

Groundwater Management in Land Administration

A Spatio-temporal Perspective

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- Groundwater Regulations across the World;
- Groundwater modeling: hydrologic and land administration perspectives;
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Groundwater Resources

- Benefits from the use of groundwater:
 - A revolution in irrigation, positively impacting the lives of millions of rural farmers;
 - Allowed farming in semi-arid regions, increasing the gross cultivated area.
- Threats from the overexploitation of a scarce resource:
 - Land Use changes affect aquifer recharge areas;
 - Lack of an integrated land – groundwater management;
 - Climate changes are negatively impacting recharge

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Rights to Groundwater

- Two main legal traditions on land and water rights:
 - Civil Law Tradition:
 - Groundwater is the property of the owner of the land above it;
 - There are dispositions on the flow of surface waters, but not on groundwater.
 - Common Law Tradition:
 - A landowner is entitled to sink a borehole or well on his land to intercept groundwater;
 - There are no disposition enabling a landowner to maintain an action against another interfering with the supply of groundwater.

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Rights to Groundwater: inadequacies

- Consequence of modern drilling techniques:
 - Approaches of the main legal traditions no longer offer a viable means of effectively regulating the use of groundwater.
- Example from Texas:
 - Traditional land-based approaches were unable to prevent depletion of aquifers (60% of water used for irrigation and urban uses).
- International Groundwater Law:
 - Few legal instruments contain groundwater specific provisions; fewer address groundwater exclusively.

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Groundwater Regulations across the World

- Recent change from a case law example in India (Kerala State vs. Coca Cola):
 - The right to use groundwater remains with the ownership of land above it;
 - Extraction rights should be curbed by the State if the use is considered excessive.
- Radical approach in Spain and Mexico:
 - Groundwater became a national property. Water use rights must be registered;
 - It has been proved difficult to enforce registration and thus, the new legislation.

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Groundwater Regulations across the World (2)

- The Alaska Water Use Act:
 - A water right covers surface or ground water. Becomes appurtenant to the land where the water is being used.
- Extending riparian rights in China:
 - Through riparian rights, any person owning land on river banks acquires water use rights;
 - Any drawing of water for family use, livestock drinking, emergency uses or minor demands do not need permits;
 - There are no legal principle to restrict groundwater abuse.

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Groundwater Regulations across the World (3)

- European Groundwater Directive:
 - Groundwater collection and protection areas exist, in which land use is partly restricted.
- Netherlands Use Permits:
 - Groundwater use permits are issued by the Provinces (and Water Boards). For minor extractions, no registration and permit is required;
 - For larger quantities, a registration is required, and for even larger extractions, also a permit;
 - There are few spatial aspects within such regulations.

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Groundwater Regulations across the World

- Multiple registrations in Portugal:
 - For deep aquifers with water of drinking quality, the use is regulated as a Geological Resource;
 - Extraction of water (surface or groundwater) in the Public Water Domain requires use permits issued by the Waters National Institute INAG;
 - Groundwater not included in above categories is open to private use and conforms to Civil Law tradition.

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Groundwater Modeling

- Spatial Information Science support
 - GIS and Remote Sensing are making it possible to represent phenomena in three dimensions and to simulate temporal patterns;
 - Three dimensional analysis based on process models can benefit the formulation of new laws and regulations;
 - According to India planning commission report, the use of these tools can help to get a more accurate, holistic and efficient groundwater management plan.

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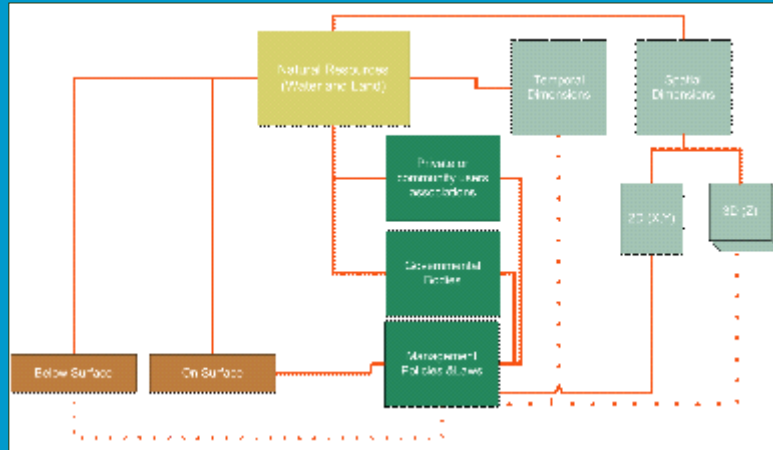
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Conceptual Diagram

Current policies & laws regarding natural resources



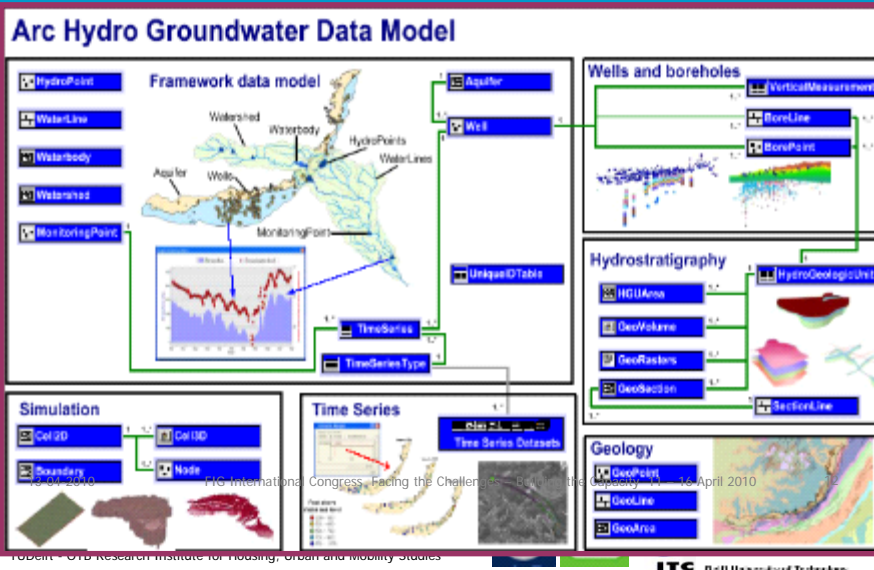
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Hydrological Modeling

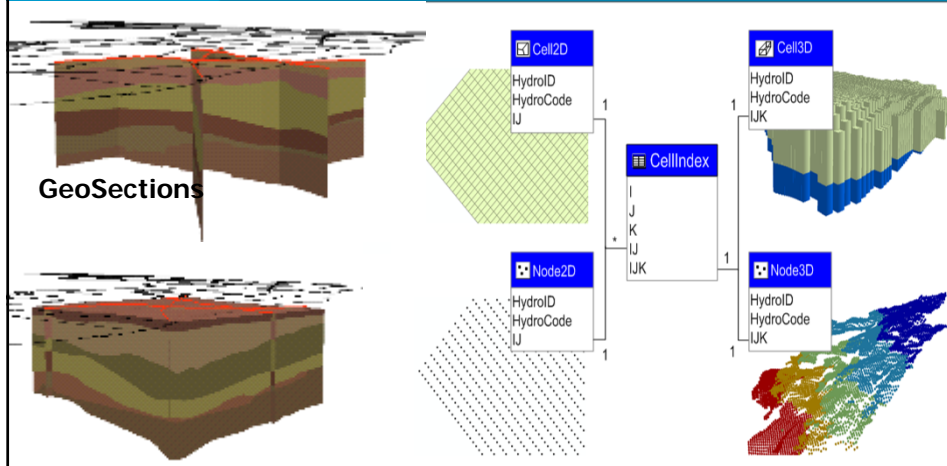
Temporal and 3D Groundwater Data Modelling from ESRI



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3D Geometric Calculations with Arc Hydro

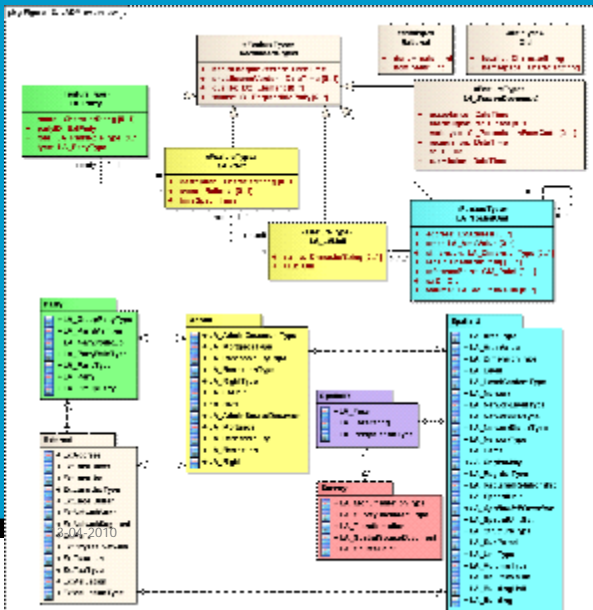


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Land Administration Modeling



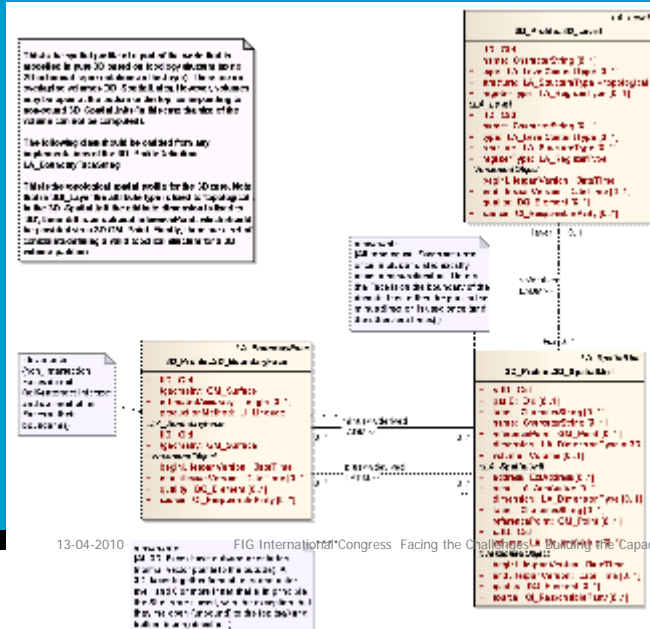
LADM Core Model Representation and involved packages (from ISO/TC211, 2009)

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LADM 3D type of spatial units

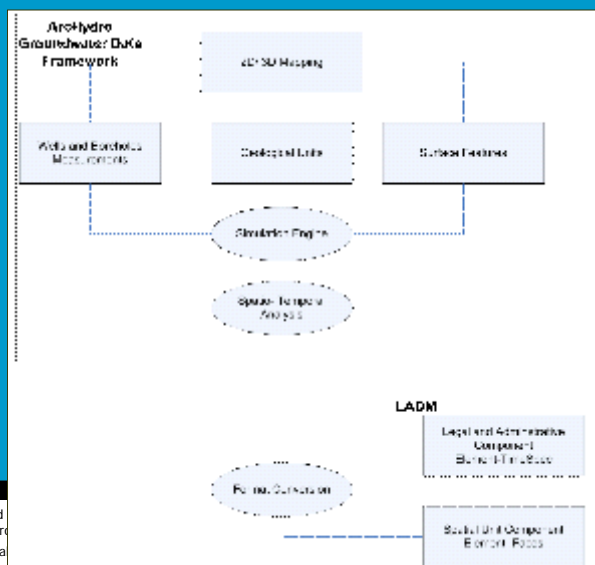
The 3D topological spatial unit profile



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Integrating hydrological and land administration perspectives



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Modeling Examples

- Use Cases
 - Private use of groundwater for a certain recurring pattern (time share in water use);
 - Private shared use of a collective resource (a serving groundwater parcel) [→] ;
 - Private groundwater extraction lease;
 - Public use of groundwater for a certain recurring pattern (time share in water use);
 - Public use of private groundwater for a limited time period (extending requisition to water rights).

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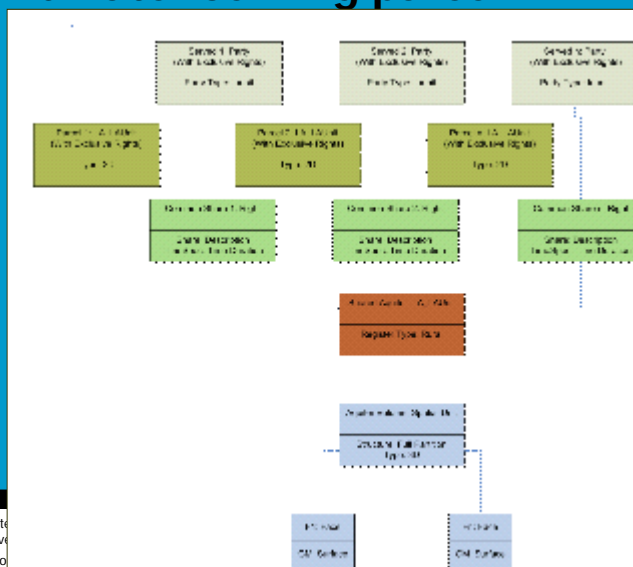
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Instance Level for a groundwater serving parcel



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Conclusions and Recommendations

- Advancements in Spatial Information Science can provide solutions for groundwater issues;
- It is essential to include spatio-temporal dynamics in the standard data models;
- An integrated perspective can promote greater sustainability in the use of such resources;
- Future research should focus:
 - More use cases reflecting concrete situations in diverse countries, reported using a common modeling framework;
 - A generic Groundwater Rights Profile could be derived for the legal component of LADM;
 - A generic Aquifer Spatial Profile could be derived for the spatial unit component of LADM.

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