Precision for Whom? –
Mapping Ambiguity and Certainty in (Participatory)GIS

Mike McCall
ITC, Enschede
February 2006

To know that we know what we know, and to know that we do not know what we do not know, that is true knowledge.

Copernicus

Summary

How important is precision in PGIS mapping? Maps consist of different layers of spatial information – such as roads, distances between places, boundaries, physical features or land uses. But how do maps represent fuzzy and imprecise spatial information, such as seasonally variable resources?, or the real effort and drudgery of walking from one place to another?, or people's mental maps (images) of places they like, or are afraid of, or are sacred to them?

This article explores some issues that are important when considering how precise – or imprecise – a map and the spatial information that it represents should be. It also asks, who is it important for, and why?

Standard GIS approaches can place unnecessary and misleading emphasis on precision, often legitimising elite control (by planners or GIS experts) over both spatial knowledge and the tools used. The flashiness of GIS outputs impresses decision-makers, but it can also create a false impression and legitimise what is actually bad data (Abbot et al. 1998). The political implications of ignoring imprecision and ambiguity is critical for PGIS practitioners and spatial decision makers. So the conventional questions of:

- 'What degrees of precision or accuracy are needed in participatory mapping?' and
- 'What are the costs of working with lower levels of precision and accuracy?'

…need to be replaced by more pertinent questions:

- 'For what purposes, and under what conditions, is it necessary to represent ambiguity and uncertainty?'
- 'What are the costs of misrepresenting ambiguity and replacing it with an unwarranted security of false preciseness?'

This article asks,

- Do accuracy and precision have value in a PGIS and planning context?
- How do precision and fuzziness, ambiguity and certitude of information function in the context of the tasks and intentions of PGIS?
- Can we better represent non-accuracy, imprecision and ambiguity in geo-information?

Participatory Mapping and Participatory GIS

Participatory Mapping and PGIS is special, because

- it includes information about local interests and priorities
- It can be representative of social communities, as well as individuals
- It involves multiple processes of people's participation in information identification and selection
- It contributes to capacity-building: groups can be empowered, by involvement in P-mapping / PGIS processes; and in particular
- it elicits local (and indigenous) knowledge

    - There are also other aspects that add value to the use of GIS: We can use it for spatial analysis of e.g. proximity, buffer zones, overlaying different types of land use, efficient networks (e.g. of people, or roads etc.).
- We can use it for recording, protecting, exchanging, and sharing spatial information.

PGIS and P mapping can be used to handle a range of real problems and applications of spatial information. For example:

- ADDING to CONVENTIONAL INFORMATION: i.e. recording technical spatial knowledge of specific resources, e.g. natural resource management (NRM) systems, or environmental and social hazards. This is often referred to as ISK - indigenous or local spatial knowledge. It also incorporates the mapping of indigenous technical knowledge (ITK). There are numerous cases of applications to NRM (McCall 2006)
- FINDING OUT NEW & UNKNOWN INFORMATION from new sources, previously unknown to conventional surveys and science, which can be used for making specific claims e.g. to resources, which can then be conventionally mapped. But it may include locations and resources which people want to keep secret from outside exploitation.
- ALTERNATIVE COMPETING POSITIONS: An explicitly political application, this refers to local spatial knowledge of people's interests, priorities, entitlements and values, information that is unrecorded in the standard maps of the 'powerful'. This is especially important when made by the relatively disadvantaged, inarticulate, or dispossessed; and is often termed as "counter-mapping".
- P mapping is used to discover and interpret people's 'natural geography', or MENTAL MAPS, including spaces, places and things of cultural value, sacred and historical spaces and cosmovisions [1]. These are frequently, but not confined to indigenous peoples. This is the most problematic application of P mapping because it must often handle alternative indigenous spatial concepts.

2) Spatial Imprecision and *Fuzziness* in Maps

Precision is seen as basic to a scientific approach, like accuracy and reliability of information; surely we cannot reject it? If inaccuracy is a distortion of reality, imprecision is seen as a failure of observation and measurement.

BOX 1 Spatial Precision and Accuracy

[1] Cosmovisions relate culture groups to their territories, landscapes and resources in terms of shared histories and practices, sacred values and origin mythologies

In ordinary usage, **precision** refers to the level of spatial resolution, or, to the accuracy and reliability of the geo-referencing. And in measurement terms, **accuracy** refers to the percentage of real (actual, named) objects which can be correctly located on the map. Maps deal with two sorts of accuracy :

- **representational accuracy** (which object?) and,
- **positional accuracy** (which location?)

Positional accuracy is how well we measure the location of features on a map. It depends on how reliable the data source is, the measurement device used, and how the data has been presented or changed. It is difficult to assess positional accuracy, it can only be checked against another 'better' source.

Attribute or representational accuracy, on the other hand, measures the characteristics of features. It is inevitably affected by people's understanding, interpretation, and classification of the features shown on the map. Different people have different interpretations of features. So it is not only important to understand 'who chooses the map legend?', but also 'what do the choosers understand by the symbolism?'

END BOX 1

But, we should question why precision is considered a necessity in Participatory GIS.

- Spatial reality is <u>not</u> precise, it is always fuzzy and frequently ambiguous.
- So it can be misleading to misrepresent it as being precise and accurate – this is 'false precision'.
- there are developing approaches in software and hardware which increasingly allow for fuzzy representations.

Spatial imprecision and ambiguity can originate from various other causes, e.g. the technical limitations of maps, . or the (mis-)interpretation of spatial reality. At complex political and ideological power levels, the ambiguity comes from the false precision, which obscures local claims and competing viewpoints.

Scale and resolution are Technical constraints

Whether a location is accurately or precisely marked on the map is related to *resolution.* Resolution is the 'size of the smallest feature in a data set that can be discerned' and is chosen by the map-maker. Resolution and the scale of the display (map or photo) are related. Take a 1:50000 map sheet, the smallest item you can see on it with good eyesight and luck is 0.5 mm, thus 25 m. square, in practice more likely, 50 m. square, so a road may appear five times its real width.

This also effects the level of *map detail* – what gets included and what gets left out. PGIS practitioners maintain that the quality of the information, particularly the representational accuracy, is always more significant than mere quantity of data.

Uncertainty of Spatial Information - no clear hard boundaries

Are boundaries precise in reality? Boundaries are dynamic, e.g. rivers are seasonal movers, as are wetlands, vegetation cover.

The same is also true for e.g. social classes or cultural groups who do not have a unique or fixed location with precise boundaries, such as women, pastoralists, students, or, the "poorest 10%". Official maps often fail to reflect this.

Positional and representational ambiguity - shadows

'Shadows' are the external impacts which are necessary, inseparable implications of the mapped objects, connected by real processes - such as 'downstream' and 'upstream' impacts, and ecological footprints. Buildings have shadows of light and microclimates of cold and wind; cities have resource impacts; plantations and mines create local and distant changes in landuse and households; likewise with consumer shopping patterns; national economic policies have international impacts; and we find ecological footprints at all scales.

Mapmakers normally ignore the shadows of the located objects, although they are inevitable and concrete spatial 'by-products'. We need to ask, for whose benefit are these shadows ignored?

Competing viewpoints and power

Spatial precision is of course needed for certain situations e.g. processing legal land claims, or for calculating taxes owed on land owned. But often, the final map/GIS product also needs to show competing alternative viewpoints of different actors. These might be about resource claims, or development visions. Mapping has always been associated with formalising and legitimising property relations, ownership, inheritance, social distribution, etc. (Wood 1998). But all too frequently they present only one viewpoint, usually that of those in power and control - 'possession is 9/10ths of the law' is not just a cliché in NRM.

This can often lead to (sometimes deliberate) disputes and to conflicts. Reports from many countries, e.g. Philippines, Bolivia, Mexico, give instances of violence arising when boundaries are put on maps where none existed before, or when local people lose their rights to collect medicinal plants, food and building materials, fuel, etc. from forests and 'wastelands' (e.g. Fox et al. 2005)

GIS approaches are weak in representing fundamental **power relations** (cf. Abbott et al. 1998). Standard GIS outputs do not reflect actual political processes and the realities of social-political power. For instance, conventional mapping of land titles over-simplifies overlapping claims from different stakeholders and reduces them to a simplistic 2-D space of 'private (household) title' which can lead to exclusion and conflicts.

Competing viewpoints can be partially solved by 'counter maps', the explicit mapping of the priorities, needs, problems, claims, etc. of the disadvantaged and less articulate. Early examples were specifically for women's maps, such as of forest areas for gathering woodfuel, or women's utilisation of so-called 'wastelands' for collecting medicinal plants, but counter maps are applicable to any power-deficient groups (Peluso 1995).

Representing and interpreting 'fuzziness'

Some argue strongly that GIS and local or indigenous knowledge are inherently incompatible. On the one hand, is the ultra-precision of the digitised geo-data. On the

other hand, there is ambiguity, spirituality and emotion e.g. the use of stories and dance rather than documents or maps as forms of knowledge communication. So how do people in a 'natural geography' context regularly handle local spatial knowledge or ISK? What does this imply for using PGIS tools to represent fuzzy, ambiguous, uncertain spaces?

- Maps and GIS can't be very precise about indistinct **descriptive spatial terms** like 'near', 'far', 'isolated', 'crowded' (Rundstrom 1995)
- 'Real space', as perceived by people has fuzzy **boundaries** and flows not well expressed in GIS. Boundaries do not exist in isolation, and are not necessarily seen by neighbours in the same place.
  Local boundaries as not easily translated into digital format. 'Flexible' boundaries are identifiable, but open to change through negotiation or force. 'Fuzzy' boundaries exist where different social groups have different uses for the same, or overlapping. areas.
- **Multiple levels** of detail. E.g. traditional land users maintain that hunting, fishing, and collecting do not occur at specific sites but over spatial and temporal (seasonal) ranges, which also have complex social user regulations, and thus do not fit into standard resource mapping.

- Real space and **distances** are tightly coupled with **time** in people's cognition; e.g. traditional words for land areas are often related to the time needed for ploughing.
- Space is not always the same as distance. Often the most important thing to people is the point of interest, and not the spaces between them, e.g. fishermen know individual points of significance (e.g. fishing grounds) in fine detail, with non-linear 'space jumps' between them.
- Distances are **not symmetric**, they seem 'longer' or 'shorter' depending on the direction, e.g. uphill or downhill, or, with or against the commuter traffic flow, - not simply the time, but also the effort and drudgery involved
- People certainly do not conceptualise space in only two dimensions, as do map and aerial photo images. "Escaping this **flatland** is the essential task of envisioning information – for all the interesting words (physical, biological, imaginary, human) that we seek to understand are inevitably and happily multivariate in nature" (Tufte 1990)
- Our consciousness can operate at several **spatial scales simultaneously;** people have the ability to easily jump from one scale to another, e.g. our thoughts can skip instantly from finding our car keys in a room to a mental map of the city to drive through. This 'jumping scales' is better represented by dynamic GIS than by conventional maps.

- **Multi-signal, multi-sensual, multi-media** The mental maps and 'memoryscapes' inside our heads include **sounds** and remembered smells and tastes, as well as multiple moving and still images.

- Decision-making in participatory spatial planning must deal with **incomplete information**, i.e. people have to make a guess at missing information using 'common sense' rules.
- Understanding and interpreting **spatial images** (maps, photos, etc.) including the concepts of direction, distance, density, etc., is culture-specific and language-specific. (Rundstrom 1995).

- Mental maps are naturally spatio-temporal, i.e. they consider factors of both space and time. They recognise the flows and rates of e.g. physical resources,

information, and ideas, as well as the extent of spheres of influence, power, and control, etc.

4) When does PGIS need to be precise?

How do precision and fuzziness, or ambiguity and certitude relate to PGIS practice?

The figure below shows common applications of PGIS:

FIGURE

PGIS and the need for precision

There is need for more:

Fuzziness	*Precision*
Qualitative Information	*Quantitative Data*
Broad scale	*Detailed scale*
Incorporation	*Inscription* [2]
Lower resolution	*Higher resolution*

◀----------▶

In order to Represent:

Ambiguity	*Certitude*

◀----------▶

PGIS applications:

Intergenerational Knowledge Transfer & Community Awareness	**Culture & Heritage Spaces**	**Conflict Analysis & Management**	**Risk Zones**	**NRM systems**	**Indigenous Knowledge of natural resources**	**Hazard Locations**	**Land & Property Claims**

5) What can we do with imperfect information?

Gathering and assessing information or data using participatory approaches is closely linked to local interpretations of accuracy and relevance. How can PGIS tools recognise, understand and handle 'imperfect data' in all its glorious fuzziness, non-exclusivity, ambiguity, and imprecision? Visualisation and GIS technologies which are appropriate for understanding mental maps and for handling typical information in participatory spatial planning need different capabilities than are found in standard GIS.

BOX 2

Representing ISK and mental maps using PGIS needs to:-

[2] Many spatial concepts, especially of indigenous peoples, make use of 'incorporative' (stories, dance, etc.), rather than 'inscriptive' (documents, maps, etc.), modes of communicating knowledge.

- select the map resolution appropriate to the local context, There seems to be a window of 'natural' scale most appealing to users, usually large scale, 1:5,000 – 1:20,000, which makes the map display easier to read and understand, and ensures a sufficient level of detail.
- gather and incorporate qualitative and emotional knowledge by using qualitative rather than quantitative methods (e.g. story-recording, sketching, video), and then transferring it into regular maps or digital geo-information
- show some areas as fuzzy or multi-layered zones, with fuzzy, blurred, boundaries, and flexible or multiple boundaries;
- represent long-range visions with fuzzy margins (whether in space, in time, or as objects) to symbolise that they are not yet detailed and can be changed
- represent some objects or locations as uncertain, hidden (e.g. sacred) or restricted locations;
- be linked to other information, e.g. using hyperlinks to other documents or media files.
- be transparent, e.g. showing multiple land rights and entitlements;
- be able to 'jump scale' enabling people to become involved at scales relevant to their daily lives or long-term interests;
- present counter-maps of disadvantaged social groups and genders;
- represent flows of physical resources, information, ideas, or flows of influence, power, and control;
- to be dynamic, showing changes over time in resource management, in locations, boundaries, or in conflicts.

END of BOX 2

6) Conclusions

It is better to be roughly right than to be precisely wrong.
John Maynard Keynes

Some of the innovative GIS and visualisation ideas which are better able to respond to the needs of ISK are these:

- Layering information, even in standard GIS, allows data from different groups and communities to be recorded. So comparisons between groups can be easily analysed and applied in negotiations, contributing to respect and legitimacy.
- Dynamic, interactive mapping and multi-media approaches show multiple views and voices, layers of information, and layers of time.
- Three-dimensional material models, like the P3DM family, give people a bird's eye view, which literally provides alternative viewpoints.
- Features of dynamic animation or flash maps and new graphics software include: e.g. transparent layers, layers 'turn-on/off', shading, fuzzy symbols, blurring boundaries, etc.
- Sound can be added to the display, and interactive hyperlinks via click and display to other material and web sites including photographs, videos, texts, images.

To finish on a hopeful note, PGIS is eventually developing the potentials to elicit and create displays of ambiguous, fuzzy, non-precise, - even discursive and emotional, - spatial knowledge and rich pictures of a multi-textured world.

REFERENCES

Abbot, Jo; Robert Chambers; Christine Dunn; Trevor Harris; Emmanual de Merode; Gina Porter; Janet Townsend; and Daniel Weiner (1998)
Participatory GIS: opportunity or oxymoron?
Participatory Learning & Action PLA Notes (IIED) 33, 27-34.

Aitken, Stuart C. (2002)
Public participation, technological discourses and the scale of GIS.
pp. 357-366 (Chap. 27) IN: IN: Craig; Harris; and Weiner (eds) (2002) Community Participation and Geographic Information Systems. London: Taylor & Francis.

Alcorn, Janis B. (2000)
Borders, Rules and Governance: Mapping to Catalyse Changes in Policy and Management.
London: IIED, Gatekeeper Series No. 91. (24p.)

Bunge, William W.; and Ron Bordessa (1975)
The Canadian Alternative: Survival, Expeditions and Urban Change.
York University, Atkinson College, Geographical Monographs No. 2.

Carlstein, Tommy (1982)
Time Resources, Society and Ecology.
Lund: Lund Studies in Geography, Ser. B. no. 49.

Carver, Steve; and Zhong-Ren Peng (2001)
Internet GIS for public participation.
Environment and Planning B. Planning & Design 28 (6) 889-906.

Chacon, Miguel (2002?)
Principles of PPGIS for Land Conflict Resolution in Guatemala.
Buffalo, NY: SUNY-Buffalo, Dept. of Geography (28p.)
http://www.iapad.org/publications/ppgis/ppgis_conflict_resolution_guatemala.pdf

Cousins, Ben (2000)
Tenure and common property resources in Africa.
Chap. 8. IN: Camilla Toulmin and Julian Quan (eds) (2000) Evolving Land Rights, Policy and Tenure in Africa. London: IIED.

Dunn, Christine E.; Atkins, Peter J.; and Townsend, Janet G. (1997)
GIS for development: a contradiction in terms?
Area 29 (2) 151-159.

Egenhofer; Max J.; and David M. Mark (1995)
Naïve geography.
pp. 1-15 IN: A. U. Frank & W. Kuhn (eds) (1995) Spatial Information Theory: a Theoretical Basis for GIS. Berlin: Springer, Lecture Notes in Computer Sciences No. 988.

Fox, Jefferson (1998)
Mapping the commons: the social context of spatial information technologies.
The Common Property Resource Digest 45, 1-4.

Fox, Jefferson; Krisnawati Suryanata; and Peter Hershock (eds) (2005)
Mapping Communities: Ethics, Values, Practices.
Honolulu HI: East-West Center. (118p.)
http://www.eastwestcenter.org/res-rp-publicationdetails.asp?pub_ID=1719

Hall, Carol (1996)
Gender and GIS.
pp. 120-122 IN: Harris and Weiner (Comps) (1996) Varenius Tech. Rept. No. 96-7. (3p.)
http://www.geo.wvu.edu/www/i19/hall.html

Kingston, Richard; Steve Carver; Andrew Evans; and Ian Turton (2000)
Web-based public participation GIS: an aid to local environmental decision-making.
Computers, Environment & Urban Systems 24 (2) 109-125.

Kwan, Mei-Po (2002)
Is GIS for women? Reflections on the critical discourse in the 1990s.
Gender, Place & Culture 9 (3) 271-279.

Marozas, Bryan A. (1991)
The role of GIS in American Indian land and water rights litigation.
American Indian Culture & Research J. 15 (3) 77-93.

McCall, Michael K. (2006)
"pgis - psp – ik – (cb)nrm" Applying Participatory-GIS and Participatory Mapping to Participatory Spatial Planning and to Local–level Land & Land Resources Management utilising Indigenous & Local Spatial Knowledge: A Bibliography.
http://ppgis.iapad.org/pdf/pgis_psp_itk_cbnrm_biblio_mccall.pdf

Nietschmann, Bernard (1995)
Defending the Miskito reefs with maps and GPS. Mapping with sail, scuba, and satellite.
Cultural Survival Quarterly 18 (4) 34-37.

Porteous, Douglas (1990)
Landscapes of the Mind: Worlds of Sense and Metaphor.
Toronto: University of Toronto U.P.

Peluso, Nancy Lee (1995)
Whose woods are these? Counter-mapping forest territories in Kalimantan, Indonesia.
Antipode 27 (4) 383-406.

Rambaldi, Giacomo (2005)
Who owns the map legend?
URISA Journal 17 (1) 5-13.
http://www.urisa.org/Journal/JrnlContents17-1.htm

Rambaldi, Giacomo; and Jasmin Callosa-Tarr (2002)
Participatory 3-Dimensional Modelling: Guiding Principles and Applications.
Los Banos: ASEAN Regional Centre for Biodiversity Conservation (ARCBC) (72p. + CD-ROM)

Rocheleau, Dianne; Thomas-Slayter, Barbara; and Edmunds, Thomas (1995)
Gendered resource mapping. Focusing on women's spaces in the landscape.
Cultural Survival Quarterly 18 (4) 62-68.

Rundstrom, Robert A. (1995)
GIS, indigenous peoples and epistemological diversity.
Cartography & GIS 22 (1) 45-57.

Scott, Michael; and Susan Cutter (1996)
GIS and environmental equity: an analysis of the assumptions.
pp. 169-174 IN: Harris and Weiner (Comps) (1996) Varenius Tech. Rept. No. 96-7. (6p.)
Initiative 19 Position Paper.
http://www.geo.wvu.edu/i19/papers/scott.html

Shiffer, M. J. (1998)
Multimedia GIS for planning support and public discourse.
Cartography & GIS 25 (2) 89-94.

Southworth, Michael (1969)

The sonic environment of cities.
Environment & Behavior 1 (1) 49-70.

Thom, Brian; and Kevin Washbrook (1997)
Co-management, negotiation, litigation: Questions of power in traditional use studies.
Paper given at: Ann. Meeting of Society for Applied Anthropology, Seattle, March 1997.
http://home.istar.ca/-bthom/sfaa.htm

Tufte, Edward (1990)
Envisioning Information.
Cheshire, CN: Graphics Press

Weiner, Daniel; Harris, Trevor M.; and Craig, William J. (2002)
Community participation and geographic information systems.
pp. 3-16 (chap. 1) IN: Craig; Harris; and Weiner (eds) (2002) Community Participation and Geographic Information Systems. London: Taylor & Francis.

Varanka, Dalia (1996)
The Social Implications of how People, Space, and Environment are Represented in GIS.
Position Paper on GIS and Society.
pp. 188-189 IN: Harris and Weiner (Comps) (1996) Varenius Tech. Rept. No. 96-7.
http://www.geo.wvu.edu/i19/papers/varanka.html

Weiner, Daniel; and Trevor M. Harris (2003)
Community-integrated GIS for land reform in South Africa.
URISA Journal 15 (2) 61-73. (APA II) Special Issue.
http://www.urisa.org/Journal/APANo2/Weiner.pdf

Williams, Craig; and Christine E. Dunn (2003)
GIS in participatory research: assessing the impact of landmines on communities in north-west Cambodia.
Transactions in GIS 7 (3) 393-410.

Wood, Denis (1998)
The Power of Maps.
New York, NY: Guilford. (248p.)