GIS for post-war reconstruction: take two

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1. Introduction

At GISRUK 2002 in Sheffield, Barakat, Car and Halls (2008) presented a research agenda for the application and development of GIS in conflict resolution, peace building and post-war reconstruction. Twelve years have passed but only now has it become possible to undertake the research to make the dreams discussed in 2002 a reality. This paper looks at the GIS aspects of Barakat et al (2008) and seeks to bring these up to date, taking account of the relatively recent developments in crowdsourcing, GIS in the Cloud and within the United Nations organisations.

PRDU have been active in research and consultancy in post-war reconstruction for twenty years and have worked in almost every conflict and post-conflict situation in that time. Much of the thinking in Barakat et al (2008) derived from experiences in the Balkan conflicts, in particular in Bosnia-Hercegovina and in Croatia. However, work in Acheh, Afghanistan, the Lebanon, Palestine and Timor Leste also contributed. The separatist conflict in Aceh, Indonesia, resulted in weakend civil society ill prepared for the tsunami disaster in 2004 (Phelps, Bunnell, Miller 2011). Post-war reconstruction is of necessity multi-disciplinary: not only is there a requirement for physical reconstruction, of services, infrastructure and buildings, but also reconstruction of civil society, governance and a sustainable economy. Phelps et al are very much concerned with this less visible but essential economic component.

2. The Vision

Barakat et al (2008) proposed a web-based GIS application, combining Public Participation GIS, Public Participatory Spatial Decision Support Systems, Natural Language Processing / Ontologies and spatial modelling, to provide a planning tool that would enable agencies in the field and members of the diaspora to contribute in an integrated manner. Typically, post-war recovery situations involve people displaced from their homes, often their countries, along with relict governments of varying scales of effectiveness and multinational humanitarian agencies. The personnel involved, inevitably, includes representatives of all the professions and the general public, raising significant difficulties in understanding the technical descriptions and relating concepts from the range of actors. This issue alone, where there is no mutual understanding, has the potential to destroy any efforts towards peace.

Arnstein (1969) introduced the concept of a *Ladder of Citizen* Participation, with eight rungs starting with *citizen manipulation* rising to *citizen control*. This was introduced using a somewhat cynical French student poster declining the verb *participate* in terms of (in English) "*I participate; you participate; he participates; we participate; ...* ***They profit.***" Arnstein expounded each of the rungs of the ladder in terms of degrees of citizen power, where the initial rungs of the ladder represented no citizen power, through to the top rung where citizens have control. Arnstein's

concept has since been adapted for a number of participatory examples, directly and indirectly – as in the case of Choguill, Marisa (1996) and Kingston (1998).

Table 1: Arnstein's Ladder of Citizen Participation		
Rung		
8	Citizen Control	Degrees of citizen power
7	Delegated Power	
6	Partnership	
5	Placation	Degrees of tokenism
4	Consultation	
3	Informing	
2	Therapy	Non-participation
1	Manipulation	
Source: Arnstein (1969) Figure 2. (p217)		

Barakat et al modified Kingston's (1998) *Participation Ladder* to reflect the reconstruction process more nearly (Table 2) and proposed a scale of participation (Table 3). Community participation and ownership is essential to prevent a gradual slide back into conflict.

Table 2: The Public Participation Ladder

Public participatioon in final decision	Full	Public Participation
Public participation in risk assessment and in recommending solutions		
Public participation in defining interests, actions and agenda		
Public right to object		
Informing the public		
Public right to know	Little	

Source: Adapted from Kingston, R., in Web based GIS for public participation decision making in the UK. Paper Presented at the NCGIS PPGIS Meeting, *Santa Barbara, CA.*

Table 3: The Public Participation Scale in Assisted Recovery

External support of local initiatives	Full	Public Participation
Cooperative action		
Collaborative decision-making		
Consultation of local populace by external agencies		
Information dissemination regarding external agencies' intentions	Little	

Source: Barakat et al (2008) Table 11.2 (p272)

Current methodologies in peace-building and reconstruction planning remain focused on those on

the ground, to the exclusion of any unable to be present. Barakat et al saw a potential for the use of the web as a means of including those displaced, the diaspora, in the discussions and the use of planning models to enable former combatants to contribute, where their presence at a focus group could be disruptive. This vision has not changed, however, there are now additional methodologies available which offer potential for greater effectiveness.

3. Since 2002

The United Nations established a small GIS team, based in New York, in 2000. When Barakat et al reported, this group was still in its infancy and its potential effectiveness could not be evaluated. Today, the UN GIS Group has expanded significantly and staff are stationed within the various UN organisations to work in the field within each theatre of operations. So far as can be judged, this work remains soundly map-based: generating maps reflecting changing situations on the ground – in a similar manner to the work undertaken by Map Action during the response to natural disasters. So far, at least, there is no evidence of the UN GIS Team undertaking spatial analysis using their data nor of these data being contributed into non UN-based activities, such as planning. Digital access to these data for other teams, rather than simply consuming maps supplied in PDF / image form, would be very valuable and currently ongoing work to establish an UN Spatial Data Infrastructure (SDI) may make this a reality in the relatively near future (http://www.ungiwg.org/content/united-nations-spatial-data-infrastructure-unsdi accessed 21.3.2014).

Crowdsourcing, obtain information or input into a particular task or project by enlisting the services of a number of people, either paid or unpaid, typically via the internet (OED*Online*) and Volunteered Geographic Information (VGI) a special case of the more general Web phenomenon of user-generated content (Goodchild 2007 p212; Hardy, Frew & Goodchild 2012) together provide a mechanism for people to contribute spatial information for the benefit of others. OpenStreetMap (http://www.openstreetmap.org/) is often suggested as an effective example and research by the French National Mapping Agency, IGN, has shown OpenStreetMap data to be of a similar level of accuracy as IGN products of a similar scale (Girres and Touya, 2010). However Ushahidi (Swahili for *testimony*) which originated in Kenya during the unrest following the Presidential Elections in 2007 and was employed widely during the so called *Arab Spring*, the Haiti and Fukashima earthquakes and the recent typhoon damage to the Philippines, is particularly relevant to our purpose (MIT 2010; Marsden 2013). Most recently, Ushahidi has been employed in Kiev to report the atrocities committed on unarmed protesters during the recent popular uprising against the Ukraine government of President Viktor Yanukovych (see http://www.galas.org.ua/); it has been used in Ukraine since 2012 in connection with reports of corruption and violations of land tenure legislation. It has been suggested that the assurance available to individuals, that they are not alone, given by crowdsourcing has been influential in the Ukraine context (http://www.crowdsourcing.org/article/how-internet-tools-turned-ukraines-euromaidan-protests-into-a-movement-/29618 accessed 10.3.2014). Ushahidi is sometimes termed a *crowd-mapping* application, where participants report their position and observations; other crowd-mapping applications tend to used the anonymised cell-phone position information, as described by IEE (http://spectrum.ieee.org/telecom/wireless/crowdmapping-with-cell-phones accessed 10.3.2014). These methodologies deliver much of the web-based GIS vision of Barakat et al (2008), although the level of participant interaction is fairly minimal.

Greater participant interaction, at the expense of additional complexity, is available using one of the web GIS packages or a GIS Cloud product. The web GIS packages provide an interface via a web browser in which the tools normally provided in a GIS package are exposed to the user. These have been available for a number of years and Barakat et al (2008) envisaged the use of ESRI's ArcGIS Server product. Cloud applications have become ubiquitous: here an application is delivered on demand over the web (*Software as a Service*), examples including Google Apps and Microsoft

Office 365, where the user has no need to install the product on their computer. ESRI have introduced ArcGIS *Online* to provide GIS as a service; this service offers a number of modes of operation, including interfacing to a user's local ArcGIS Server installation (ESRI undated). As piloted by Google with Google Maps, the basic user interface of these products is substantially simpler than those of the GIS packages, although ArcGIS *Online* does support the delivery of greater functionality, where required.

Considerable progress has been made in Public Participation in decision making, leading to the discussion paper by Herz & Ebrahim (2005) urging the World Bank to adopt participatory approaches into its civil society activities, in particular. Civil Society is typically one of the casualties of conflict and the World Bank has been a major funder of activities to re-establish civil society as part of peace building efforts. Herz and Ebrahim call for direct representation of those affected in the World Bank's decision making processes. Sieber (2006) includes a brief history of Participatory GIS along with a critical review of the relevant literature at that time. However, much Participatory GIS is, as described by Cinderby, Snell, & Forrester (2008), based upon paper mapping, with communities encouraged to update map material provided or to sketch maps of the phenomena concerned. Rarely, if ever, are the public encouraged to use the GIS to explore the information provided or to contribute to the analysis. For our purposes, for transparency and in respect for those involved, it is critical that the *public* be enabled to contribute throughout the processes – to be *involved* rather than *spectators* in the reconstruction of their communities.

There have been significant developments in the processes of modelling individual behaviours. Expert Systems, expertise is captured into a set of rules to define the activities of a model (eg Leszczyńska 2011), enable the assembly of the parameters necessary for the modelling envisaged by Barakat et al. The release in 2012 of *Agent Analyst*, a Repast-based extension for ArcGIS Desktop, brings a new dimension to access to spatial Agent-based modelling. Agent-based modelling is a computer modelling technique that enables a system to be modelled according to the behaviour of its individual components, where each individual component's behaviour is defined by a set of rules. Agents can be spatially and temporally mobile, such that combining with a GIS to provide the spatial context enables the generation of dynamic models (Gimblett, 2002, pp3-5). Decision making is a process in which the best possible solution to a problem is sought, typically by evaluation and modelling the various alternatives (Sugumaran, DeGroote, 2011, pp8-10). *Spatial* Decision Support, then, is the support of decision making in a spatial context – such as in planning for post-war reconstruction.

Modelling is a critical step in decision making and there have been significant developments in Public Participatory Spatial Decision Support and in multi-criteria analysis, including the introduction of Agent-based techniques, as envisaged by Barakat et al (2008). The complexity of the models involved is illustrated by Saarloos et al (2008). Crooks, Wise (2013) describe the use of GIS and agent-based systems, exploiting crowdsourced information, to model damage and the population affected by this damage in order to provide accurate information to humanitarian aid organisations. Their focus is on the effective use of the aid available and does not look forward to the repair / rehabilitation / reconstruction stage, essential for the longer term sustainability of the population. Several workers report on the impact of uncertainty within the information used for decision making (eg Kordi, Brandt 2012; Verstegen, Karssenberg,m van der Hilst, Faaij 2012). Uncertainty is a characteristic of spatial information, although many workers seem to ignore its effects. Leszczyńska (2011) describes a decision support system in which an expert system is used to validate the information provided by project participants and to infer missing information. The combination of agents controlled by the weighted approach of Kordi, Brandt, the pattern analysis of Verstegen et al, with the expert system of Leszczyńska, offers an approach to handling uncertainty that is worth exploring.

Uncertainty is also introduced in the language used to describe a phenomenon. Barakat et al (2008) recognised this and proposed a Natural Language Processing approach based on ontologies. This is an area where, especially for the Semantic Web, considerable work has been done, most recently by such as Ballatore, Wilson & Bertolotto (2013), Delgado, Martinez-González & Finat (2013) and Eldrandaly (2013).

Models and support systems require calibration. Brömmelstroet (2013) is concerned about how to measure the performance of planning support systems in order to deliver a measure of confidence in the results presented. Few of the planning support systems investigated included built-in facilities to measure performance and, as yet, there appears to be no systematic approach.

4. Taking it forward

Boroushaki, Malczewski (2010) combined Participatory GIS and Multicriteria analysis to provide an online participatory decision support tool utilising Rinner et al (2008)'s concept of *Argumentation Maps*. Rinner, et al, define an Argumentation Maps as providing "the theoretical foundations for PGIS tools that support the deliberative aspects in spatial decision-making. More generally, the concept aims at supporting any argumentative process that has a spatial component and can benefit from explicit links between arguments and the corresponding places they serve." Boroushaki, Malczewski (2010) employ the Argumentation Maps concept to provide a decision-making prototype that combines both the analytical and deliberative functions, delivered using a Web-based GIS. Arciniegas, et al (2013) report the results of an experiment providing maps for participation groups to modify in providing evidence for decision-making. Cinderby (1999) and Cinderby, et al (2008) also prefer the use of maps for public participants to annotate in making their contribution to the process. Such approaches, especially that of Cinderby, lend themselves well to face-to-face focus groups that are managed or mediated by an investigator. However, for conflict situations where participants to be involved include (former) combatants from each side, present and former residents, including those displaced to other locations, including the diaspora, as well as aid and military agencies, etc, such face-to-face approaches are less suitable. The use of maps, especially 'official' materials of uncertain age or where lines are drawn to create separation, requires a measure of caution: such demarcations can themselves become the cause of future conflict (Carton, Thissen 2009). Including spatial material contributed by volunteers, together with spatially located situation reports, collected and published using online technologies as described by Barakat et al (2008) appears to offer a more practical approach.

To address the issues of face-to-face and diaspora in planning and implementing post-war reconstruction, we propose a web-based approach initially based on ESRI technology. This offers an advantage in that systems can be developed in ArcGIS Desktop and then published through ArcGIS Server, enabling edit access on certain layers to facilitate participation. The whole can then be thoroughly tested before use in the field. The schematic design is:

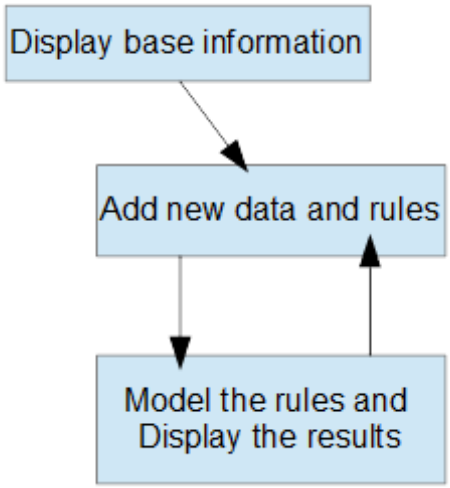

Figure 1: block schematic

Of course, the two blocks *Add new data and rules* and *Model the rules and Display the results* are iterative and data and rules may be added or removed as the model is refined. New data are added as new layers in ArcMap and rules are added to Agent Analyst, which is then run to evaluate the results. Eventually, we envisage that this will be captured into a Python script that will also record the parameters used for each iteration. At present, Agent Analyst is not available for ArcGIS Server: this may change or it may be necessary to replicate the Agent Analyst facilities, so far as they are required, in a wrapper for Repast that can run under ArcGIS Server.

The original Barakat et al (2008) paper envisaged the use of natural language processing and ontologies to 'translate' terminologies used by actors in defining their needs into a common framework and to report the results into an understandable format. Recent Semantic Web work has produced tools to achieve substantial amounts of this requirement (eg Ballatore et al, 2013 and Delgado et al, 2013) however, this is not currently included within this first phase.

Ushahidi has become virtually synonymous with peoples in trouble and collates information submitted using mobile devices in order to display them spatially (Marsden 2013). The Ushahidi team have been working with ESRI, who are already involved in providing disaster mapping services, to provide an integration between Ushahidi and ArcGIS (http://www.esri.com/news/releases/10_4qtr/ushahidi.html accessed 12.3.2014). This integration was announced in 2012 as the Ushahidi2ArcGIS add-in for ArcGIS Desktop (http://www.arcgis.com/home/item.html?id=f2cc3c6018a745a4aaa38c15e68b2df0 accessed 12.3.2014). This tool connects ArcGIS to Ushahidi over the web, so it should be possible to use without a private Ushahidi implementation.

At this stage it is not yet clear whether it will prove practical to rely on these standard tools or whether specific integrators or tools will be required.

5. Conclusions

The vision described by Barakat, Car & Halls (2008), envisaged in 2002, has stood the test of time. A significant number of the necessary components are now in place, in particular the recent developments of Volunteered Geographic Information (VGI) and Crowdsourcing. Other workers have pursued and implemented systems that demonstrate or tackle various of the components giving a measure of confidence. A broad design is currently being test-implemented with a view to refining that design into a usable tool which can then be applied in a more sensitive context. There will be a need to scope the present activity as the entire Barakat et al vision is most probably beyond the range of the present research: it is likely that this scoping may reflect needs in some

conflict zone.

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Bibliography

ARCINIEGAS, GUSTAVO, JANSSEN, RON, RIETVELD, PIET, 2013, Effectiveness of collaborative map-based decision support tools: Results of an experiment. Environmental Modelling & Software **39** pp159-175.

ARNSTEIN, SHERRY R., 1969, A Ladder of Citizen Participation. Journal of the American Institute of Planners **35**(4) pp216-224.

BALLATORE, ANDREA, WILSON, DAVID C., & BERTOLOTTO, MICHELA, 2013, Computing the semantic similarity of geographic terms using volunteered lexical definitions. International Journal of Geographical Information Science (published online DOI 10.1080/13658816.2013.790548).

BARAKAT, SULTAN Z, CAR, ADRIJANA, HALLS, PETER J, 2008, GIS methodologies in Post-war Reconstruction. *In* Wise, Stephen, and Craglia, Max, (eds), *GIS and Evidence-Based Policy Making*, Boca Raton, Fl: CRC Press; pp261-282.

TE BRÖMMERELSTROET, MARCO, 2013, Performance of Planning Support Systems: What is it, and how do we report it. CEUS **41** pp299-308.

BOROUSHAKI, SOHEIL, MALCZEWSKI, JACEK, 2010, *ParticipatoryGIS:* A Web-based Collaborative GIS Multicriteria Decision Analysis. Journal of the Urban and Regional Information Systems Association **22**(1) pp23-32.

CARTON. L.J., THISSEN, W.A.H, 2009, Emerging conflict in collaborative mapping: Towards a deeper understanding? Journal of Environmental Management **90** pp1991-2001.

CHOGUILL, GUARALDO, MARISA B., 1996, A Ladder of Community Participation for Underdeveloped Countries. Habitat INTL **20**(3) pp431-444.

CINDERBY, STEVE, 1999, Participatory Geographic Information Systems (GIS): The future of environmental GIS? International Journal of Environmental Pollution **22** (3) pp304-315.

CINDERBY, STEVE, SNELL, CAROLYN, & FORRESTER, JOHN, 2008, Participatory GIS and its application in governance: the example of air quality and the implications for noise pollution. The International Journal of Justice and Sustainability **13**(4) pp309-320.

CROOKS, ANDREW T., WISE, SARAH, 2013, GIS and agent-based models for humanitarian assistance. CEUS **41** pp100-111.

DELGADO, FRANCISCO, MARTINEZ-GONZÁLEZ, M. MERCEDES, & FINAT, JAVIER, 2013, An evaluation of ontology matching techniques on geospatial ontologies. Intenational Journal of Geographical Information Science (published online: DOI 10.1080/13658816.2013.812215).

ELDRANDALY, KHALID A., 2013, Exploring multi-critera decision strategies in GIS with linguistic quantifiers: an extension of the analytical network process using ordered weighted averaging operators. International Journal of Geographical Information Science (published online DOI 10.1080/13658816.2013.815356).

ESRI, undated, ArcGIS *Online*. Available online at http://www.esri.com/software/arcgis/arcgisonline (accessed 10.3.2014).

FÉLIX, DANIEL, BRANCO, JORGE M., FEIO, ARTUR, 2013, Temporary housing after disasters: A state if the art survey. Habitat International **40** pp136-141.

GIMBLETT, H. RANDY, (ed) 2002, Integrating Geographic Information Systems and Agent-based Modeling Techniques for simulating Social and Ecological Processes. New York: Oxford University Press.

GIRRES, J.-F. AND TOUYA, G. (2010), Quality Assessment of the French OpenStreetMap Dataset. Transactions in GIS, **14**(4) pp435–459.

GOODCHILD, MF, 2007, Citizens as Voluntary Sensors: Spatial Data Infrastructure in the World of Web 2.0 (Editorial). International Journal of Spatial Data Infrastructure Research **2** pp24-32.

HARDY, DARREN, FREW, JAMES, & GOODCHILD, MICHAEL F., 2012, Volunteered geographic information production as a spatial process. International Journal of Geographical Information Science **26**(7) pp1191-1212.

HERZ, STEVE, EBRAHIM, ALNOOR, 2005, A Call for Participatory Decision Making: Discussion Paper on World Bank-Civil Society Engagement. Civil Society Members of World Bank-Civil Society Joint Facilitation Committee (JFC).

KINGSTON, RICHARD, 1998, Web Based GIS for Public Participation Decision Making in the UK. Paper presented at the NCGIS PPGIS Meeting, Santa Barbara CA.

KORDI, MARYAM, BRANDT, S. ANDERS, 2012, Effects of increasing fuzziness on analytic hierarchy process for spatial multicriteria decision analysis. CEUS **36** pp43-53.

LESZCZYŃSKA, MAŁGORZATA, 2011, Decision support system for optimisation of marginal rural area development based on GIS technology. Proceedings of GISRUK 2011, Session 6b Urban & Rural Planning and Modelling pp295-300.

LIZARRALDE, GONZALO, MASSYN, MARK, 2008, Unexpected negative outcomes of community participation in low-cost housing projects in South Africa. Habitat International **32** pp1-14.

LYONS, MICHAL, 2009, Building Back Better: The Large-Scale Impact of Small-Scale Approaches to Reconstruction. World Development **37**(2) pp385-398.

MARSDEN, JANET, 2013, Stigmergic self-organisation and the improvisation of Ushahidi. Cognitive Systems Research **21** pp52–64.

PHELPS, NICHOLAS A., BUNNELL, TIM, MILLER, MICHELLE ANN, 2011, Post-disaster economic development in Aceh: Neoliberalization and other economic-geographical imaginaries. Geoforum **42** pp418–426

MIT, 2010, Humanitarian of the Year. technology review september /october 2010 pp44-47

RINNER, CLAUS, KEßLER, CARSTEN, ANDRULIS, STEPHEN, 2008, The use of Web 2.0 concepts to support deliberation in spatial decision-making. CEUS **32**(5) pp386-395.

SAARLOOS, DICK J.M., ARENTZE, THEO A., BORGERS, ALOYS W.J., TIMMERMANS, HARRY J.P., 2008, A multi-agent paradigm as structuring principle for planning support systems. CEUS **32** pp29-40.

SIEBER, RENEE, 2006, Public Participation Geographic Information Systems: A Literature Review and Framework. Annals of the Association of American Geographers **93**(3) pp491-507.

SUGUMARAN, RAMANATHAN, DEGROOTE, John, 2011, Spatial Decision Support Systems: Principles and Practices. Boca Raton, Fl: CRC Press.

VERSTEGEN, JUDITH ANNE, KARSSENBERG, DEREK, VAN DER HILST, FLOOR, FAAIJ, ANDRÉ, 2012, Spatio-temporal uncertainty in Spatial Decision Support Systems: A case study of changing land availability for bioenergy crops in Mozambique. CEUS **36** pp30-42.

Biography.

Peter Halls recently took early retirement from his long standing role as GIS Advisor at the University of York in order to undertake a PhD within the Post-war Reconstruction and Development Unit investigating spatial methodologies for post-war reconstruction.