

Spatial Solutions for the Environmental Protection Agency “Brownfields to Healthfields” Program: Utilization of Mixed Methods to Assess Application Effectiveness and Usability

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Abstract

Geographic Information Systems (GIS) can serve as a planning tool to promote community health at many levels, such as the policy, organizational and public levels. The Brownfields to Healthfields (B2H) program involves creating new opportunities to support community public health, including the development of park spaces and new hospital facilities. However, there was no existing portal for organizations to access a map of brownfields data to meet the required criteria of the organization in seeking a space for transformation to a “healthfield” or other public services facility. Since the various types of community and demographic data were scattered, it was necessary to combine the data in a web application available to all stakeholders. This paper discusses the utilization of a new concept of operation, which includes participative and volunteered approaches that are addressed to include the contribution of various stakeholder groups, and to further improve planning for public health.

1. Introduction

Geographic Information Systems (GIS) promotes community health through both top-down and bottom-up approaches. Brownfields to Healthfields (which we refer to as B2H in this study) is a program developed by the Environmental Protection Agency (EPA) that currently works with brownfields to transform them into less contaminated areas, by removing toxic storage containers from underground at these sites and restoring these areas for community use [1]. Ideally the purpose of this process is to improve public health for diverse populations and underprivileged neighborhoods. The new sites can be

used for different purposes such as park spaces, hospital and clinic facilities.

Redhorse Corporation, an EPA consulting company, determined the need for providing nonprofit community based organizations (CBOs) with online mapping resources to locate and identify available cleaned-up brownfield sites in order to build healthy community facilities [2]. The organization has provided Claremont Graduate University (CGU) with the details of the project and the need for an application with mapping accessibility to community based organizations. Additionally, CGU is responsible for the management and maintenance of a data portal that contains demographic and community spatial data relevant to the needs of all stakeholders such as the EPA, Redhorse Corporation, and the nonprofit CBOs in Los Angeles County.

Founded in the processes of urban planning, Public Participation GIS (PPGIS) involves a multiple stakeholder approach to the design and utilization of maps for community planning, including for the design of healthier communities [3,4]. Important to PPGIS and Participatory GIS (PGIS) are the concepts of effectiveness of mapping tools available to stakeholders [3]. Moreover, it is important that stakeholders find the maps meaningful, applicable, relevant, and useful. Using the concepts of Volunteered Geographic Information (VGI) [5], the bottom-up approach to effective community Healthfields design can be optimized at the user level of the facilities by residents and individuals who ultimately determine the usability of the application as well as the use of a selected site.

The concept of collaborative systems brings in stakeholders from various organizations, affiliations and levels at various geographic locations to work together in order to implement, apply and develop

policies. Through this technology, collaborative processes such as PPGIS and VGI can help include a more diverse array of participation levels throughout the socio-environmental landscape. With the inclusion of all stakeholders, a level of accountability is achieved in the policy application process through web-based technology, which increases the level of consideration, collaboration and trust with marginalized groups. Furthermore, the participation of a broad range of community members is needed in order to understand the implications of certain investment decisions with particular brownfields sites.

Through a mixed methods approach, qualitative data was collected through focus groups in order to analyze the effectiveness of the design of the application in meeting the EPA program and the Redhorse Corporation requirements. Quantitative data is collected through survey design with the focus group members in order to assess the usability and effectiveness of the web application for the purposes of the nonprofit CBOs.

2. Related Work

2.1. Public Participation GIS (PPGIS)

Recent literature has addressed the concept of Public Participation Geographic Information Systems (PPGIS) or Participatory GIS (PPGIS). Influenced initially by the field of urban planning, PPGIS is seen as a method that involves community based organizations as well as grassroots groups [5]. PPGIS includes mapping data about individuals at the demographic and community levels to visualize community needs and successes, also addressing transportation and social services. However, there were known challenges for PPGIS in discussing design and system usability with the involvement of diverse user populations [7]. Though traditionally considered a top-down process to understand neighborhoods and to improve public management and social services, these processes have been addressed and have been open to critique [6]. PPGIS was known to be the method for non-expert GIS involvement, distinct for “empowering” GIS users of diverse backgrounds for purposeful use of the technology in the inclusion of local knowledge [8]. The main goal in developing PPGIS was to design applications in order to empower underprivileged and marginalized populations [3], or at least to increase involvement of affected populations, to understand their observations, experiences, and needs [11]. Nonetheless, the concern with PPGIS was that it did not accomplish enough to represent marginalized peoples.

In theory, PPGIS included the citizen in the process of mapping, but the definitions of “public”, the concept of “participation” remained unclear and inconsistent, and the intended goals for PPGIS remained questionable, or at least represented a “multitude of possible realizations” [10,4]. Additionally there was no clear differentiation on who the “public” is defined to be, and the details on their level of participation were not measured. Based on these concerns, there was still a need for the concepts of PPGIS not only to be clarified, but also to be improved [11], as well as for new approaches to continue to be advanced in the process. PPGIS should not only be effective in including community voices and perspectives such as the policy makers, those with additional knowledge, and those affected by the policy [4], but it should also improve GIS for health and policy equity for diverse populations. Through the development of a framework combining PPGIS with VGI, the goal is to increase the role and participation of groups who generally have less access to information or decision making abilities.

In 1998, some of the preliminary discussions on PPGIS took place at the National Centre for Geographic Information and Analysis (NCGIA) and three main principles of PPGIS emerged [12]:

- [1] As a web based concept, PPGIS should be able to provide data and information access to all participants in the community
- [2] PPGIS should be able to empower community members through providing relevant and necessary data and information to meet the needs of community members
- [3] High levels of trust and transparency must be involved as well as maintained with the public to incorporate validity, relevance, effectiveness, applicability and accountability.

Similarly, work which continued along the lines of PPGIS in the United Kingdom included features such as providing a large scale regional model for the public to share open ended ideas and comments, where the process was led by the community, and meetings took place at a time when members were available to participate, and where relevant information across stakeholders was shared [12].

2.2. Volunteered Geographic Information (VGI)

In an extension from PPGIS, the framework of volunteered geographic information (VGI) has been established. As a recent example, Lei and Hilton presented a participatory framework of VGI in the work of environmental impact assessment (EIA) [5]. In the authors’ development of a spatially intelligent participative system (SIPPS), public users and decision

makers both participate in online interactions to develop several components of the SIPPS, which also includes database storage of the data. Through citizen participation in VGI, individuals are able to collect as well as share data, creating new forms of information [13].

Though VGI has many benefits in terms of community participation and bringing individual and underrepresented voices into spatial processes, because it is very much a public process, there will be concerns of quality, reliability, value and credibility [14]. Despite these challenges, there is potential for VGI to provide spatial solutions in a clearly bottom-up approach to data incorporating citizen engagement, and can also help improve the development of descriptive/qualitative rules for determining geographic features of improved data classification [15]. Additionally, in connection to developments in PPGIS and VGI, the concepts of the effectiveness of participation models are addressed, with particular emphasis on mapping, community planning and collaboration [6]. Effectiveness in web applications has also been addressed with regards to their usefulness by organizations as well as community members.

3. Concept of Operations

3.1. Spatial Analysis and Volunteered Participative (SAVP) Concept of Operations

The concept of operations model was adapted from the Lei and Hilton 2013 conceptual framework for the Spatially Intelligent Public Participative System (SIPPS) [5]. In our model, the process involved the EPA and Redhorse Corporation, who are directing the B2H program, and have requested that Claremont Graduate University (CGU) participate in the development of spatial solutions in the form of a data portal and web applications of the brownfields cleanup sites. This application connects to the Internet, which was utilized for communication and interaction. Next, three components were used for the B2H Concept of Operations. These include the Spatial, Comment, and Analysis Components connecting to the spatial data portal. The Spatial Component includes the use of spatial data to develop web applications and story maps. The Comment Component is an important part of this process, where our research data collection takes place through focus group and survey responses to improve the effectiveness and the usability of the web application. Comments from stakeholders are also crucial in the reiterative design of the web application and contents of the data portal. The Analysis

Component involves the use of the spatial data to provide analyses and charts for stakeholder use (government, corporate, academic, and nonprofit CBOs).

4. Problem Statement

For the purposes of brownfields cleanup site mapping, the data was not consolidated to provide a broader picture of demographics and community resources as well as population needs. The program managers of B2H required data from a variety of sources to be made available in a data portal.

Next, stakeholders needed a web application to be developed in order to share the cleaned-up brownfield sites locations with the nonprofit CBOs in Los Angeles County [16]. Combining spatial data layers into one web application, the goal was to meet the needs of many organizations, and the application was presented to over 20 CBOs. Their feedback was gathered and collected in a focus group format. Currently, the Community Based Organizations are the emphasis of the project in the spatial analysis and selection of the most appropriate sites for health-related projects being considered. Map layers and data sources in the portal included the following:

- *EPA Brownfields Cleanups in My Community*
- *CalEnviroScreen 2.0 to identify communities disproportionately burdened by 90-100% from multiple pollution sources*
- *Environmental Justice (EJ) Screen – to show where greater than 50% of the population is linguistically isolated as well as where greater than 50% of the population is minority.*
- *Areas Underserved by Community Health Services – census tracts where more than 10,000 people are underserved by community clinics*
- *Public Parks - ½ mile buffer*
- *Bike Paths and Lanes*
- *Low Income and Low Food Access – at ½ mile - 10 mile buffer*

The NCGIA principles of PPGIS were utilized in this process of web application development to include all community participants. This included ways to empower community members with relevant and necessary information to meet their needs, and incorporated the goals of high trust and transparency with the public for effectiveness of both the participation process as well as the technological product of the web application.

The Three-Phase Model of GIS Planning and Feedback involves individual user and resident-level feedback into the GIS process, where members of the community would have the opportunity to participate

and contribute, bringing in additional features which may or may not have previously been considered. For example, several factors can influence whether a community park will or will not be used, based upon

the types of features it includes, in addition to features such as park access, distribution, maintenance and safety conditions [17, 18, 19].

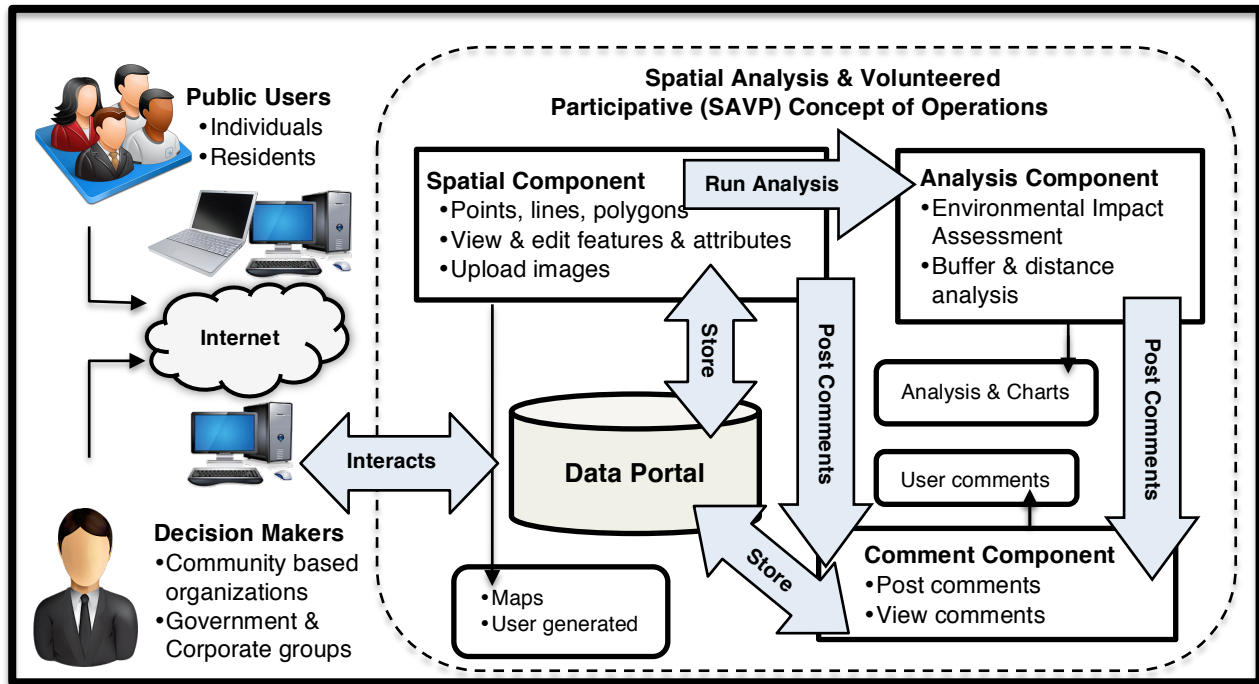


Figure 1. SAVP Concept of Operations (Adapted from Lei & Hilton’s 2013 SIPPS Model [5])

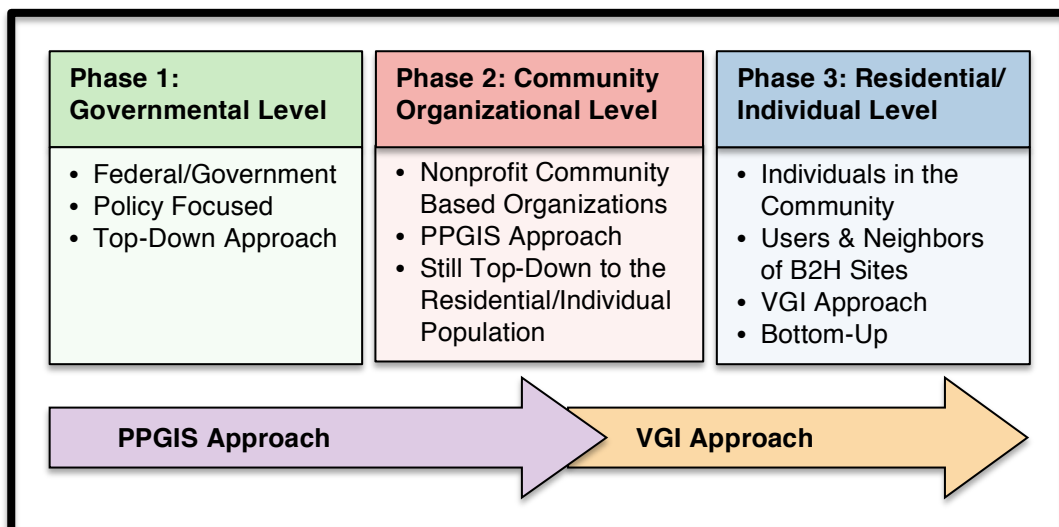


Figure 2. Three-Phase Models of GIS Planning and Feedback for the Brownfields to Healthfields (B2H) Program

The three phases of public participation in the process of B2H site selection can help to understand the less obvious reasons for why a community facility remains unused even when the site is well maintained and appears to be adequate. This theoretical approach was developed to bring an additional dimension into the project following with the theme of VGI. Currently, the B2H program exists at the second phase, and this research defines a model for a third phase of the B2H, in which the individual resident/underrepresented member is part of the community health fields planning process in a bottom-up GIS decision making approach. Additionally, this brings in the continuum of integration of the three-phase B2H model, beginning with PPGIS and integrating VGI, with the continued focus on community participation and engagement, rather than strictly a technological/user centered design focus [8].

5. Solution

The solution for nonprofit CBO participation was developed in the form of a spatial portal to store data layers, as well as to encourage the utilization of a web application accessible to all potential stakeholders. The web application was demonstrated to over 20 nonprofit CBOs in the Los Angeles County area. The organizations were given access to a web link and were able to utilize the application to determine factors such as site suitability of a cleaned brownfields site in their region. The initial focus group took place in order to collect feedback from the organizations for both Redhorse Corporation as well as Claremont Graduate University to be able to iterate the design of the application to meet the needs of the organizations. Upon completion of the next phase of the web application and spatial data collection in the portal, a second focus group will take place to determine the effectiveness of the web application.

The Brownfields to Healthfields web mapping application contains a mapping interface along with a side bar that shows a legend, the various layers on the map, the choice of different basemaps and the ability to print out the selected map, as shown on 3. The application provides the user with a site selection tool that can be customized according to the user's preference. Figure 4 shows the buffer feature that can be applied on a specific point, line or area drawn on the map.

6. Analysis

A mixed methods approach was utilized in this project. Qualitative methods in the form of focus groups were used at the first and second iteration of developing the web application. Approximately 20 nonprofit CBOs were involved in the feedback gathered to determine the effectiveness of the application in communicating necessary information to purchase potential cleared brownfields properties. The responses from the initial focus group were grouped as follows:

Table 1. Initial Focus Group Responses

Positive Feedback	-Accessibility -Ability to print out customized maps based on needs of each organization
Negative Feedback	-Wanted to see more customization -Wanted an easier process to access and utilize maps -Difficult to customize pages for every stakeholder or to customize layers
Future Requests	-Requested to see the web portal to include data for other counties and states -Requested to make a single web application at the national level

The feedback from the focus group provided a variety of comments for improvement as well as ideas on how the web application could be of relevance and use to the particular CBOs. The following types of feedback were received:

Positive Feedback: Focus group attendees generally appreciated the existence of the web application for the B2H program. Additionally, the opportunity to select layer elements and to customize the map by relevant layers as well as by geographic region was of benefit. It was apparent to attendees that the goal of the web application was to provide geographic information for their purposes.

Negative Feedback: Focus group attendees were interested in seeing more options for customization of the web application and also requested an easier process for map access and utilization.

Future Requests: Attendees requested for the web portal to include more data on other counties and states beyond Los Angeles County. Additionally, there was a request to see a national-level web application made available

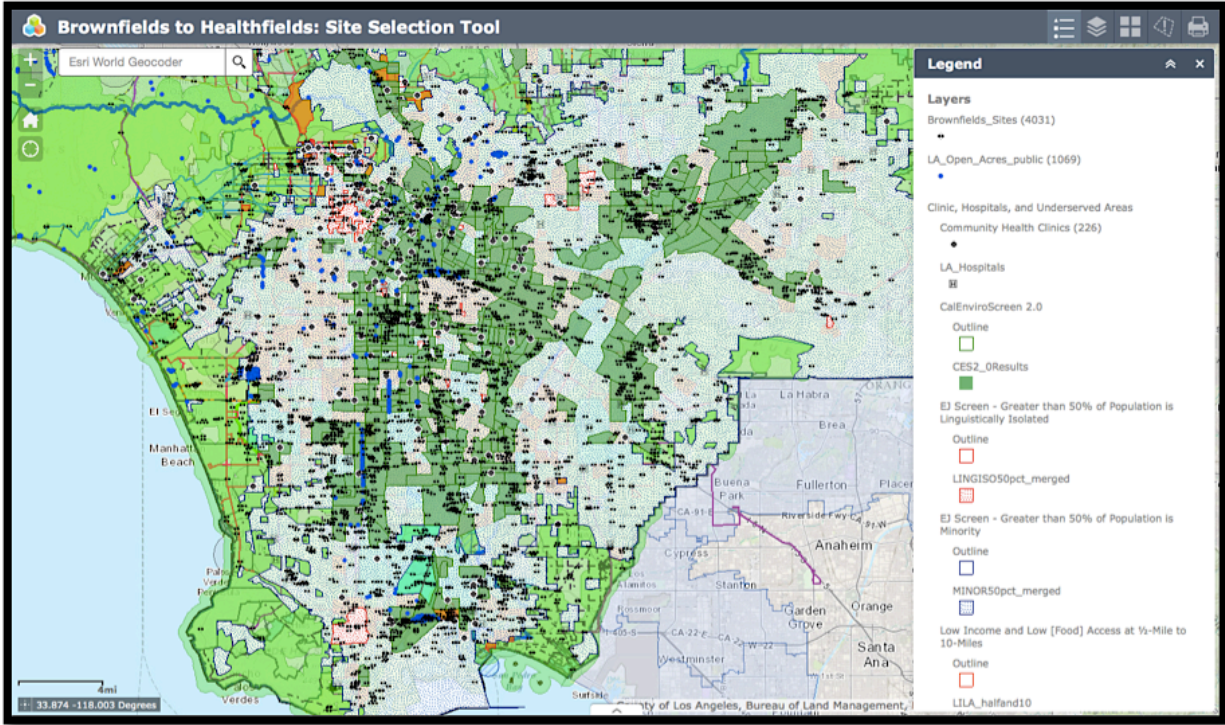


Figure 3. B2H Web Mapping Application

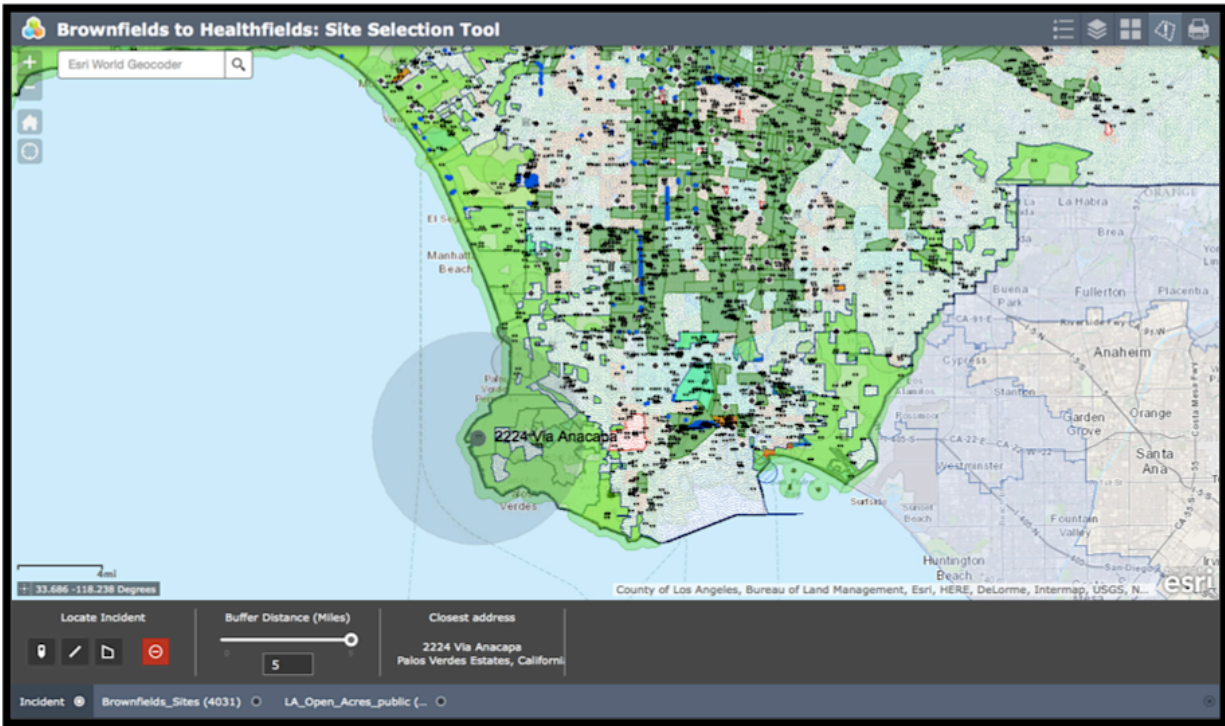


Figure 4. B2H Site Selection Tool as a Feature on the Web Mapping Application

Focus group attendees were primarily representatives from Phases 1 and 2 (business/organization employees and community based organization representatives). Their feedback on the web application (Table 1) was grouped into four indicators: (Accessibility of the Web Application, Customization of the Use of the Web Application, Complexity of Use, and Expansion of Use.)

Three surveys were included to assess usability of the web application from the three levels of user classification. Categories for the contents of the survey questions were based on the National Institute for Standards and Technology (NIST) design guidelines for Common Industry Specification for User Requirements (CISU-R) usability Level 1 measures, with a focus on the context of use (Table 2) [20,21]. Next, questions were designed in order to be of relevance to the particular groups being involved in the survey, which are referred to as Phases 1, 2 and 3 in Table 3. Furthermore, continuation of the survey design included indicators from the emerging topic of discussion of the initial qualitative research [22], in this case, the focus group (Table 1).

Table 2. Usability Categories & Questions (adapted from Ferguson et al. 2016 [21])

Category	Question
Stakeholders	-Are stakeholders able to participate? -Are stakeholders involved in the spatial, comment, and analysis processes?
Intended Users	-Are the intended users involved in the process? -Do the intended users have the capabilities to utilize the application?
Community Impact	- How does the organization involve community members in the process?
Technical Environment	-Is the application designed for use at all technical levels? -Does the organization have the technical capability to utilize the application?
Physical and Social Environments	-Is the application accessible for varying capabilities and varying language skills? -Does the social environment encourage diverse users of the application?

6.1. Public Responses

The above questions were incorporated into a survey instrument to be distributed to all three levels of participants in the B2H web application project. This ensures that a range of responses will be received and that a variety of perspectives will be addressed. This will also include policy makers, those with additional community/ environmental knowledge, and those affected by the policies such as underrepresented or marginalized communities. This approach of combining PPGIS with VGI methods increases the range of public participation at more levels, and contributes to the clarification of who the “public” is and what “participation” includes in this cross-organizational collaborative systems decision making process.

7. Conclusions

By addressing the effectiveness and usability of the web application and spatial data contents relevant to CBOs who would be interested in purchasing cleaned-up brownfield sites for community planning and health promotion purposes, CGU was able to serve as a bridge between the federal and corporate sectors (EPA and Redhorse Corporation) to develop an application that meets the needs at this level. The SAVP Concept of Operations for web application and spatial data portal is currently similar to the methodology of PPGIS, traditionally top-down in nature. B2H currently works with the federal, corporate, academic, and CBO levels to produce web applications and collect spatial data.

The SAVP Concept of Operations combined with the Three-Phase Model of GIS Planning and Feedback, is beneficial in that through working with CBOs, it serves the role of some of the intended purposes of PPGIS. These benefits include communicating the uses of existing policy with community groups while accepting comments and feedback from communities. Nonetheless, in order for PPGIS to be more effective, the technology needs to be available and easy to use by communities and individuals through processes such as human computer interaction (HCI). [8]

Table 3. Three Phases of Survey Questions to Address Usability Context Measures

Category	Questions for Phase 1 Survey Policy/Decision Makers	Questions for Phase 2 Survey Groups with Additional Community/Socio-Environmental Knowledge	Questions for Phase 3 Survey Groups Affected by Policy/Underrepresented Groups
Stakeholders	<ul style="list-style-type: none"> - What is your role in the planning of this process? The web application tool? - What is your position at your company/organization? - To what extent have you been able to participate in the spatial, comment and analysis processes? 	<ul style="list-style-type: none"> - What is your community role? - How interested are you in the B2H web application? - To what extent is the web application relevant in your opinion? 	<ul style="list-style-type: none"> - Do you live in a community impacted by the B2H program? - To what extent do you feel enabled to participate in the process of planning, designing, and data needs for the web portal? - To what extent does this web application feel that it is of relevance and importance to you?
Intended Users	<ul style="list-style-type: none"> - Are your organization's/company's intended users involved in the web application design process? 	<ul style="list-style-type: none"> - Are there any other organizations that should know about the web application? - Are there any additional map layers, which should be incorporated? - Are there any additional map layers you may have be able to help bring to the web application? - Do you see any challenges to the effectiveness of the web application? 	<ul style="list-style-type: none"> - Do you believe that the web application tool is of benefit to you? - Do you believe that it is user-friendly? - Are there individuals who would not be able to use this tool? Who? - What needs to be improved to include more users? - Do you feel that your comments and opinions are welcome and heard by policymakers and community organizations?
Community Impact	<ul style="list-style-type: none"> - To what extent do you envision the community to benefit from the web application tool? 	<ul style="list-style-type: none"> - To what extent is your knowledge the community interest in contributing to improve the web application? 	<ul style="list-style-type: none"> - Have you been able to participate in the planning, design, or the use of the web application? - Do you have concerns with the B2H web application for your community? What are these concerns?
Technical Environment	<ul style="list-style-type: none"> - Does your organization/company have the technical capacity to utilize the web application? - Has your organization/company developed a process to continue participation with the development of the web application? 	<ul style="list-style-type: none"> - Do the organizations in your community have technical background to utilize the web application? - Is it useful for varying technical levels? If not, what should be improved? 	<ul style="list-style-type: none"> - Do you feel that all technical levels in the community can use the web application? - What should be removed, added, changed or improved to help people use the web application?
Physical & Social Environments	<ul style="list-style-type: none"> - Is the web application accessible to your organization's/company's staff, regardless of ability, language, etc.? 	<ul style="list-style-type: none"> - Does the B2H web application planning process welcome diverse community members? If not, who is missing from the discussion? 	<ul style="list-style-type: none"> - Do you feel that there are language, culture, ability, or educational needs that need to be addressed in the B2H planning process? - Are planning meetings scheduled at reasonable times for members of the community? - Are people missing from being invited in this process? Who?

In the Three-Phase Model presented, community and individual-level participation takes place in Phase Three. This is where concepts of VGI are particularly relevant. Through VGI, project participation and feedback are expanded to the citizen level, where individuals in the community would be able to provide comments and feedback on the mapping process, while sharing additional collections of spatial data with the data portal. Ultimately, the goal in this process is for all stakeholders to be included and satisfied with the development and the performance of the web application. By involving all levels of stakeholder participation, the additional goal is to improve the quality of the collaborative process. This is achieved by improving the quality of the web application, in order to increase trust in policymakers, and to encourage commitment from stakeholders of all levels. Based upon the design of the model, future testing involves the ability to make changes addressing the comments provided by stakeholders as well as the alignment of these comments and requests with the initial requirements of what the EPA and Redhorse Corporation envisioned in mapping the Brownfields to Healthfields program.

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