-based slum mapping is widely studied, what is typically missing are clear guidelines for dealing with ethical and privacy concerns associated with slum mapping [9]. The task of slum mapping is a sociotechnical problem with an increased risk of unwitting consequences. Sociotechnical means that the slum mapping task is not just technical but also has complex sociocultural dimensions that need to be considered [10]. Products are used in a real-world context for making decisions and can heavily impact society. Information on slums is sensitive and political, and its misuse is a threat to marginalised communities [9].

In this study, we analysed the geo-ethics associated with EO-based slum mapping. Geo-ethics refers to fairness, accountability, and transparency in the way people (i.e., slum communities) are mapped, represented and treated [10].

2. METHOD

2.1. Study area

The study area is the Greater Accra Region of Ghana, situated along the Gulf of Guinea of West Africa. In 2019, the total population was 4.9 million, with about 38.4% of the population living in slums [11]. The growth of slum communities is due to the historical effects of race-based town planning, migrant communities, and uncontrolled urbanization [12].

2.2. Method

The study adopted the conceptualization of Brey [13] for analysing geo-ethics. The conceptualization consists of three levels: the technology level, the product level, and the application level (Figure 1). In this paper, the technology

level focused on ethical concerns of machine learning in terms of methods, input features, and accuracy metrics. The product level focused on the product and the deliverables to make slum information publicly available. The application level focused on the uses of the product by different institutions and community-based organizations and the impact on slum dwellers.

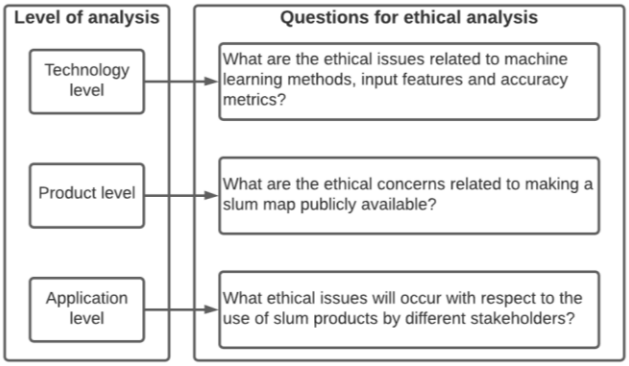

Figure 1. Overview of central questions for ethical analysis adapted from Brey (2020).

Data to analyse the geo-ethics was collected via topic-focused interviews. We identified and purposely selected the following institutions and an NGO (representing slum dwellers) (Table 1) as they deal with slum issues in Accra. To ensure diversity of views on the subject matter, we interviewed four planners, two experts from Public Works Department (PWD), and one from each other institutions.

Table 1. Local experts related to slum*s* and their roles.

Level	Institution	Roles
National	National Disaster Management Organisation	Ensuring disaster prevention and management
District	Physical Planning Department	Human settlement planning and management
	Public Works Department	Responsible for ensuring development control
NGO	People's Dialogue	Responsible for slum profiling and communication participation
Research	Department of Planning, Kwame Nkrumah University of Science and Technology	Slum related research
Company	Tema Development Company	Managing all land and slum regularisation within the Tema catchment area

3. RESULTS AND DISCUSSION

3.1. Technology level

In general, most of the experts raised geo-ethical concerns across all levels of analysis, i.e., machine learning algorithms, input features, and accuracy metrics. Regarding machine learning, most interviewed experts attested that they have little knowledge of how the maps are produced. They lack knowledge on geospatial artificial intelligence (GeoAI), including machine learning, and cannot comprehend the mapping process. This lack of knowledge hinders the use of EO products.

In addition to the physical aspects, experts also highlighted the need to include the socioeconomic dimension in slum mapping. For example, old townships and slums have similar morphological characteristics, introducing uncertainties into the earth observation model. They indicated that the use of citizen science approaches can provide massive socioeconomic data.

Most interviewed experts were willing to use maps with an accuracy of over 70% on model error. However, they cautioned that some errors are more costly than others and should be mitigated. For example, the wrong classification of planned residential as slums can lead to stigmatization. When asked about potential solutions to deal with the foreseen model error, they mentioned that the map producers should clearly describe how the accuracy measures were computed and provide information about the confidence of the map. EO scientists should make the metrics available to support the interpretation of the map. They should make clear why the model behaves that way. Experts recommended that map producers report on the uncertainties related to the final product and elaborate on the potential implications of using such information to deal with such problems appropriately.

3.2. Product level

Another aspect of geo-ethics relates to the way information is represented and disseminated. Figure 2 summarizes the expected deliverables that should be included when making slum information publicly available. These deliverables include that the final map package should include metadata, guidelines on the use of EO information, a report on accuracy metrics, a report on the integration of local context, and show areas with/without ground validation. This inclusion will increase the usability and acceptability of EO information.

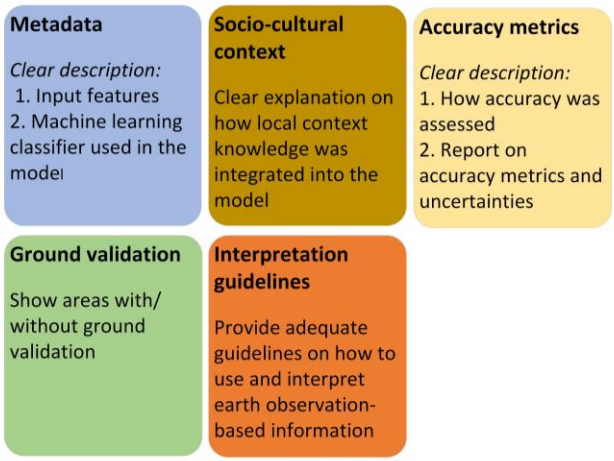

Figure 2. Geo-ethical deliverables for earth observation-based slum information sharing.

3.3. Application level

The last aspect of geo-ethics raised was about how the information is used to treat slum dwellers. In general, there was an application mismatch among institutions. While the NGO and the research institution wanted information to develop pro-poor initiatives, the government institutions were more interested in using the information for eradicating slums and preventing their growth. Most experts from the government institutions mentioned that slums are urban planning and management challenges that need to be addressed. This acknowledges that slum information can be used to develop initiatives in support of the wellbeing of inhabitants or as a 'weapon' for eviction/stigmatization. While new slums have a higher risk of eviction than old slums, a potential solution is to aggregate spatial information at a scale that will omit high-risk slums. Such aggregation avoids providing unnecessary details to the public and has clear geo-ethical guidelines for data sharing.

3.4. Example of geo-ethically produced slum map

By integrating the insights and lessons, we produced a map that considers geo-ethics. While some expectations were met, others will require further resources and studies. We relied only on the physical characteristics and integrated local context-knowledge. In this study, we built a machine learning-based model where; (i) slums were mapped at the streetblock level and the minimum size of the block was set to 0.5 hectares to omit slums, which are the most vulnerable group for eviction, and (ii) show certainty levels per streetblock and (iii) areas with ground validation using an interactive web map. Figure 3a shows an example of how typical slum maps are produced, and 3b shows how a slum map can be provided to ensure geo-ethics. The map can be found at https://slummap.net/index.php/geoknowledge/.

Typical slum maps detect the exact boundary of slums [7], [14], but our proposed approach aggregates slums to avoid unnecessary details to ensure ethical data sharing.

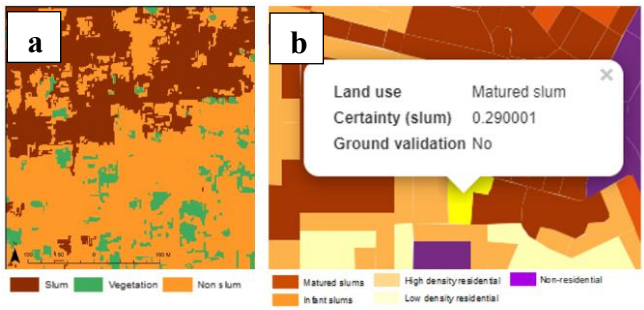

Figure 3. Example of slum maps in Accra (a) Typical example of slum map produced using object-based Image Analysis (OBIA) and (b) Random forest machine learning-based slum map considering geo-ethics.

4. CONCLUSION

This paper describes the geo-ethics associated with making slum information publicly available using geo-based methods. There exists an application mismatch among institutions that can considerably improve or worsen slum dwellers living conditions. While most local experts have little knowledge of EO-based methods, we have provided a guide for disseminating results that will improve acceptability and usability and ensure ethical data openness and sharing.

5. ACKNOWLEDGMENTS

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