Spatial Knowledge Interchange Environment: leveraging Web 2.0 technologies to breach the knowledge divide in agricultural development

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ABSTRACT

Agricultural output has been declining in the Caribbean although several strategies are being implemented to enhance development. The dichotomy between modern external experts (MEE) and locally grounded experts (LGE) generates a fracture that limits agricultural development and hinders good governance. There is a need for a change in the language and interface for decision making in local rural villages amongst stakeholders. This paper discusses the use of modern web technology in support of collaborative exercises that bring agricultural practitioners and their traditional knowledge closer to more remote, modern external experts.

A more people friendly spatial language application will be explored, harnessing volunteered geographic information (VGI) and participatory decision making on an ESRI ArcGIS platform, while leveraging Web 2.0 technologies that will support knowledge building for agricultural development. Participation represents a new developmental paradigm that fosters empowerment and is needed at the domestic level to propagate a strong sense of democracy in the decision-making process enabling the micro actor, cultivating greater involvement, accountability and thus more sustainable solutions. The effective management of agricultural land and its resources require spatial data that is current, reliable and easily accessible. By extension, this will require systematized informal data and simplified formal data to incorporate and network a functional participatory program for agricultural development.

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Categories and Subject Descriptors

C.O [**Computer Systems Organization**]: General;
D.2.1 [**Requirements/Specifications**] Elicitation methods

General Terms

Theory

Keywords

Web 2.0, agricultural development, participatory

1. INTRODUCTION

The environment in which decisions are made and knowledge is created, discovered, shared and applied is vital to establishing this papers main aim of creating a spatial knowledge interchange environment that encourages interaction amongst multi-knowledge stakeholders in agricultural development (Collins and Parcell 2007). Web 2.0 technologies will be utilised to enhance the spatial knowledge interchange environment that facilitates both modern external experts (MEE) and locally grounded experts (LGE). The full integration of innovation and knowledge across all knowledge bases, instead of the traditional exclusive integration, will offer greater freedom to innovate and imagine new systems of knowledge. If development is to continue, societies have to embrace authority across the board to include the poor, working class and locally grounded experts (LGE) (Johnson 2011).

The paper will refer to the scientists, government technical staff and researchers as modern external experts (MEEs) and the local farmers and the community working class as locally grounded experts (LGEs). Little research has been done on developing a methodology that strives for their integration and mutual interdependence (Davis 2006 and Ocholla 2007). This is partially due to methodological issues such as uneven emphasis on different knowledge systems, inappropriate work processes, poor validation and hand over (Erickson and Woodley 2005). In an attempt to combine both knowledge systems in theory as well as practice this research has embarked on a program to democratise the agricultural development process in Trinidad and Tobago through spatially enabling citizens.

In recent years, the popularity of spatially enabled applications (such as ArcGIS and Google Earth) and accessible positioning technology (GPS) have combined to enable users from many differing and diverse backgrounds to share geographically referenced information. Geographic Information Systems (GIS) has continued to play an expanded role in the way we analyse spatial data, manage our resources, view, and understand spatial phenomena. The empowerment of underprivileged groups has emerged as a popular field of GIS research and applications such as Participatory GIS (PGIS). This practice is the result of a spontaneous merger of participatory learning and action methods with geographic information technologies (Rambaldi et al 2005). Web 2.0 standards and VGI have also emerged gradually from efforts in areas such as Participatory GIS, where opinions and perspectives are canvassed through GIS portals either online or within constrained environments (McDougall 2012).

Technologizing of deliberative democracy through participatory practices, mobile technologies and internet protocols currently offer a more effective path towards individual and community empowerment. In essence, an analytical as opposed to largely visual process that actively seeks citizen involvement (Haklay 2007). Participatory GIS (PGIS) uses modern spatial information technologies and community centered initiatives that offer the possibility of complementing spatial data sets with local knowledge. We also have to beer in mind the additional policy and ethical issues that are involved in establishing this collaborative space and integrating volunteered and authoritative data.

Web 2.0 standards have transformed the web into a more dynamic technology space which rapidly evolves to meet the changing user demands. We therefore see a large growth in web based applications driven by the ubiquity of web 2.0 devices, increased service demands and the underlying platform which facilitates easy deployment (Sharma 2008). The use of a Web 2.0 website will allow users to interact and collaborate with each other in a social media environment. They will serve as both creators and consumers of the content in a virtual community that share a common goal. It is important to establish a democratic paradigm that is inclusive, and also allows two-way communication of spatial information as opposed to traditional web platforms that may be limited to passive viewing of content that was created for users by power holders (MEE). In essence, an environment that facilitates a role change for the actors involved, interacting as both consumers and producers of knowledge (Rutherford 2010).

In addition to the advantages mentioned, the trend towards the mobile web through the use of tablets and smartphones enhances our argument. The growth in mobile and smart device usage is nothing short of phenomenal. While the number of subscribers for data service has also risen tremendously, the price of handsets continues to lower as newer and more powerful devices are rolled out almost daily. Studies show that more and more people are accessing the internet by mobile or handheld device. The Caribbean is not very far behind in terms of mobile penetration. A report by C News (2011) asserts that "…according to recent data, Trinidad and Tobago has the highest penetration of mobile phones of any country in the world." With 1,846,345 mobile subscribers in 2009 in a population of 1.3 million people (TATT 2010). These developments underscore the importance of multiple platform integration and the advantage that web 2.0 offers to integrating our multi-knowledge data sources.

2. CASE STUDY OVERVIEW

Former Caroni (1975) Ltd workers were assigned agricultural and residential lots in 2003, by the Government as part of their Voluntary Separation of Employment Package (VSEP). These workers were given priority access to two (2) acres of agricultural lands for food crop farming and a residential lot. Of the 76,608 acres of available lands, 27% (20,319 acres) was allocated for sub-division into the two acre lots. Estimated at approximately 7000 farmers, Caroni workers will be recipients of these two-acre plots, although the precise number of beneficiaries remains to be finalized. The allocated property is highly segmented and a digital single map of the territories is not yet available. The information was provided by the Strategic Environmental Assessment Consultants (SEA) (2009) and is incomplete as the VSEP Program is still a work in progress. As a result, it is only appropriate to assume that efforts will continue to move along the current trajectory. Plans and strategies are subject to change, and therefore the SEA's assessment was based on the best available information as of May 2009.

The Government fully recognises that over the years the small farmer and family farms have been the backbone of the agricultural sector in Trinidad and Tobago and has therefore implemented programmes throughout the years to ensure growth of this sub-sector. Although the VSEP Programme has recommendable intentions, the agricultural infrastructure provided to farmers on the agricultural plots leave a lot to be desired. The result has been un-cultivated plots, costly re-development schemes for the farmers and a reduction in agricultural output. There is a need for collaborative soil remediation, assisted extension services, cost-effective redevelopment of present infrastructure. The overall proposed outcome will entail a multi-stakeholder capacity building effort for low impact and high yield sustainable agriculture (Matthews and Ennis 2009).

Structured interviews began in September 2012 and are to be completed in December 2012, with a random selection of approximately 5% of the 7000 Caroni small-scale food crop farmers. The interviews (conducted before and after intervention) provided information for the initial stages of the spatial knowledge interchange program on farmer needs, problem identification and Web 2.0 and PGIS feasibility study. All farmer interviews were also evaluated using a common 5-level rating scale to measure the Agricultural Knowledge Gap Index (AKGI) and Agricultural Decision-Making Gap Index (ADGI). The indices will be used to construct a single score to validate the objectives of the research. Statistical analysis of the results will be done using a repeated-measures test (before and after the intervention) to prove/disprove the hypothesis.

Agricultural Knowledge Gap Index (AKGI)

$$\frac{\sum \text{(Credit x Competence Points)}}{\text{Total Credits}} = \frac{\text{Total Score}}{\text{Total Credits}} = \mathbf{AKGI}$$

Agricultural Decision-Making Gap Index (ADGI)

$$\frac{\sum \text{(Credit x Competence Points)}}{\text{Total Credits}} = \frac{\text{Total Score}}{\text{Total Credits}} = \mathbf{ADGI}$$

Based on preliminary interviews with some of the Caroni farmers (2 acres) the problems they experience with the land stem from the wholesale infrastructure development on the lots, constructed by the Government. The major problems identified include the 60m x 60m irrigation ponds placed at random locations on each 2 acre plot. The ponds were also constructed with an additional embankment of approximately 5 m. Farmers with larger estates (40 acres and above) have not expressed any concern over these ponds as they have sufficient land and these farmers usually have enough capital to substantiate the unsuitable infrastructure with private irrigation and drainage facilities. Whereas, 2 acre small-scale farmers view the ponds as occupying viable land and do not have additional irrigation facilities to overcome the inadequate infrastructure provided.

A second problem identified was the stockpiling of soil (from dredging of the drains) unto the farm plots which also makes that portion of the land unusable due to compaction and waterlogging, this by extension makes it difficult for tractors to pass or any other affordable solution. Finally the drains are built alongside the perimeter of the plot in almost perfect squares which do not cater for the variations in soil type and slope of the land, thus additional drains have to be built to cater for this problem. These issues amongst other socio-economic problems have led to several lots being un-cultivated; farmers are subject to additional cost to rehabilitate the land and a general reduction in agricultural output. This research is an on-going process and the results discussed are from preliminary interviews and field visits.

2.1 Intervention

Problems identified need a platform that will provide a spatial knowledge interchange environment for collaborative spatial analysis and democratic discussions necessary for proposed precision type infrastructure development.

2.1.1 Infrastructure Rehabilitation and Maintenance PGIS Program

1. Transect walks to garner LGE VGI based on their intimate traditional knowledge of the land and spatially corroborated GIS information for precision drainage.
2. LGE information on ways to identify soil health based on existing vegetation in the absence of extensive soil testing.
3. Collaborative discussions amongst stakeholders to provide alternate location for stockpile of dredged soil.
4. Community mapping sessions for alternate cost-effective irrigation techniques – site-selection and cost-analysis of proposed pond re-location or nearest water source (river, well).

2.1.2 Web 2.0 based MEE and LGE collaboration

1. Geo-tagged farmer request for land assessment that will assist in fast tracking pre-approval for much needed government incentives and Agriculture Development Bank (ADB) loans.
2. Commodity production history and review in both tabular and map view.
3. Access to GIS base-map data and georeferenced LGE uploads for combined analysis.
4. Geo-tagged incidence of praedial larceny to assist with locating hot spots and trends of incidents.
5. GIS direct information for drainage network optimization and irrigation planning.

3. WEB 2.0 FOR SUB-FIELD VARIATION AGRICULTURAL MANAGEMENT

The Caroni landscape comprises of the typical rural mix of flat and hilly land, with a variety of land uses and drainage lines ranging from small short-lived creeks to large rivers. The range of soil type and slope that exists requires a more precise type variation management. Farmers have known this for as long as they have been growing crops, but without methods for observing or reacting to this variation, small-scale farmers who rely on government provisions and incentives have been forced to utilise wholesale infrastructure and tools provided as though the plots were uniform.

Variation management requires spatial data on slope, crop performance, water sources amongst other georeferenced records of traditional knowledge on individual production. The Web 2.0 platform provides access to a central store of multi-source data that will be collected through community mapping sessions and transect walks. Spatially corroborated data is essential at this point due to financial constraints that do not allow access automated technologies typical of precision agriculture (CSRIO 2006).

4. PGIS WEB 2.0 DEVELOPMENT METHODOLOGY

To establish an effective PGIS Web 2.0 development process, a few critical issues need to be addressed. The researcher has generated a Rapid Application Development (RAD) methodology for implementing the PGIS Web 2.0 application. Figure 1 shows the process while the steps are explained in detail below. RAD methodology proved to be more suitable as the research is still in its preliminary stages and involves methods like iterative development and software prototyping.

4.1 Analysis and Planning

This involves a comprehensive assessment of all users and their environment including habits and socioeconomic status. It is important not to make any assumptions about the users or undermine their specific needs. The analysis should unveil fundamental issues that will impact the design. It will also answer many questions relating to the trade-offs that will be made later in the development process. During this process, consultation with the users is essential and is effected through interviews and community mapping sessions where ideas and experiences are shared. Awareness is also very important since we need to have the users as active participants in the development process. The planning stage incorporates the result of the analysis, interviews, discussions and surveys to put together the right resources, strategies and contingencies for the RAD process. During this stage the design methods are formulated taking all the objectives into consideration. The human resource, technical requirements, interface, usability studies and integration mechanisms are considered. In addition the timeline, budget, implementation and deployment strategies are formalized.

4.2 Design

This is a critical part of the RAD process and includes the following:

4.2.1 Hardware and Software integration (install/configure/set-up) – This includes servers, storage and interface devices, base map services, GPS integration, geoprocessing, plugins and social networking add-ons. Other hardware requirements for integrating the system include GPS handheld units, mobile devices and laptops.

4.2.2 Map design – Design data in base map layers to be used as background layers and operational layers which change with user interaction providing task based functions and decision making capabilities. The base map layers typically do not change frequently and can therefore be cached while the operational layers can be served dynamically thus optimizing the use of the ArcGIS server. With an ArcGIS subscription it is also possible to rapidly create custom maps or even use existing maps. This could significantly reduce both the design and development times.

4.2.3 Web Application Design – The website design uses a standard web 2.0 framework (HTML, JavaScript, PHP/ASP.NET, CSS, FLASH) incorporating a variety of rich internet applications (RIA).

These RAD tools provide the interactivity, functionality and speed to standard computer software enabling the implementation of a highly functional, user friendly and scalable application in very short time. In addition, the features can be scaled with plugins or add-ons for spatial data handling tools such as, import, export, cataloguing and visualization. The design is therefore a balance between functionality and usability, with the usability taking a slightly greater focus due to the ease of implementing the functionality.

4.3 Development

Web 2.0 services such as integrated SMS, micro-blogging and instant messaging (IM) make it possible for quick and seamless communication between participants. Additionally applications can communicate remotely regardless of the platform the stakeholder uses. Using AJAX and other modern scripting to develop applications, widen the scope of services that are possible. The design will therefore integrate seamlessly with ArcGIS server providing platform independence and cross browser compatibility, ArcGIS Viewer for Flex also provides a rich user experience and its availability on multiple.

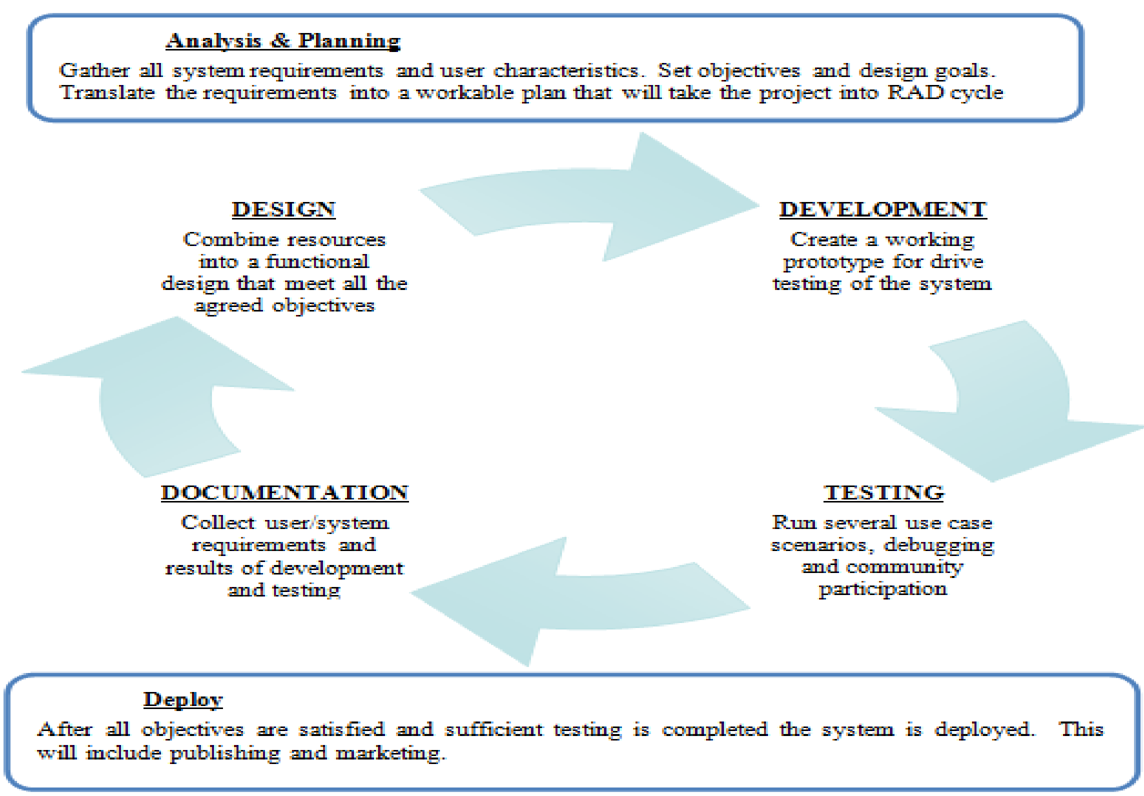

Figure 1: PGIS Web Application Development Methodology

5. TECHNICAL CASE AND CUSTOMISED INTERFACE

As shown in the Figure 2, the PGIS Web 2.0 site will entail a combination of:

5.1 Front end user interface that runs on top of ESRI ArcGIS. This is primarily to input data and view various reports, tables and map layers. Viewing spatial data collected by a collaborative mapping exercise between MEEs and LGEs through ArcGIS published service. Also an Application Programmable Interface (API) for the administrator to add or manipulate functionality.

5.2 Harnessing the capabilities of Web 2.0 dynamic interface VGI will be added post-deployment through the location based forum that allows users to geotag a location of the area to be discussed in an online forum or community mapping session.

5.3 Live chat utility using VoIP application integration to facilitate real-time commenting and interaction. This anonymous contribution also helps to erode the differentiation between MEE and LGE, because it hides from the reader any information about who is contributing, what their authority is and why we should listen to them (Haklay 2007).

5.4 Social networking and bookmarking integration for a broader coverage.

5.5 A library of terms that were previously documented through the community mapping exercise. This interactive folksonomy of spatial and non-spatial data definition will also be accessible from the AgriData 2.0 website. Also functioning in the backend will be a translator application that will access the library of terms built in with both colloquial and scientific terminology with additional user generated terms, definitions and verification.

The RAD framework is built on a philosophy of participation that encourages users to add value to the application as they use it (O'Reilly 2005). The concept of web-as-participation-platform or PGIS Web 2.0 has to have some level of security to avoid unscrupulous users, incidence of spamming and trolling (Decrem 2006). Therefore the website will be password sensitive for all stakeholders within the project.

6. CONCLUSION

The underlying idea is to abolish the dichotomy that was established in the colonial era in Trinidad and Tobago. This has increasingly infringed on local policies and programs. Knowledge is a single concept that refers to familiarity with something acquired through experience and/or education. The mitigation of the divide between LGE's and MEE's is necessary if we wish to have competent citizens in this emerging knowledge society (Bonmati 2004).

Establishing a democratic platform using Web 2.0 standads and technologies, adopting participatory practices and manipulating ESRI ArcGIS software, provides the ideal environment for knowledge interchange. This allows users to not only be spatially enabled but incorporates recommended two-communication efforts by utilising user-generated content through internet protocol.

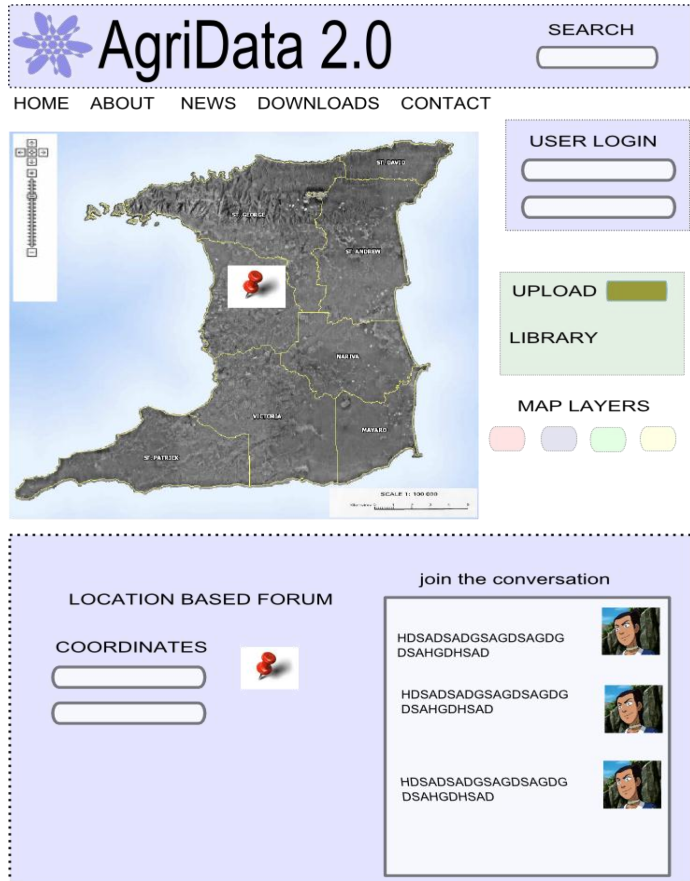

Figure 2: AgriData 2.0 Conceptual Design

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