Questionnaire 3D-Cadastres: status September 2014 Poland

This questionnaire is an activity of the FIG working group 3D-Cadastres 2014-2018. The purpose of the survey is to make a world-wide inventory of the status of 3D-Cadastres at this moment and the plans/expectations for the near future (2018). By sharing this information, it should be possible to improve cooperation, learn from each other and support future developments. This is the second time that the questionnaire on 3D-Cadastres is conducted by the FIG working group on 3D-Cadastres. The first time was in 2010 in order to document the status in 2010 and expectations back then for 2014. The responses have been analysed (van Oosterom et al. 2011, Karki 2013). For more information on the FIG working group on 3D-Cadastres see the website www.gdmc.nl/3DCadastres. Now a few notes and suggestions, which should be helpful when completing the questionnaire:

- The conceptual model used as background for the 3D Cadastres questionnaire is the ISO 19152 standard (ISO, 2012): the Land Administration Domain Model (LADM).
- In this questionnaire the concept of 3D-Cadastres with 3D parcels (or 3D spatial units in LADM terminology) is intended in the broadest possible sense. However, what exactly is (or could be) a 3D parcel is dependent on the legal and organizational context in the specific country (state, province). 3D parcels include land and water spaces, both above and below surface.
- A more formal definition: A 3D parcel is defined as the spatial unit against which (one or more) unique and homogeneous[1] rights (e.g. ownership right, lease or other land use right), responsibilities or restrictions are associated to the whole entity, as included in a Land Administration system.
- As the definition above is quite abstract, it is tried in the questions to be more specific and real world situations are used. Many examples with partial/preliminary answers from 2010 are available on-line at http://www.gdmc.nl/3DCadastres/participants/. Inspecting some of the completed 2010 questionnaires from different other countries might help when formulation the answers for your jurisdiction.
- A 3D parcel is a 'legal object' describing a part of the space. Often there is a relationship with a real world/physical object, which can also be described in 3D. Please be aware of the difference between these two types of objects and that the focus in the context of 3D-Cadastres is on spaces of the legal objects and not the registration of the physical objects as such.
- If a certain question is not relevant or if you have no clue what to respond, do not spend any time on this (and leave the field blank).
- The questionnaire has been prepared by a mixed Australian (Rod Thompson/Sudarshan Karki)/Dutch (Jantien Stoter/Hendrik Ploeger/Christiaan Lemmen/Peter van Oosterom) team. The questionnaire is grouped in the number of blocks. This has no meaning in the sense of priority and it is often the case that a question could belong to multiple blocks. Please do not feel disturbed by this.
- Similar to the Questionnaire 3D-Cadastres, the completed forms will be made available on website of FIG working group on 3D Cadastres.
- Please complete this questionnaire before *1 October 2014* and send it to P.J.M.vanOosterom@tudelft.nl (or Peter van Oosterom, TU Delft, OTB, P.O. Box 5030, 2600 GA Delft, The Netherlands).

---

[1] Homogenous means that the same combination of rights equally apply within the whole 3D spatial unit. Unique means that this is the largest spatial unit for which this is true. Making the unit any larger would result in the combination of rights not being homogenous. Making the unit smaller would result in at least 2 neighbour 3D parcels with the same combinations of rights.

1. General/applicable 3D real-world situations

This part of the questionnaire refers to the applicable 3D real-world situations to be registered by 3D parcels. It also addressed the types of 3D geometries, which are considered to be valid 3D representations for these parcels.

	Status 2014	Expectations 2018
1.1. Are all 3D parcels (3D spatial units in LADM terminology) constrained to be within one surface 2D parcel?	3D parcels are not defined	Not necessarily.
1.2. Are 2D and/or 3D ambulatory[2] boundaries permitted?	No	No
1.3.a. Is it allowed to have 3D parcels (spatial units) not related to physical constructs or objects? (e.g. airspace, subsurface volumes)		No
1.3.b. If 1.3.a positive: approximately what proportion of new 3D parcels (spatial units) would involve such cases (not related to physical object)?		
1.4. Are disconnected parts of a single 3D parcel allowed?		No
1.5. Spatial limitation – e.g. must the 3D parcel be related to a closed volume or is it allowed to have 'open' or unbounded 3D parcels (e.g. towards the sky).?		Closed volume mandatory
1.6. Are curved surfaces to bound the 3D parcels allowed?		No
1.7. Must the curved surfaces (if allowed) be cylindrical sections, or any other constraint?		
1.8. Any other constraints – e.g. all surfaces must be horizontal or vertical?	The limitations for potential 3D parcels are defined within the Aviation Law and the Geological and Mining Law	The limitations for potential 3D parcels are defined within the Aviation Law and the Geological and Mining Law
1.9. Is there legislation (law and/or regulations) for 3D descriptions of parcels? If so please, mention law and article(s).	No	Yes. 3D parcel description.
1.10. Is the legal text available in original language?	No	Yes
1.11. Is the legal text (relevant part) available in English translation?	No	No
1.12. Do you have example descriptions of typical 3D parcels;	No	Yes

[2] An ambulatory boundary is a boundary of a land parcel which follows the movements of a natural feature such as a river. Its position determined at points of time (when a survey is carried out), but between such "fixes", the definition of the property is the position of the real world natural feature.

either 'prototype' or 'operational'?		
1.13. Is there a formal model for the 3D parcels (UML style); e.g. based on ISO TC211 series (especially LADM, ISO 19152)?	No	Yes
1.14. Are natural resources (groundwater, mining rights) shown in your land administration? If yes, are they considered as 3D parcels (spatial units) with RRRs attached?	No	No
1.15. Are legally restricted spaces, above or below, such as polluted areas considered as 3D parcels?	No	No
1.16. Are spatial plans considered as 3D parcels (as rights or restrictions are related to them)? Sometimes also called spatial development plans, zoning plans or physical plans (land use, urban, regional, environmental,...)	No	No
1.17. Any other geometric issues related to 3D parcels?		

2. Infrastructure/utility networks

This refers to the situation where an infrastructure network is considered to be defined within the land administration. For example in some jurisdictions, an underground network might be privately constructed for the purpose of leasing space in it for other organisations to run cabling. In this case, a network, or part of that network may be considered to be a real estate object.

	Status 2014	Expectations 2018
2.1. Do you register networks as an entity in the land administration? (e.g. subterranean conduit networks)	Yes	Yes
2.2. If so, then (a) can the network structure be viewed graphically in the land administration? (b) can the network structure be traced in the database(s)? (c) are networks registered by means of a cadastral identifier (such as a 'parcel number')? (d) are RRRs and parties attached to these network objects?	a) Yes b)Yes c)No d)Yes (Easement of transfer)	a) Yes b)Yes c)No d)Yes (Easement of transfer)
2.3. Does the jurisdiction have private networks? If so please, mention law and article(s).	Yes. The Civil Code, Art. 49	Yes
2.4. If so, are they registered as 3D property parcels (spatial units)?	No	No
2.5. Is the text of relevant laws or regulations (question 2.3) available in original language? If so, give references to relevant document(s).	Yes. Regulation of the Minister of Administration and Digitization of 12 February 2013 concerning geodetic database of utilities, topographical objects database and base map.	Yes
2.6. Is the text of laws and regulations (relevant part) available in English translation?	No	No
2.7. Do you have example descriptions of typical 3D parcels (spatial units) for networks; either 'prototype' or 'operational'?	No	No
2.8. If the network (legal) objects break at the surface parcel, how do you deal with intersecting networks or vertically parallel networks?	Utilities networks localization is agreed in the stage of its designing in the Groups for Design Documentation Coordination on the *powiat* (county) level.	Utilities networks localization is agreed in the stage of its designing in the Groups for Design Documentation Coordination on the *powiat* (county) level.
2.9. Any other geometric issues related to the registration of networks?		

3. Construction/building units

This refers to 3D properties that are related to constructions and apartment (condominium) buildings. The individual units are often defined by the actual walls and structure of a building, rather than by metes and bounds. E.g. "unit 5 on level 6 of … building".

	Status 2014	Expectations 2018
3.1. Do you register 3D construction/building units?	Yes	Yes
3.2. If so, what are the most important types? E.g. apartment units, or also other buildings or even more general constructions (infra related; such as bridge, tunnel or even other, such as windmills,..)	Buildings, constructions, apartment units	Buildings, constructions, apartment units
3.3. Does the jurisdiction have construction/building units? If so please, mention law and article(s).	Yes. Geodetic and Cartographic Law. Art. 2.8	Yes
3.4. Is the legal text available in original language?	Yes	Yes
3.5. Is the legal text (relevant part) available in English translation?	No	No
3.6. Do you have example descriptions of typical 3D parcels; either 'prototype' or 'operational'?	No	Yes
3.7. What would be typical 3D boundaries in an apartment complex: middle of the wall and floor/ceiling, or walls, floors/ceiling as neutral/shared 3D space? Is it mentioned in any legislation or is it the convention?	No rules defined	Yes. Boundaries defined by legal regulations.
3.8. Is common property inside the building registered? If so, how?	No	No
3.9. Who owns the common property inside the building?	Apartment units owners in respective parts	Apartment units owners in respective parts
3.10. Who owns the land on which the apartment is built?	Building owner(s) Apartment units owner if separate apartments have been established. State or local government if the right of perpetual usufruct of building has been established.	Building owner(s) Apartment units owner if separate apartments have been established. State or local government if the right of perpetual usufruct of building has been established.
3.11. Do you allow sub-division of apartments or apartment blocks?	Yes, only vertically if created parts are not connected with windows doors and so like, and have separate entrances and installations. Horizontal division is not	Yes, only vertically if created parts are not connected with windows doors and so like, and have separate entrances and installations. Horizontal division is not

	possible, except establishing of independent apartments.	possible, except establishing of independent apartments.
3.12. Can the land on which the building is built be sub-divided or sold or mortgaged without the consent of majority of the apartment owners?	No	No
3.13. What is the numbering convention for apartments (please specify in terms of cadastral parcel as well as street addressing)	Cadastral parcel: Mostly ParcelNo.BuildingNo (subsequent) Street addressing: BuildingNo / ApartmentNo	Cadastral parcel: Mostly ParcelNo.BuildingNo (subsequent) Street addressing: BuildingNo / ApartmentNo
3.14. Any other geometric issues?		

4. X/Y Coordinates

	Status 2014	Expectations 2018
4.1. Do the plans of survey guarantee X/Y coordinates? (and are they relative or in an absolute spatial reference system?)	Absolute	Absolute
4.2. Are the cadastral database coordinates authoritative?	Yes	Yes
4.3. If not, what is the authoritative source of X/Y coordinates?		
4.4. Do you have parcels defined by the walls of a building (with no recorded geometry)?	No	No
4.5. What is the spatial reference system for X/Y Coordinates?	XY coordinate systems: Generally: PL-2000 (EPSG: 2176-2179) – scales (1:10 000 and larger) also PL-1992 (EPSG:2180) PL-LAEA (for maps on European level) PL-LCC (for 1:500 000 and smaller scales) PL-UTM (scales 1:10 000 – 1: 250 000 also sea and national security maps)	
4.6. Any other X/Y coordinate issues?		

5. Z Coordinates/height representation

	Status 2014	Expectations 2018
5.1. Are the Z coordinates of 3D parcels relative to local ground?		No
5.2. Are Z coordinates reduced to a standard datum (absolute)? If so, what is the spatial reference system for the Z coordinate?	Yes. PL-KRON86-NH PL-EVRF2007-NH – as a physical and mathematical realisation of European height system EVRS	
5.3. In principle possible to store both relative and absolute Z coordinate?		
5.4. Is the earth surface (height) explicitly stored (in the DCDB or other accessible register)?	Yes. The database of aerial and satellite imaging, orthophotomap and Digital Terrain Model.	Yes. The database of aerial and satellite imaging, orthophotomap and Digital Terrain Model.
5.5. What is the source of elevation for the 2D surface parcel?	Usually, there is not Z coordinate for boundary points	Usually, there is not Z coordinate for boundary points
5.6. Any other Z coordinate issues?		

6. Temporal Issues

	Status 2014	Expectations 2018
6.1. Are temporal limits part of the definition of a parcel (2D or 3D)?	No	No
6.2. Are moving parcels allowed?	No	No
6.3. Are there any limitations on the range of temporal limits? (e.g. only on 3D apartments).		
6.4. Are there any attempt to integrate 3D space and temporal representations, into a single 4D space/time representation?	No	No
6.5. In the case of tidal boundaries, what happens to the 3D ambulatory parcel if the 2D land parcel changes extent due to the movement of High Water Mark?		
6.6. Any other temporal issues?	The right of perpetual usufruct may be granted for 40-99 years	The right of perpetual usufruct may be granted for 40-99 years

7. Rights, Restrictions and Responsibilities

	Status 2014	Expectations 2018
7.1. Range of RRR on 3D parcels.		
7.2. Are there any limitations on the range of rights related to 3D spatial units? (e.g. subterranean parcels must be owned by Govt).	The limitations for potential 3D parcels are defined within the Aviation Law and the Geological and Mining Law	The limitations for potential 3D parcels are defined within the Aviation Law and the Geological and Mining Law
7.3. Are there any limitations on the range of restrictions or responsibilities related to 3D spatial units? (i.e. currently in use and related to 2D spatial units, but that would not be applicable to 3D).		
7.4. Are there RRRs that are only allowed in 3D (and not valid for 2D)		
7.5. Is there specific legislation (laws, regulations) defining 3D RRR types? If so, provide details, e.g. references to documents/ articles.	No	No
7.6. Can 3D sub-surface/above-surface parcel be owned by someone other that the person owning the land parcel?		
7.7. What applications do you foresee for 3D land administration?		Solving problems if ownership or rights overlaps or interlaces in the third dimension
7.8. Are the administrative source documents (source of RRRs) title or deed based?	Both, but nowadays there are usually deeds.	Both, but nowadays there are usually deeds.
7.9 Who is responsible for the correctness of the specified 3D boundaries in spatial source documents (which authority)?		Cadastral authorities.
7.10. Is registration of 3D parcels done inside the cadastral mapping agency, the land registry or elsewhere?		Cadastral authorities.
7.11. Are 3D registrations handled by the same organisation that handles traditional (2D) land administration?		Yes
7.12. Do you supply paper-based titles or deeds or proof of ownership? If yes, does this contain depictions of the 2D or 3D parcel?	Yes. They contain depictions of 2D parcel or plans for apartment units.	Yes. They contain depictions of 2D parcel or plans for apartment units.
7.13. Any other RRR issues?		

8. DCDB (The Cadastral Database)

	Status 2014	Expectations 2018
8.0. Is database schema LADM based?	No, but it is prepared applying UML.	No, but it is prepared applying UML.
8.1. Does the DCDB contain representation of 3D parcels (in any form)?	No	No
8.2. If so, how are they represented (in the DCDB)?		
8.3. If so, how are they presented on cadastral "maps" (including screen presentations)?		
8.4. Are there possibilities to store geometry of 3D parcels in the DCDB?		Probably yes.
8.5. Is it possible to manage a 3D topological structure in the DCDB?		
8.6. Are constraints/rules defined for valid 3D objects (closed volume, no overlap, no gap in 3D)? What about rules for a mix of 2D and 3D representations?	No	Closed volume.
8.7. How can internal and external user query and visualize the 3D content supporting rotating, slicing, transparency, perspective (3D web/view service, 3D pdf documents,..)?		View services for internal users.
8.8. What Spatial DBMS software do you use? Any 3D capabilities included and used?	Software varies depending of *powiat* (county). Some of software systems are original Polish productions, some are AutoCAD, Microstation, or ArcGIS based.	Software varies depending of *powiat* (county). Some of software systems are original Polish productions, some are AutoCAD, Microstation, or ArcGIS based.
8.9. Do you have any validation rules for 3D representation in the database?		
8.10. What (GIS/CAD) software is used for updating, editing, analysis, and visualization of the cadastral data? Any 3D capabilities included and used?	Any software that meets criteria for input data may be used.	Any software that meets criteria for input data may be used.
8.11. What web software is used for remote data access/distribution and visualization? Any 3D capabilities included and used?	Depends on *powiat* (county)	Depends on *powiat* (county).
8.12. Is your DCDB organised as Multi-Layers or Object Oriented or some other data model?	At the moment is in the transition period from multi-layer to object oriented	Object oriented.
8.13. How do you query 3D objects in		

your DCDB?		
8.14. Is it possible to query neighbourhood parcels to a 3D object, vertically as well as horizontally?		
8.15. Any other DCDB issues?	The cadastre in Poland is managed according to the Geodetic and Cartographic Law at the level of *powiat* (county). It results in fact that the rules for the entire country (Poland) are the same but the organisational and especially technical issues vary strongly depending on place.	The cadastre in Poland is managed according to the Geodetic and Cartographic Law at the level of *powiat* (county). It results in fact that the rules for the entire country (Poland) are the same but the organisational and especially technical issues vary strongly depending on place.

9. Plans of Survey (including field sketches)

	Status 2014	Expectations 2018
9.1. Do the survey plans carry 3D parcel representations?	No	Yes
9.2. If so, how are they represented?		
9.3. Is there specific legislation (regulations) describing the requirements for Plans of Survey in 3D? If so, please give link to the relevant documents.	Yes. Regulation of Minister of Internal Affairs of 9 November 2011 concerning technical standards for topography and mapping, results elaboration and forwarding to the state geodetic and cartographic resource (Jo. Of Law no 263, item 1572)	The changes in the legislation are expected
9.4. Is sketch level allowed (low geometric quality, but in principle enough to indicate the 3D object)?		
9.5. Is it possible to define a 3D parcel by referring to other 3D real world objects/ topography (and not specifying coordinates)?		No
9.6. In what format are the 3D parcels submitted for registration; attached to legal document in a single pdf (which has good 3D capabilities) or in an extension of (city)GML for 3D parcels, or….?		Pdf
9.7. Are the 3D parcels somehow checked for spatial validity; e.g. volume is closed, does not overlap with neighbour volume (and also no unwanted 3D gaps)?		
9.8. Do you have examples of (prototype or production) 3D survey plans available?	Yes	Yes
9.9. Are any reference objects visible on the survey plan (e.g. real buildings, roads, that is 3D topography)?	Yes	Yes
9.10. What form of 3D data acquisition is used (CAD, terrestrial surveying, sketches, stereo/oblique images, laser scanning,…)?	Any possible.	Any possible.
9.11. What software do you use for creating and processing survey plans? Any 3D capabilities included and used?	Any meeting input criteria.	Any meeting input criteria.
9.12. Can 3D parcels be subdivided, consolidated or nullified?		Yes. Subdivided or consolidated.

9.13. Is there any existing technical circular or directive to assist Surveyors in 3D data collection in the field?	Yes.	Yes
9.14. Are the surveyors required to undertake a field survey for 3D cadastral data?	No	Yes
9.15. Are building construction plans used to compile 3D cadastral information for apartments?	Yes	Yes
9.16. Is 2D/3D field survey done by private licensed surveyors or by government surveyors?	Both possible, but usually private.	Both possible, but usually private.
9.17. Are plans of survey created for each new 2D/3D parcel or are they updated in an index map or a cadastral database.	Yes	Yes
9.18. Do you show dimensions or isometric views of 3D parcels on survey plans (do you also store this in a database)		Yes for dimensions.
9.19. Any other survey plan issues?		

10. Dissemination of 3D Cadastral information

	Status 2014	Expectations 2018
10.1. Is there a general purpose web-based dissemination of 2D cadastral (graphical or text) information (e.g. a portal for the public or for professionals)? If yes, does it include 3D data?	Cadastral data are disseminated via country geoportal and often reginal geoportals. 3D data are not included.	Cadastral data are disseminated via country geoportal and often reginal geoportals. 3D data are not included.
10.2. Are specific file formats or standards used to distribute 3D Cadastral information? (e.g. LandXML, CityGML, BIM/IFC, 3D pdf,…)		
10.3. Are there specific cartographic styling rules for representing 3D cadastral plans, or to represent 3D cadastral objects on 2D cadastral maps?	No	No
10.4. Are there specific cartographic styling rules for 3D cadastral maps (models; e.g. as disseminated in 3D pdf)? If yes, are there 3D specific cartographic rules developed or being developed?	No	No
10.5. Is the 3D Cadastral information accessible in integrated manner with the 2D Cadastral information?	No	
10.6. Are there specific symbols on the 2D cadastral map (paper, digital or web-based) indicating the presence of 3D Cadastral objects (and in web-context perhaps even linked)?	No	No
10.7. Is the legal information (RRRs and Parties) available in integrated manner in dissemination portal with the 3D Cadastral objects? (even if source of legal data may be a different organization, but then use information infrastructure approach)	No	No
10.8. Are 2D/3D cadastral data available to the general public or just to the relevant parties?	2D data - Only graphical information (including parcel identification) is available to general public via geoportals. No personal data is available.	2D data - Only graphical information (including parcel identification) is available to general public via geoportals. No personal data is available.
10.9. Any other 3D cadastral information dissemination issues?		

11. Statistical information

This part of the questionnaire refers to statistical information (and is most relevant for jurisdictions with parts of 3D Cadastre registration operational, but all are encouraged to complete this section, and especially the expectations for 2018).

	Status 2014	Expectations 2018
11.1. What is the smallest 2D and 3D parcel that is present/ allowed to be registered in the land administration?	No such restriction in 2D	
11.2. What is the largest 2D and 3D parcel that is present allowed to be registered in the land administration?	No such restriction in 2D	
11.3. What is the typical (or average) size of 2D and 3D parcels which are registered in the land administration? Subdivide by nature of 3D parcel when relevant (e.g. related to building, apartment, airspace, tunnel,…)	Vary significantly, depending of the region (2D parcel).	
11.4. How many 2D and 3D parcels do you currently have in your land administration?	35 800 992 - 2D parcels (31.12.2013)	
11.5. Which year did you start registering 3D parcels in the land administration?		
11.6. What is the ratio of 3D parcels in rural vs. urban areas?		
11.7. Please specify names of cities or towns or suburbs or regions or locations where there are significant numbers of 3D parcels.		
11.8. Please provide the following data: (a) Size of jurisdiction in square kilometres (b) Current number of 2D parcels (c) Current number of 3D parcels (d) Current population	Poland (data on end of 2013) a) 312 679 b) 35 800 992 c) 0 d) 38 496 thousands	
11.9. Approximately what are the proportions of various types of the 3D parcels (related to apartments, subsurface parking, subsurface shopping centres, bridges, tunnels, airspace, utility networks, etc)?		
11.10. Approximately what surface area of the jurisdiction is affected by 3D parcels (the total area of all the footprint of all 3D parcels).		
11.11. Any other interesting statistical fact(s)?		

12. Reflection

This section is only relevant in case also in 2010 the 3D cadastres questionnaire for your jurisdictions was completed (otherwise skip this section).

	Remarks
	Remarks
12.1. Compared to the 2010 expectations, which 3D land administration developments did go faster than expected?	No
12.2. Same question, but now, which developments did go slower than expected?	The 3D cadastre ideas got quite a big popularity, especially (but not only) in academic community but they have not not followed by legal regulations
12.3. If some (limited) form of 3D Land administration functionality has become available, what are the observed benefits? And for who?	Gives the general building parameters. Enables apartments units general localization within the building (apartment units complex).
12.4. What are the (top-3) challenges of issues to be addressed to realize further 3D Land administration progress?	Formal definition of 3D cadastral objects in legal regulations. Pilot project. Creating at least circulars for 3D cadastral surveys.
12.5. Any other reflections?	

13. Other Issues

Please include any other issues that may be of interest in an international context. For example, in some foreign jurisdictions 3D parcels can only be separated by horizontal planes.

	Remarks
13.1. Country (State, Province)	
13.2. Your name, function/position and your organization	Jarosław Bydłosz, PhD, lecturer and researcher Agnieszka Bieda, PhD, lecturer and researcher Anita Kwartnik-Pruc, PhD, lecturer and researcher AGH University of Science and Technology,
13.3. Contact details: address email, telephone	AGH University of Science and Technology, 30-059 Kraków, al. Mickiewicza 30, paw. C-4 bydlosz@agh.edu.pl , bieda@agh.edu.pl , + 48 12 617 22 67 akwart@agh.edu.pl , + 48 12 617 33 26
13.4. Other issues	

References

ISO 19152:2012 'Geographic information - Land Administration Domain Model (LADM),
http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=51206

Peter van Oosterom, Jantien Stoter, Hendrik Ploeger, Rod Thompson and Sudarshan Karki (2011). World-wide Inventory of the Status of 3D Cadastres in 2010 and Expectations for 2014. presented at the FIG Working Week 2011, Marrakech, 21 p.
http://www.gdmc.nl/3DCadastres/literature/3Dcad_2011_02.pdf

Sudarshan Karki (2013). 3D Cadastre Implementation Issues in Australia. MSc Thesis, University of Southern Queensland (Master of Spatial Science Research), 162 p.,
http://eprints.usq.edu.au/23560/1/Karki_2013_whole.pdf