Spatial crowdsourcing in natural resource revenue management

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A R T I C L E   I N F O

A B S T R A C T

In many resource-rich developing countries, policymakers, academics, and practitioners alike seek to promote citizen engagement and monitoring in the management of natural resource revenues. However, many of the approaches to improve citizen engagement have not been effective as citizens often lack access to relevant information and opportunities to voice their concerns, and governments have faced financial challenges in engaging citizens. In this article, the authors propose spatial crowdsourcing as an alternative to the traditional ways of encouraging citizen engagement. The proposed approach is illustrated using a simple, intuitive multimedia-based spatial crowdsourcing platform that was tested among farmers who were benefiting from a petroleum-funded project in Ghana. The farmers accessed the platform via their mobile phones and completed a survey relating to the project and petroleum revenue management in Ghana. The findings suggest that spatial crowdsourcing is a promising approach to promote informed citizen engagement in the context of natural resource revenue management. In particular, the farmers indicated that an opportunity to give feedback on the project through a user-friendly platform was very important for them. Furthermore, the representatives of both the government and an oversight body for petroleum revenue management regarded spatial crowdsourcing as a useful tool for collecting feedback on petroleum-funded projects and to increase citizen engagement in natural resource management in general. The authors conclude that although spatial crowdsourcing can help in citizen engagement, its effectiveness in the management of natural resource revenues depends on behavioural changes in governments and citizens.

1. Introduction

In many resource-rich developing countries, policymakers, academics, and practitioners encourage governments to engage their citizens in matters relating to natural resource revenue management in order to curtail opportunities for corruption and mismanagement, as well as to ensure economic growth and societal development (Ofori and Lujala, 2015; Epremian et al., 2016; Ghose et al., 2017; Cameron and Stanley, 2017). Citizens' access to information and their opportunities to provide feedback and demand change has been promoted as a key condition for improved natural resource revenue management (Kolstad and Wiig, 2009; Haufler, 2010). However, many of the approaches used to promote citizen engagement in natural resource revenue management have not worked effectively, as people have often lacked access to relevant information and/or opportunities to voice their concerns, and governments have faced financial challenges in providing for citizens engagement (Ofori and Lujala, 2015; Gyampo, 2016; Kasimba and Lujala, 2019; Lujala et al., 2020).

In this article, we propose *spatial crowdsourcing* as a feasible and cost-effective method for governments and other organisations to disseminate information to people and to obtain citizens' opinions on natural resource revenue governance. Spatial crowdsourcing has been used in various ways, such as in transport management (e.g. by Uber), map services (e.g. Waze and OpenStreetMap) (Tong et al., 2017), forest and marine management (McCall and Minang, 2005; Jarvis et al., 2015), and nature conservation (Walden-Schreiner et al., 2018). However, as far as we know, spatial crowdsourcing has not been applied to natural resource revenue management.

To illustrate the potential of spatial crowdsourcing, we use the case of Ghana's petroleum revenue programme, the Annual Budget Funding Amount (ABFA). In Ghana, petroleum production started in 2011, which ignited a lot of hope in the country (Ayensu, 2013). Many were optimistic that the production would contribute to massive infrastructure development and improve living standards among all Ghanaians, while others were less optimistic. Based on experiences in neighbouring Nigeria and beyond, as well as past experiences in handling the mining

sector, they voiced concerns about Ghana's ability to turn its newly found riches into developments that would benefit all citizens.

In taking seriously the concerns for effective and equal petroleum revenue spending, the Government of Ghana enacted the Petroleum Revenue Management Act (PRMA) in 2011 (PRMA, 2011). Under the PRMA, new mechanisms and institutions were established to manage the petroleum sector and the revenue it generates, among them the ABFA to finance development projects across the country and the Public Interest and Accountability Committee (PIAC) to, inter alia, inform and collect feedback from Ghanaians on the use of the ABFA (PRMA, 2011).

However, it has been difficult for the PIAC to reach Ghanaians with information on the petroleum sector, as it has faced severe financial constraints and has not had enough staff to fulfil its mandate (Gyampo, 2016; Akonnor and Ohemeng, 2019; Graham et al., 2019). Consequently, when 3500 Ghanaians were surveyed in 2016, less than 30% had, in the past 12 months, heard about how petroleum revenue was managed in Ghana and many stated that they lacked easy access to voice their views on petroleum revenue management (Brunnschweiler et al., 2021; Lujala et al., 2020). Therefore, there is an urgent need to connect the citizens (i.e. the intended ABFA beneficiaries) to the PIAC and Government of Ghana. In this article, we propose that spatial crowdsourcing could be an innovative way of disseminating information to citizens and monitoring revenue spending, as well as for citizens to provide input and feedback on natural resource revenue management in Ghana and elsewhere.

Ghana serves a good case for examining the potential of spatial crowdsourcing in natural resource revenue management for three reasons. First, Ghanaians can provide feedback on the ABFA projects relatively freely: the results of an Afrobarometer survey conducted in Ghana in 2017 showed that two-thirds of Ghanaians felt 'completely free' to voice their thoughts and that the majority felt that compared with the situation a few years earlier, there was more freedom to voice political opinions and to criticise the government (Duayeden and Armah-Attoh, 2017). Second, nearly 70% of adult Ghanaians have mobile phones, and nearly half of Ghanaians are connected to the Internet (Hatt et al., 2017), thus making it feasible to spatially crowdsource Ghanaians' opinions on petroleum revenue management via mobile phones. Third, the literacy rate is high in Ghana. Nearly 80% of Ghanaians can read and write (Wolf and McCoy, 2019), which means they should be able to access a crowdsourcing platform and respond in writing.

To study the potential of engaging Ghanaians through spatial crowdsourcing, we created a spatial crowdsourcing platform using Survey123 for ArcGIS and conducted a survey among farmers who were benefiting from an ABFA-funded irrigation project in Shai Osudoku District, in the Greater Accra Region of Ghana. The farmers accessed the platform via their mobile phones and completed a questionnaire survey that probed their knowledge of petroleum revenue spending in Ghana, sources of information on the ABFA, and satisfaction with the irrigation project. We also used the platform to inform the participants that the irrigation project was funded by petroleum revenue. To understand the perceptions of the Ministry of Finance and the PIAC regarding Ghanaians' role in the management of the ABFA projects, we conducted semi-structured interviews with representatives of the PIAC and Ministry of Finance.

In this article, we use the irrigation project as an illustrative case to assess the potential of spatial crowdsourcing in natural resource governance in general and in the case of petroleum revenue spending in Ghana in particular. We aim to answer the following research questions:

1. How and to what degree do the Ministry of Finance and the PIAC collect feedback on the ABFA projects, and are they satisfied with the amount of feedback they receive and the approaches they have for collecting feedback?
2. What are the needs of the Ministry of Finance and the PIAC, and could they be addressed using spatial crowdsourcing?

3. Do the intended users, in this case, the farmers, find spatial crowdsourcing useful and relevant?
4. How could the spatial crowdsourcing platform be improved and scaled up?

Our findings suggest that spatial crowdsourcing can contribute to citizen engagement in natural resource revenue management in four ways. First, by helping governments, subnational governments, and civil society organisations to disclose information to citizens at specific locations. Second, by collecting information and opinions from citizens on revenue spending. Third, by eliciting feedback on specific revenue-funded projects. Fourth, by providing an easy and cost-effective way for dialogues between governments and large sections of citizens.

This article makes two key contributions. It adds to the existing literature on citizen engagement in natural resource governance by examining the potential of spatial crowdsourcing in the management of natural resource revenue. Equally importantly, it highlights how governments and organisations such as the PIAC can use spatial crowdsourcing in the management of extractive industry revenue by engaging citizens easily and cost-effectively through information provision and feedback collection.

The article proceeds as follows. Section 2 briefly reviews the literature on citizen engagement and spatial crowdsourcing in natural resource management. Section 3 presents the PRMA, with a special focus on petroleum revenue-funded projects (i.e. ABFA projects), the PIAC, and the Ministry of Finance. Section 4 describes the methods and research material. Section 5 presents the findings. Section 6 discusses the limitations of spatial crowdsourcing and the Survey123 for ArcGIS platform. In Section 7, we present our conclusions.

2. Citizen engagement and spatial crowdsourcing in natural resource revenue management

2.1. Citizen engagement

Studies of natural resource governance have highlighted citizen engagement as a key to improved natural resource revenue management (Smith and McDonough, 2001; Darby, 2010; Lockwood et al., 2010; Acosta, 2013; Epremian et al., 2016). Citizen engagement in the management of natural resource revenue can help citizens to form or amend their views, debate issues, and voice their concerns relating to resource governance (Fox, 2015; Epremian et al., 2016; Lujala and Epremian, 2017). Further, as Haufler (2010) and others argue, citizen engagement can act as a catalyst for governments to reduce corruption, enhance economic development, improve environmental conditions, and prevent or resolve conflicts. Thus, engaging and giving the public a voice in natural resource revenue management could lead to better and more equitable revenue management (Smith and McDonough, 2001; Lockwood et al., 2010; Lujala et al., 2020).

The Petroleum Revenue Management Act (PRMA), which governs the management of petroleum revenue in Ghana, emphasises the role of Ghanaians as an active voice in the use and management of petroleum revenue (PRMA, 2011). For that to happen, the law calls for the engagement of all Ghanaians in the management of petroleum revenue to ensure that the revenue contributes to activities that better address the needs of all Ghanaians and their communities, and thus, promote sustainable development in the country. Deeper involvement in revenue management could also give the citizens a greater sense of ownership of the revenue-funded projects (Kasimba and Lujala, 2019; Lujala et al., 2020).

Studies on information access and citizen engagement, however, have shown that the majority of Ghanaians are not well informed about the management of natural resource revenue (Edjekumhene et al., 2018; Kasimba and Lujala, 2019; Graham et al., 2019; Lujala et al., 2020). Although Ghanaians feel that they have the right to be informed about natural resource revenue and to benefit from them, they have poor and

unequal access to information about natural resource revenue in Ghana (Ofori and Lujala, 2015; Brunnschweiler et al., 2021; Kasimba and Lujala, 2019). For example, compared with elected duty bearers, traditional authorities, and other opinion leaders such as teachers or religious leaders, common citizens are less likely to be informed about natural resource revenue in Ghana (Lujala et al., 2020). With regard to citizen engagement, Brunnschweiler et al. (2021) observed that most Ghanaians are rather passive when it comes to discussing natural resource revenue-related issues with their immediate leaders and voicing their concerns about revenue management. Hence, there is a need for improvement in both disseminating information and encouraging citizens to voice their concerns relating to resource revenue use in Ghana.

Furthermore, the literature on the management of natural resource revenue calls for decisions on the use of revenue from natural resource extraction to reflect the will of the majority, not just those of the elite. Hence, governments must create spaces for citizens' influence, empower the marginalised and amplify their voices, and enhance inclusive decision-making (Fung et al., 2004; Fox, 2007). Fox's strategic approach to social accountability emphasises the role of an enabling environment created by governments to coordinate citizens' voices and to bolster the responsiveness of the public sector (Fox, 2015). Thus, in Ghana and elsewhere, there is a need for a solution that connects ordinary citizens and governments regarding the management of natural resource revenue. This solution should enable vast sections of the population to easily and cost-effectively receive information about the revenue and how they are managed, present views on their priorities and needs, and provide feedback on the progress of revenue-funded projects. We propose that spatial crowdsourcing could be such a solution.

2.2. Spatial crowdsourcing

Spatial crowdsourcing is the involvement of individuals, groups, and communities in the collection, analysis, and dissemination of environmental, social, and other spatiotemporal information (To et al., 2014). Spatial crowdsourcing differs from general crowdsourcing in that it includes location-specific tasks that require people's physical presence at precise locations to complete them, such as to send location-specific text, pictures, audio, or other location-specific information (Zhao and Han, 2016). Thus, spatial crowdsourcing requires a device incorporating a global positioning system (GPS) to record locations (Chatzimilioudis et al., 2012; Miao et al., 2016).

Spatial crowdsourcing is a fast and cheap way to reach a large group of people (Howe, 2006) and can be considered as a form of volunteered geographic information (VGI) that uses the Internet to create, assemble, and disseminate geographical information (Goodchild, 2007). Additionally, it is a type of citizen science in which the academic community involves members of the public actively in academic work (Doyle et al., 2019). Compared with other forms of citizen engagement such as community-level meetings, offline surveys, or radio broadcasts, Alonso (2013) claims that spatial crowdsourcing has four benefits: it increases the speed of data collection, reduces costs, improves data quality, and increases the diversity of participants.

The use of spatial crowdsourcing within natural resource management has been studied in forestry (McCall and Minang, 2005), nature conservation (Walden-Schreiner et al., 2018), marine spatial planning (Jarvis et al., 2015), and the redevelopment of extractive landscapes (Scarlett et al., 2018). The studies have found that spatial crowdsourcing can increase the degree of citizen engagement and improve governance of natural resources through providing citizens with relevant information on issues at hand, as well as related government policies and

practices. Furthermore, spatial crowdsourcing can serve as a platform for citizens to provide input to public institutions, thus enhancing two-way dialogue between citizens and public institutions. Other, non-resource related but notable spatial crowdsourcing applications include the following: Ushahidi, which is used in over 160 countries to report crises and human rights abuse, as well as to monitor elections (Okolloh, 2009); iRain, which is used to report local precipitation conditions from anywhere in the world to the Centre for Hydrometeorology and Remote Sensing at the University of California, Irvine (To et al., 2016); gMission, which is a platform for conducting various crowdsourcing tasks based on location (Chen et al., 2014); and Wikicrimes, which allows users to report crimes on a global map (Furtado et al., 2010).

Based on experience, it is likely that spatial crowdsourcing can contribute to citizen engagement in natural resource revenue management in four main ways. First, spatial crowdsourcing can be used by national and subnational governments and by civil society organisations to disclose information to citizens at specific locations (McKinley et al., 2017). Second, spatial crowdsourcing can be used to collate information and opinions from citizens (Bott and Young, 2012). Third, as spatial crowdsourcing produces spatial data, it allows for governments to gather information on location-specific projects or subnational units and thus more effectively respond to citizens' concerns in specific places (Kurniawan and de Vries, 2015). Hence, spatial crowdsourcing can aid governments in monitoring and evaluating development programmes through eliciting and implementing feedback directly from projects' beneficiaries. Fourth, spatial crowdsourcing can provide an easy and cost-effective way for dialogues between governments and/or other organisations and large sections of citizens. For example, rather than time and money being spent on expensive and time-consuming field visits, citizen engagement through spatial crowdsourcing across a country could be facilitated by a few employees at an organisation's headquarters (To et al., 2016).

3. Annual budget funding amount

The Annual Budget Funding Amount (ABFA) is the part of petroleum revenue intended to finance developmental projects in Ghana. Following the discovery of oil in economic quantities in 2007, Ghana enacted the Petroleum Revenue Management Act (PRMA) in 2011 (PRMA, 2011) and an amended version in 2015 (PRMAA, 2015). The Act established how petroleum revenue should be collected, allocated, and utilised in a transparent, responsible, and accountable manner to ensure that they benefit all Ghanaians, including future generations (PRMA, 2011). The PRMA stipulates that after a 30% disbursement (50% before 2015) to the national oil company to finance its operations, c.70% of the remaining petroleum revenue should be spent through the ABFA on development projects to maximise economic growth, promote economic equality, and enhance balanced regional development.[1] From 2011 to 2018, USD 1.9 billion were allocated to the ABFA, of which about USD 1.5 billion had by the end of 2018 been spent on development projects across the country (Fig. 1) (Ministry of Finance, 2019).

According to the PRMA, the ABFA allocations must be guided by a national medium-term expenditure framework aligned with a long-term national development plan. In the absence of a national long-term development plan, the Act specifies that the ABFA should fund projects in a maximum of four of the twelve priority areas listed in the

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[1] The remaining c.30% is disbursed to a heritage fund and a stabilisation fund. For more information on petroleum revenue management, as well as how the exact shares are calculated, see STEPHENS, T. K. 2019. Framework for petroleum revenue management in Ghana: current problems and challenges. *Journal of Energy & Natural Resources Law,* 37, 119–143.

PRMA.[2] These priority areas are identified by the Ministry of Finance in consultation with the district assemblies and are reviewed every third year.

As Ghana did not have a long-term national development plan, in the period 2011–2016 (the first two three-year periods) the four selected priority areas were agriculture modernisation, roads and other infrastructure, expenditure and amortisation of loans for oil and gas infrastructure, and capacity building in oil and gas sector (Fig. 2).[3] For the period 2017–2019, the priority areas were agriculture, roads and other infrastructure, health, and education. During the period 2011–2016, 37% of all ABFA funding was allocated to roads and other infrastructure, as the government sought to improve and expand the road infrastructure in the country, followed by agriculture modernisation (27%) and expenditure and amortisation of loans for oil and gas infrastructure (25%) (Ministry of Finance, 2019). In the years 2017 and 2018, education became the most prioritised area (41% of all ABFA funding), followed by roads and other infrastructure (29%) and agriculture (15%). To augment the financial capacity of the PIAC, the 2015 amendment to the PRMA specified that the PIAC should be funded directly from the ABFA. Consequently, the financial situation of the PIAC has improved, and it received a total of USD 1.3 million of ABFA funding in the period 2016–2018.

Two national projects – free upper secondary education and an onshore natural gas processing plant – received USD 210 million in ABFA funding by the end of 2018 (Ministry of Finance, 2018).[4] By the end of the same year, 400 community-based projects had received ABFA funding across the country (Fig. 1). ABFA funding for these projects varied from USD10,000 to USD 320,000 per project and in total, just over USD 1 billion having been spent on the community-based projects by the end of 2018 (Ministry of Finance, 2019).

The ABFA-funded community-based projects have been criticised on several grounds (PIAC, 2017; Edjekumhene et al., 2018; Stephens, 2019). For example, the projects have tended to be ad hoc and have been implemented without clear goals and objectives. Also, the projects have been too small, and thinly spread to have a transformational impact on development. Moreover, the projects' selection and implementation have excluded community members, thus making it questionable whether the projects have met the needs of the people, and it has also made it difficult for the community members to monitor the progress of project implementation.

The PRMA assigns specific roles to both the PIAC and the Ministry of Finance regarding the ABFA. The PRMA mandates the PIAC to monitor and evaluate the government's compliance with the Act, provide space and platforms for the public to increase its knowledge and awareness of petroleum revenue management, improve citizens' capability and willingness to hold the government accountable in managing petroleum revenue, and provide an independent assessment of the management and use of revenue (PRMA, 2011 Sections 51 - 57). The PIAC is an independent body with 13 representatives drawn from civil society, media, organised professional groups, academia, religious and traditional authorities, and the Ghana Extractive Industries Transparency Initiative (GHEITI).

Under the PRMA, the Ministry of Finance is responsible for the overall management of petroleum revenue, inclusive supervision of transfers into the ABFA, and disbursements from it. Additionally, in the absence of a national medium-term development strategy (based on inputs from the district assemblies), the ministry decides the ABFA priority areas, the ABFA allocations, and the projects to be funded through ABFA. Per the PRMA, the Ministry of Finance needs to make an annual announcement about these issues and decisions to the Parliament.

4. Methods and data

Fieldwork was conducted in Ghana in October and November 2018 to collect data through interviews and testing of a pilot spatial crowdsourcing platform. The interviews were conducted in Accra, while the rest of the fieldwork was done in Dawa, a rural community located in Shai Osudoku District, 75 km east of Accra, in the Greater Accra Region. In Dawa, research material was collected by testing a spatial crowdsourcing platform and using it to conduct an online survey. The fieldwork in Dawa included also informal talks and discussions with the farmers and the local agriculture extension officer.

We conducted semi-structured interviews with representatives from the Ministry of Finance and the Public Interest and Accountability Committee (PIAC). The interviews focused on understanding the roles of the Ministry of Finance and the PIAC in the management of the ABFA, as well as to what extent and how they collected feedback from Ghanaians on the ABFA projects and their views on the spatial crowdsourcing platform. The interviews, which were conducted in English, were recorded and transcribed. We analysed the transcribed interviews thematically (Matthews and Ross, 2010). By placing the participants' responses side by side, we identified the roles of the Ministry of Finance and the PIAC concerning the ABFA and identified relationships between their roles concerning the ABFA, as well as similarities and differences in how they collected feedback from the ABFA beneficiaries.

For our spatial crowdsourcing platform, we used Survey123 for ArcGIS, which is part of ESRI's Geospatial Cloud for ArcGIS. The software allows for the creation, sharing, and analysis of online surveys and can be used to collect data via computers, tablets, and mobile phones that are connected to the Internet. Survey123 for ArcGIS can generate geographical coordinates for the devices' location and can be used to upload pictures, videos, and responses to questions.

We selected the Dawa Irrigation Dam Project as a case to test the spatial crowdsourcing platform because the project has been completed (in 2012), it is a community-based ABFA project, and it has a specific spatial location (as opposed to, for example, capacity-building programmes such as Free Senior High School programme). Internet connection in Dawa (it being a rural community) is unstable and as the platform needs an Internet connection to function, Dawa served as a good location for a pilot study as we wanted the test platform under challenging conditions.

The irrigation project consisted of the construction of a reservoir and an earth-filled embankment (wall), as well as the provision of farmland below it (Fig. 3). ABFA funding for the project amounted to USD 132,000 (Ahunu et al., 2018). The dam is located 800 m from the Dawa community. According to the agriculture extension officer, the reservoir was constructed in a place where rainwater collected before running into the sea. The irrigated farmland covers 23.5 ha and is divided into individual plots, called *pans* in the local language. Each *pan* measures
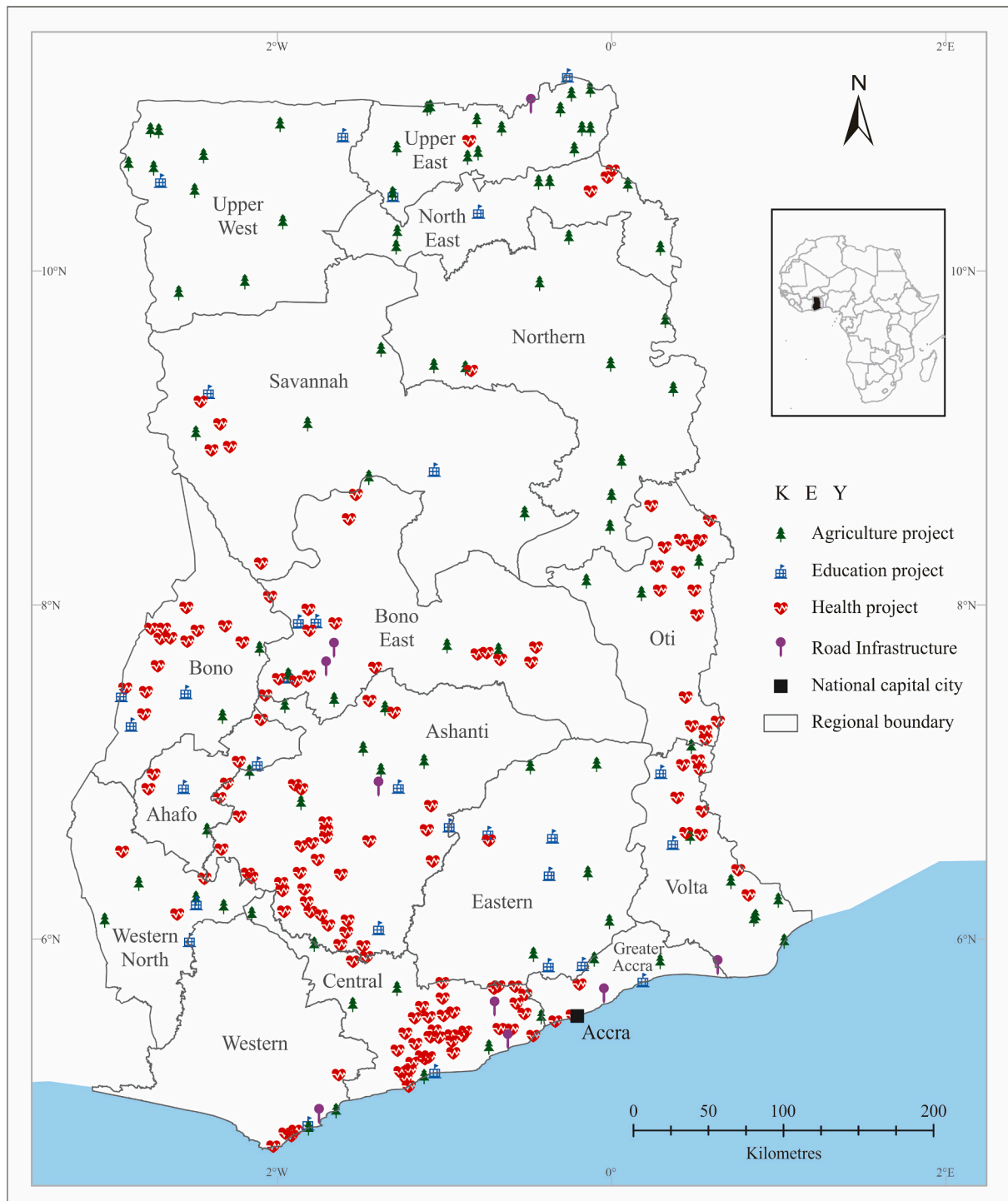
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[2] The priority areas are: agriculture and industry; physical infrastructure and service delivery in education, science, and technology; potable water delivery and sanitation; infrastructure delivery in telecommunications, road, rail, and port; physical infrastructure and service delivery in health; housing delivery; environmental protection, sustainable utilisation, and protection of natural resources; rural development; developing alternative energy sources; strengthening of institutions of the government concerned with governance and maintenance of law and order; public safety and security; and provision of social welfare and protection of the physically handicapped and disadvantaged citizens.

[3] The names of the identified priority areas do not directly correspond to the 12 priority areas listed in the PRMA, as under the Act (Section 21:3), the Minister of Finance is permitted to modify the names of the prioritised areas. For example, expenditure and amortisation of loans for oil and gas infrastructure, and capacity building in the oil and gas sector both fall under the priority area named environmental protection, sustainable utilisation, and protection of natural resources.

[4] The Free Senior High School programme, which started in 2017, removed all fees and expenses for upper secondary school pupils, including fees for boarding and meals. The Atuabo Gas Processing Plant, which was completed in 2015, produces c.35% of the electricity generated in Ghana.

Fig. 1. Completed community-based ABFA projects, 2011–2018. Data source: Ministry of Finance (2019). Note: The data source indicates the name of the town located closest to the ABFA project. This information was used to determine the approximate location of the project.

between 0.15 and 0.55 ha. In the event of flooding, a spillway and a spillage gutter direct excess water away from the farmland. The water from the reservoir is used for irrigation, laundry, bathing, cooking, and construction.

The agriculture extension officer, together with the chairperson of the irrigated land's farmers association is responsible for the demarcation of the *pans*. The annual rent for a *pan* is c.USD 5. At the time of the interview, most of the farmers (48 in total) were from Dawa, while a few were from nearby communities. During the growing seasons (January–April and August–December), the farmers mainly grow vegetables. A few plant watermelons between the seasons, but most of them left the *pans* fallow. The reservoir has water throughout the year and the farmers can use the water at any time. Before the construction of the dam, the farmers depended on the rains to water their fields and some of the farmers indicated that their living conditions have improved after the construction of the dam, as they now have a reliable water source for cultivation.

In Survey123 for ArcGIS, we designed the questionnaire survey and generated a link for it. Together with the agriculture extension officer, we identified the farmers who had suitable technology (mobile phones
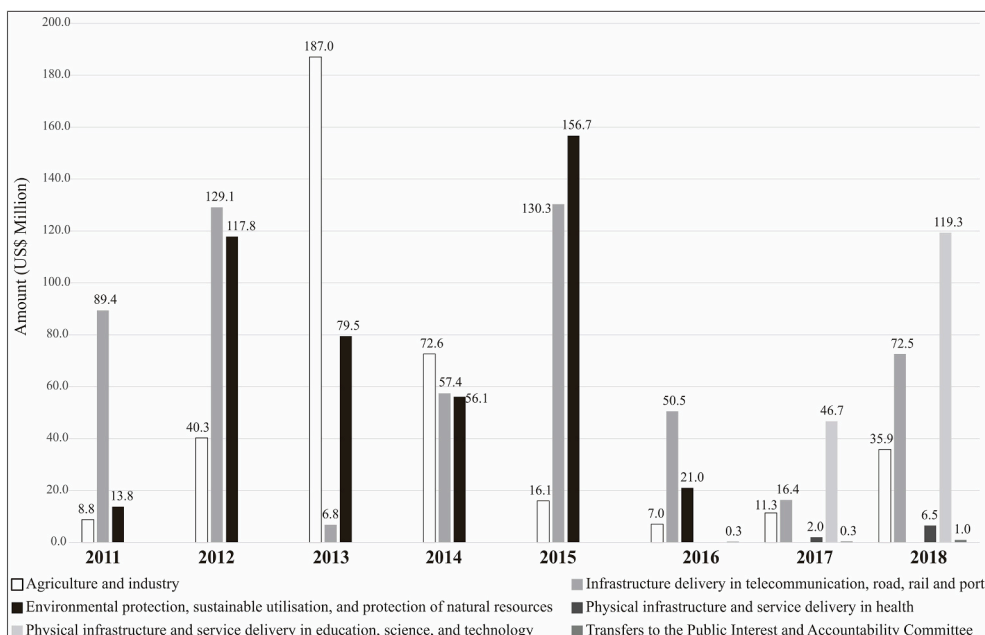
Fig. 2. ABFA spending (USD million) in the period 2011–2018. Data source: Ministry of Finance (2019). Note: Data for 2011 includes only the first three quarters of the year.

with GPS and Internet connection) to participate in our survey. Of these, 16 farmers agreed to participate in the survey. We circulated the survey link to the sampled farmers via the WhatsApp mobile messaging application. Upon receipt of the link, the farmers clicked it to access the survey, filled the questionnaire, and submitted their responses. We downloaded all responses in a spreadsheet and in shapefile format. From the spreadsheet (Excel), we created simple frequency tables and cross-tabulations. The shapefiles enabled us to display the survey participants' approximate location when they completed the survey (Fig. 3).[5]

The survey questions focused on the following: the participants' background, their knowledge about oil revenue spending in Ghana, their knowledge about the ABFA, sources of information about the irrigation project, satisfaction with the project, and experiences of using the survey platform (see Appendix 1). Most of the questions were closed, but a few open-ended questions were included to collect feedback on the platform. We also used the platform to inform any participant who did not know prior to the survey that the irrigation project was funded by petroleum revenue.

All 16 farmers were men, 4 were in the age range 18–30 years, 10 were in the age range 31–60 years, and 2 were older than 60 years. Most of the farmers (14) had completed lower secondary school education. The majority (11) were ordinary community members, two were youth leaders, and the others comprised an opinion leader, a teacher, and a tribal leader. Regarding occupation, 10 of the farmers were full-time farmers, 3 were students who were farming to finance their education, 2 were salaried workers, and 1 was self-employed. During the week prior to the completion of the survey, most participants (11) had used water from the dam two or three times, while the others had only used water from the dam once. All participant farmers were either satisfied (10) or very satisfied (6) with the completed dam project.

5. Findings

Our analysis sheds light on how the PIAC and the Ministry of Finance collect feedback from the ABFA project beneficiaries, and how useful and adequate they find this feedback. Further, using the survey results, we analysed the farmers' familiarity with the ABFA projects and their perceptions of the irrigation project in their community. Finally, we sought to understand the importance of spatial crowdsourcing to the ABFA project beneficiaries, the Ministry of Finance, and the PIAC.

5.1. The PIAC and Ministry of Finance

5.1.1. Feedback collection
The PIAC collects feedback through its annual regional forums, which are held in the regional capitals.[6] The PIAC organises the forums for selected representatives of regional and local governments, traditional leaders (chiefs and queen mothers), ABFA implementing agencies, ABFA project contractors, and the local media, inviting also some ordinary Ghanaians. By March 2020, the PIAC had organised 16 public forums in the regional capitals. In the forums, the PIAC presents key findings from their most recent annual report on the usage of petroleum revenue and the ABFA projects before opening the floor for discussions and questions. According to the interviewed PIAC officer, the PIAC has managed to hold only one forum per year due to financial difficulties: '[…] the law is clear, the PIAC should hold at least two public fora, following the release of its Annual Report. We call it the reporting requirement of [the] PIAC. But because of funding issues, what we have done [so far] is to do one forum [in each] region.'

The main channel for ordinary Ghanaians to share their views on the ABFA projects with the PIAC is through radio call-in shows. When, as part of their monitoring and dissemination responsibilities, the PIAC representatives conduct field visits to selected districts that are benefitting from the ABFA projects, they often seek to engage the public through the local state-owned broadcasting radio station. In the radio

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[5] To preserve the participants' identity, their location was offset by 100 m on the map shown in Fig. 3.
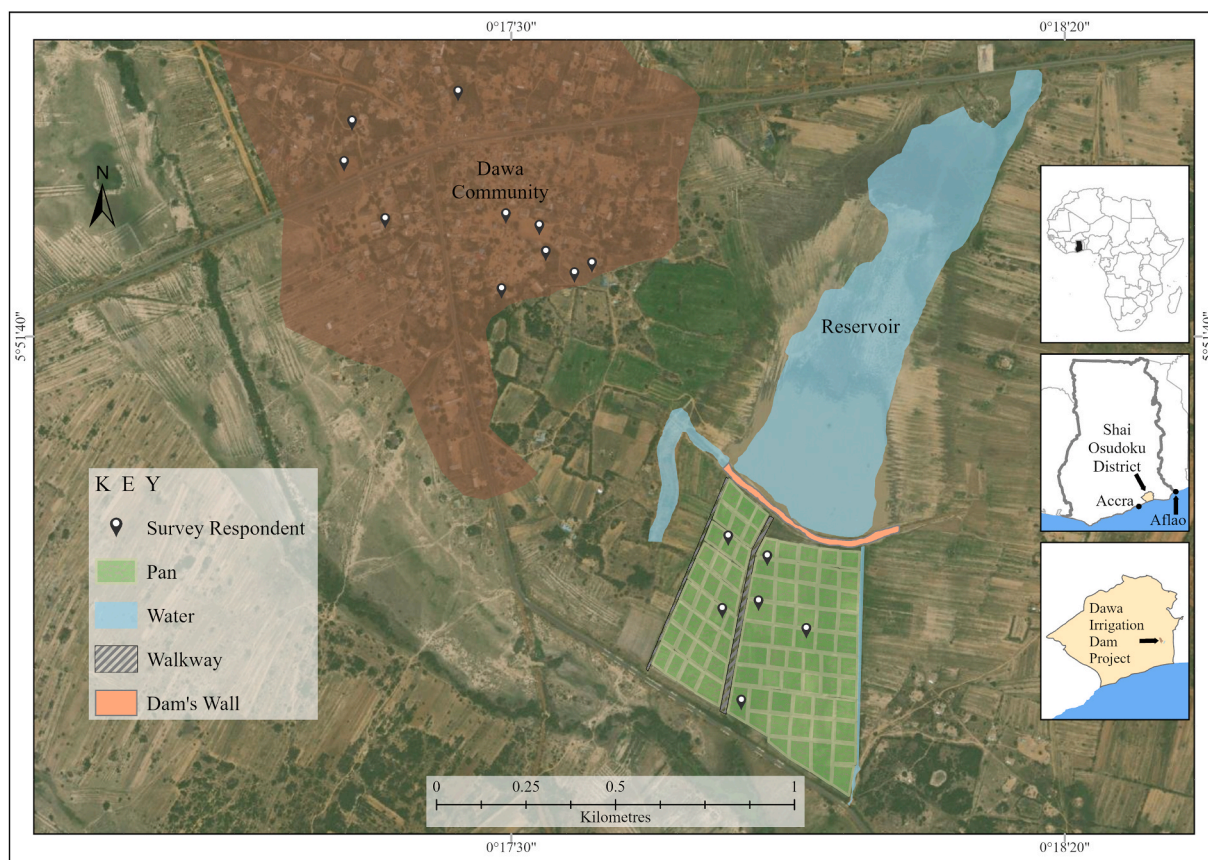
[6] Ghana has 16 regions.

Fig. 3. Study area, irrigation project, and approximate location of surveyed participants. Source: satellite image (ESRI, 2020).

shows, the PIAC presents the list of ABFA projects within the district and their state of progress. Listeners can participate by calling into the show: "usually, we have listeners calling into the show to ask questions about the projects and we also offer feedback on their concerns. Additionally, during the field inspections, the PIAC members often talk with local community members: 'you can […] get to a road project you are inspecting, and people are passing, [and] just at random, one of us will ask them questions' (PIAC's officer).

It is also possible to provide feedback directly to the PIAC: '[…] we have our website, we have our telephone numbers, we have our Facebook page, my Twitter handle and things like that. So, if you're following, you can comment on anything, you can send direct messages through the page' (PIAC's officer). However, only a few people contact the PIAC through the channels mentioned by the PAC officer: 'it's rare, but [we] have people calling in and making requests or inquiries occasionally' (PIAC's officer).

The PIAC also collects feedback directly from the ABFA project implementing agencies (e.g. the Irrigation Development Authority), the responsible ministries, the municipality and district chief executives, and the ABFA projects' contractors. According to the interviewed PIAC officer, in many cases the local chief executives contacted by the PIAC did not even know that some of the projects in their districts were funded by the ABFA:

> […] mostly the feedback we got from the municipality and district chief executives and heads of institutions is that [they] weren't aware of these projects. [They] didn't know it was [funded by] the oil revenue. That's the commonest feedback we get, and that speaks volumes. It does!

In contrast to the PIAC, the Ministry of Finance does not collect feedback from Ghanaians. Instead, it relies on the reports from the PIAC: 'we get feedback from PIAC, which represents the citizens, so [the]

PIAC's reports are always with us. So, if we get feedback from [the] PIAC, we look at their recommendations and we implement them' (Ministry of Finance's officer).

In sum, the PIAC uses open discussions, radio call-in shows, interviews, emails, telephone calls, and social media to collect feedback on the ABFA projects. They also collect information from the responsible ministries, the local government authorities and traditional leaders, project implementing agencies, and the ABFA projects' contractors. The Ministry of Finance, in turn, depends on the PIAC for feedback on the ABFA projects.

5.1.2. Usefulness of feedback

Through the feedback, the PIAC has identified non-existing ABFA projects and projects that have been relocated. Although the implementing ministries present a list of the projects with their corresponding locations, the lists contain discrepancies, as some of the projects are located at different sites or in some cases, they do not exist at all. Furthermore, the feedback 'gets you to really understand the dynamics of these projects and the importance of consultations' (PIAC's officer).

According to the PIAC's representative, the feedback has helped the PIAC to plan its ABFA project monitoring. Many ABFA projects need inspection but the PIAC has limited capacity to inspect all of them. Hence, the PIAC needs to make informed decisions when choosing projects to inspect in the field. To do that, they consider the complaints and comments they have received about the projects and factor them into their subsequent field visits. For example, the interviewed PIAC officer said:

> […] there have been times we were called by some chiefs in the Swedru [town] area about a drainage project that has been done with the petroleum revenue. It might take some time, based on our schedules, but anytime we are coming to a region, we will definitely

pass by. So, last month, when we were in the Central region, we made sure we chose that town.

Additionally, the feedback helps the PIAC to verify the reports it receives from project contractors from the ABFA projects' sites. In some cases, contractors who have received money to start work on the projects report that they are on-site and working. However, through encounters with the beneficiaries on the ground, the PIAC sometimes learns that this is not the case: 'Look, they [community members] will tell that they have lived there [on ABFA projects' sites] all their lives […] So, if a contractor is telling us that there was work done during this time, the person [contractor] is lying' (PIAC's officer).

5.1.3. Need for more feedback

Although the PIAC receives useful and good quality feedback, they want to collect considerably more feedback from the beneficiaries of the ABFA projects. The PIAC is aware that increasingly more people are willing to give feedback about a wide range of issues relating to the ABFA projects. However, the PIAC has limited access to the projects' beneficiaries: 'you see the fora are usually limited. So, we cannot get adequate feedback' (PIAC's officer).

As an example of the PIAC's quest for more feedback, the PIAC encourages the public to reach out to them through the PIAC's contacts. The PIAC asserts that it is there for the people and is willing to reach out to everyone. Therefore, to offset the limited time in the forums, ordinary Ghanaian citizens should try to contact the PIAC directly with their concerns regarding the ABFA:

> Yes, yes, we actually encourage individuals to do that [walk to the PIAC's office]. [The] PIAC is a citizen-led body. It exists for the people. It doesn't exist for any politician. It doesn't exist for the NDC [opposition party] or the NPP [incumbent party] or the president, even though we are supposed to be sending them [political parties] reports […] the core of [the] PIAC is the citizens.

5.2. The farmers

From the survey data presented in Appendix 1, it appears that most of the farmers did not know about how petroleum revenue is managed in Ghana. Regarding the national spending of petroleum revenue, 6 of the 16 farmers had no knowledge, 9 had little knowledge, and just 1 had some knowledge about the topic. Concerning the local usage of petroleum revenue, only six of the farmers knew about any petroleum-funded projects in their area. This finding is surprising considering that the Dawa irrigation project was funded from petroleum revenue, and the surveyed farmers are its direct beneficiaries.

The participant farmers felt strongly that common citizens should be able to influence the ABFA priority areas, what type of projects should receive ABFA funding and the location of the chosen ABFA projects. The farmers stated that common citizens should either always (12) or often (4) be involved in the selection of the ABFA projects' sites, while 13 farmers thought that they should always or often be involved in the selection of the projects, and 12 thought the same for the selection of priority areas. These findings suggest that Ghanaians would like to influence how the ABFA is managed. Such engagement could potentially improve people's sense of ownership of the ABFA projects, which in turn could enhance their motivation to monitor the progress of the projects' implementation and involvement in the maintenance of the completed projects.

Regarding the priority areas, the majority of the farmers (11) preferred to receive a petroleum-funded project on either education or health if they were to benefit from another ABFA project. This is probably because Dawa already has irrigated land and good road connections to national capital (Accra) and a market town adjacent to the border between Ghana and Togo (Aflao).

Regarding common Ghanaian citizens' access to information about

the ABFA projects, we asked the participant farmers about how much they knew about the irrigation project, and when and how they had acquired that information. The results revealed that most of the farmers had not been involved in the planning and implementation of the irrigation project, as 12 out of 16 had not received any information about the irrigation project before its construction started. Most of the farmers (9) had heard about the project from their friends, while the district assembly member was the second most common information source (4 farmers).[7]

To learn about the farmers' preferred point of contact, we asked them whom they had contacted when they had had any questions or concerns regarding the irrigation project. Of the 16 farmers, 5 had contacted a district assembly member and 4 contacted the chairperson of the local farmers association.[8] Lujala et al. (2020) observed that district assembly members were important information sources and key points of contact for common citizens in Ghana, and this seems to be the case for the Dawa farmers too.

5.3. Feedback on the spatial crowdsourcing platform

The farmers were very positive towards the spatial crowdsourcing platform. They found it easy to open the survey on their mobile phone, enter their responses, and submit the completed survey. They also found that the interface was clear, legible, and easy to navigate, and they assessed the platform as user-friendly. Many of the farmers (7) found that it was easy and some (6) found that it was very easy to give feedback via the platform. For the farmers, the most challenging part was to upload a picture of their farm or the irrigation project; of the six farmers who attempted this, four found it easy and two found it difficult.

According to the Ministry of Finance's officer, the ministry had discussed developing an application that the ABFA beneficiaries could use to provide feedback on ABFA projects to improve the monitoring of the projects. The officer said that the objective was to save money and time spent on arduous field visits, but most importantly to monitor the ABFA projects more effectively. However, the Ministry of Finance's discussions had not resulted in any concrete plans to develop such a platform, and the interviewed officer, therefore, said 'your platform will be very useful to the Ministry of Finance. We'll be very interested in using it when you finish it […] such a platform, will help make our work easier.'

The PIAC's objective to reach out to more Ghanaians for feedback on the ABFA projects had made them rethink their feedback collection approach: '[…] so one of the things we are doing is to upgrade our website to be more interactive. We also discussed the possibility of developing an app similar to what you are doing.' Particularly, the PIAC found the possibility to upload pictures through the spatial crowdsourcing platform pertinent for them, as it would be easier for the PIAC to monitor the progress of the projects. Moreover, the PIAC representative thought the PIAC could potentially use the platform to engage communities in deciding which projects should be implemented in their area, as it would enable the PIAC to reach to the citizens: '[…] you can't know what a priority to somebody is unless you ask the person' (PIAC's officer).

6. Limitations of spatial crowdsourcing

As Lichten et al. (2018) and Gummidi et al. (2019) assert, the availability of a participating 'crowd' is critical to the success of any crowdsourcing project, including spatial ones. However, persuading members of the public to participate in a spatial crowdsourcing project

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[7] Generally, the farmers' information sources closely reflect the results reported by Lujala et al. (2020), who studied common citizens' information sources about local issues in Ghana.

[8] See Appendix 1 for information on how the interviewed farmers contacted the person and the response (Questions 17, 18, 19, and 20).

can be challenging. The public may be unaware of a crowdsourcing project requesting their engagement or they may be unwilling to participate if they do not regard the issue at hand as important to them or if they have other, more pressing needs that they need to prioritise. Further, those who are aware of the crowdsourcing project and willing to participate may not possess the required technology (e.g. smart telephone or Internet access) or lack a channel through which they can be reached (e.g. email or social media account), or they may lack the required skills (e.g. an ability to read and write).

In our case, through the local farmers' association chairperson and the agriculture extension officer, all 48 farmers were aware of the survey and many of them were willing to participate in it but only 16 of those willing to participate had suitable technology (mobile phones with GPS and Internet connection). Hence, our survey participants were not representative of the local farmers; their use of smartphones indicates that they were likely to have been comparatively wealthier, and possibly they also had higher education levels.

Unrepresentativeness is likely to be the case for any spatial crowdsourcing project that relies on access to a relatively expensive technology (e.g. smartphones and Internet access). Thus, when a crowd self-selects to participate in a spatial crowdsourcing endeavour, the representativeness of the participants is always an issue as the self-selection could introduce biases in the sample (Bubalo et al., 2019). Whether self-selection and the biases it introduces is an issue depends on the objective(s) of the spatial crowdsourcing project (Czepkiewicz et al., 2017). For example, within natural resource revenue management, representativeness may not be an issue if the objective is to monitor the progress of uncompleted revenue-funded projects or to report the statuses of completed ones. However, it can be of great importance if the objective is to decide future revenue-funded projects as the voices of the poorer and less educated are more likely to be absent. To overcome the issue of representativeness, it is vital to provide incentives for the crowd and support participation (Wu et al., 2018; Tong et al., 2020). For example, to engage Ghanaians representatively using a spatial crowdsourcing platform, the PIAC could indicate to participants that their participation could increase the chances of their community having more or better amenities funded from the petroleum revenue and compensate their time and use of the Internet by giving them a small amount of phone recharge credits.

To increase the number of participants in studies using spatial crowdsourcing, it is important to reach a large section of the population. Therefore, it is crucial to draw citizens' attention to the platform. This means understanding how people in the target audience usually keep themselves informed about issues that concern them. In Ghana, collaboration with the PIAC through a mass media campaign on radio and/or TV could be helpful in this regard (Lujala et al., 2020).

As Internet connections in many areas in developing countries can be poor or unstable, it would be crucial to find a way of making the spatial crowdsourcing platform function offline. One solution would be to use a platform that enables the participants to access the survey, save their responses offline, and submit the responses whenever they do have access to the Internet. Also, to ensure that the project location is recorded accurately (i.e. not the location where the participant accesses the Internet), such platforms need to be able to capture and preserve the required location. However, Internet access would still be needed to download and install the software and to upload responses.

Spatial crowdsourcing that lacks a record of a project's location remains a simple survey platform. At the same time, it is problematic to collect location data relating to participants that potentially could be used to identify them. Issues such as voluntary participation, privacy, and protection of research participants are not only ethical issues but also requisite for quality data (Robinson et al., 2018). Assuring participants of their anonymity will enable them to feel safe to respond more freely and accurately. To preserve anonymity, the Survey123 for ArcGIS can be set to collect participants' location at a desired offset. We used an offset of 100 m.

On the more technical side, the interface layout and navigation within a survey are important. In our case, the participants had to scroll from the top of the screen on their mobile phone to the bottom to answer the questions. This proved somewhat tedious for some of the participants, who would have preferred the questions to appear one-by-one. Fortunately, the updated version of Survey123 for ArcGIS allows for presenting survey questions one-by-one or group some of them on a page, with the 'next' option displayed to aid in navigation through the entire survey.

7. Conclusions

In many resource-rich developing countries, policymakers, academics, and practitioners promote citizen engagement and monitoring in the management of natural resource revenue. It is, however, challenging to find feasible and cost-effective ways to facilitate such engagement. In this article, we have proposed spatial crowdsourcing as an alternative to the traditional ways of encouraging citizen participation in the management of natural resource revenue. We have demonstrated the approach through a pilot study of a spatial crowdsourcing platform with 16 farmers who had benefited from a petroleum-funded project in Ghana. The farmers accessed the platform via their mobile phones and completed a survey relating to the project and their opinions about petroleum revenue spending in general in Ghana. Our findings suggest that spatial crowdsourcing can potentially promote informed citizen participation in the context of natural resource revenue management.

Decision-makers can use spatial crowdsourcing to disclose information to citizens at specific locations, collect information and opinions from citizens on revenue spending, elicit feedback on specific revenue-funded projects, and provide a cheaper platform for dialogue between governments and large sections of citizens. Nonetheless, for the best use of spatial crowdsourcing in citizen engagement, decision-makers should use spatial crowdsourcing platforms that can function offline, reach out to most citizens, and assure them of their anonymity.

Spatial crowdsourcing alone is not a solution in the management of natural resource revenue. Although it can potentially help in reaching out to citizens and collecting their inputs, its impact on policy formulation, priority-setting, and effective resource allocation depends on behavioural changes in governments and citizens. Governments should encourage citizens to voice their concerns and constructively respond to such voices. To do so, governments must actively let citizens know of their benefits when they participate in the management of natural resource revenue. Simultaneously, citizens should become active in demanding information from authorities regarding the use of natural resource revenue and they should be active in demanding change when needed. Spatial crowdsourcing can only be a valuable tool in the management of natural resource revenue if both governments and citizens are genuinely interested in changing the status quo.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resourpol.2021.102082.

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