Contribution of Remote Sensing and Geographical Information System to Groundwater Ownership Laws

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Abstract: For sustainable use of available groundwater resources the groundwater ownership laws are incessantly evolving over the last century. One of the five "rules", the Absolute Dominion rule, the Reasonable Use rule, the Correlative Rights doctrine, the Restatement of Torts rule, and the Prior Appropriation doctrine are currently prevalent. The U.S. Supreme Court has documented some form of the private property rights in water. Nevertheless, it has held that these rights are not absolute. Groundwater operating bodies frequently regulates drinking water quality and pollution; on the other hand it has not distinctively addressed the groundwater protection.

History of groundwater laws reveals that lack of knowledge and data required for decision making are generally not available. Progressively understanding of ground water is increasing. Experience has indicated that collection, storage, analysis and dissemination of data using conventional techniques are difficult and costly. Under these circumstances it is expected that use of remote sensing can be of great help in evolving appropriate law for groundwater ownership and usage.

INTRODUCTION

The origins of groundwater law can be traced to nineteenth century English and American courts when most decisions were based on the law of property. To a much greater extent than other bodies of law such as torts, contracts, criminal law, etc., the development of groundwater law has been profoundly affected by scientific advances and our own understanding of hydrology. Most of the restrictions on groundwater use enacted by legislatures since 1931 were physical in nature and have been borrowed from the law of oil and gas. As a result, many of the regulations concerning ground water involve well spacing and the amount of water that can be withdrawn. "While some legislatures have been active as to ground water, the majority of American jurisdictions usually still leave the initiative for change with their courts."

It has been observed that the groundwater ownership laws are frequently surfacing to respond to scientific, geo-political and environmental developments. Some times in some areas inconsistency with older groundwater laws is also observed. Consequently, it is expected that the future groundwater law will be progressively more multifaceted.

Further, the groundwater availability, usage and environmental impacts are not constrained by administrative boundaries. As a corollary, inconsistent laws in contiguous areas push added impediment. The current trend has been away from the absolute ownership doctrine, towards a reasonableness or correlative rights approach. Though this trend is to be supported nevertheless, individual rights should be considered when determining "reasonableness."

Groundwater law should take into account the greater impact on groundwater resources of demands of large volume users compared to usage by household or smaller capacity wells. Any restrictions on groundwater usage should recognize these differences. Restrictions on individual well-owners should be implemented only as a last resort and supported by proof of "looming" depletion or contamination of the groundwater source. Administrative boundaries generally share common widespread underground water sources.

CATEGORIES OF GROUNDWATER LAW

As the law of groundwater has evolved, states have generally followed one of five "rules" in this area: the Absolute Dominion rule, the Reasonable Use rule, the Correlative Rights doctrine, the Restatement (Second) of Torts rule, and Prior Appropriation.

Absolute Dominion Rule

The Absolute Dominion rule (also referred to as the "Absolute Ownership rule" or the "English rule") was initially applied in twenty-eight states; however, it has been replaced in many jurisdictions (Crowford and Linsley, 1966). "Under this doctrine, a landowner may intercept the groundwater which would otherwise have been available to a neighbouring water user and may even monopolize the yield of an aquifer without incurring liability."

The English rule was established by the Court of Exchequer in Acton v. Blundell, in 1843. Most, but not all states, have rejected the rule, often on grounds that it immunized a landowner who removed the percolating water for purely malicious reasons. Eight states have either formally adopted or have indicated a preference for the Absolute Dominion rule. These include: Connecticut, Indiana, Louisiana, Maine, Massachusetts, Mississippi, Rhode Island and Texas.

Reasonable Use Rule

The Reasonable Use rule (also referred to as the "American rule") is a modification of the Absolute Ownership doctrine. The Reasonable Use rule is followed in many eastern states. This doctrine limits a landowner's use to beneficial uses having a reasonable relationship to the use of his overlying land. The rule has been described as "essentially the rule of absolute ownership with exceptions for wasteful and off-site use.

Correlative Rights Doctrine

The Correlative Rights doctrine is based on the Reasonable Use rule. The leading correlative rights case involved a dispute between agricultural users and a city water supplier in the California case of

Katz v. Walkinshaw (Ragan and Jackson, 1976). The Katz decision provided the two prongs of the Correlative Rights doctrine. First, a water transporter "can protect its right against wasteful or malicious pumping by local users and against interference by other transporters (Saaty, 1988)." Second, disputes between local users during times of insufficient supply would be settled by a court by allowing each "a fair and just proportion" of the available water (Satapathy et al., 1977).

As opposed to the Reasonable Use and Absolute Dominion rules, the Correlative Rights doctrine does not envision an absolute right of access to ground water or an unlimited right to pump (Shahlace et al., 1991). Rather, this doctrine maintains that the authority to allocate water is held by the courts. As a result, owners of overlying land and non-owners or transporters have co-equal or correlative rights in the reasonable, beneficial use of groundwater. A major feature of the Correlative Rights doctrine, however, is the concept that adjoining lands can be served by a single aquifer. Therefore, the judicial power to allocate water permits protects both the public's interest and the interests of private users.

The Restatement of Torts

The Restatement of Torts rule (also referred to as the "Beneficial Purpose doctrine") has been characterized as a combination of the English and American rules. This rule was adopted by the American Law Institute ("ALI") in the Restatement (Second) of Torts § 858. The rule merges the English concept of no liability with the American standard of reasonable use. "The result merges prior groundwater law into a standard intended to more equitably meet growing demands on water resources."

The Restatement (Second) of Torts section 858 provides: Liability for Use of Ground Water

1. A proprietor of land or his grantee that withdraws ground water from the land and uses it for a beneficial purpose is not subject to liability for interference with the use of water by another, unless
   (a) The withdrawal of ground water unreasonably causes harm to a proprietor of neighbouring land through lowering the water table or reducing artesian pressure,
   (b) The withdrawal of ground water exceeds the proprietor's reasonable share of the annual supply or total store of ground water, or
   (c) The withdrawal of the ground water has a direct and substantial effect upon a watercourse or lake and unreasonably causes harm to a person entitled to the use of its water.
2. The determination of liability under clauses (a), (b) and (c) of Subsection (1) is governed by the principles stated in §§ 850 to 857. Three states have either formally adopted or have indicated a preference for the Restatement of Torts doctrine.

Prior Appropriation

Pursuant to this rule, the first landowner to beneficially use or to divert water from a water source is granted priority of right. The quantity of ground water a senior appropriator may withdraw may be limited based on reasonableness and beneficial purposes.

POLICY

1. Groundwater law – whether federal or state – should take into account the greater impact on groundwater resources of demands of large volume users compared to usage by household or smaller capacity wells. Any restrictions on groundwater usage should recognize these differences.
2. States that continue to adhere to the "English Rule" should be encouraged to adopt a "reasonable use" or "correlative rights" approach to groundwater management. These approaches balance the individual rights of landowners with those of other users of the same aquifer. At the same time, these doctrines promote the most efficient use of a vital natural resource.
3. States, through their legislatures or their courts, should make a definitive, modern pronouncement regarding which doctrine(s) is currently being followed in their state. Such a pronouncement would provide clarity and predictability in those states whose sole pronouncement on the issue of groundwater rights are common law judicial decisions from the late 19^{th} or early 20^{th} centuries.
4. Restrictions on individual well-owners should be implemented only as a last resort and supported by proof of "imminent" depletion or contamination of the groundwater source.
5. States that share common underground water sources should develop a regionalized approach to water ownership issues to ensure equity.

One of the basic predicaments that arise while decision making is the non-availability of the required data set. This problem to a large extent can be solved by using remote sensing. Remote sensing refers to techniques used for collecting information about an object and its surroundings from a distance without physically contacting them.

Normally, this gives rise to some form of imagery which is further processed and interpreted to produce useful data for application in agriculture, archaeology, forestry, geography, geology, planning and other fields. Information about the object concerned is obtained by a sensor system located on a satellite or aircraft, which receives electromagnetic radiation which has been either emitted by the object or has interacted with the object. Here we will consider the latter case, in which the source of radiation is not the object. For carrying out decision making study remote sensing data sets can be utilized for extracting and generating the basic data required for the study. These are listed in Table 1. Remote sensing applications to study the changes in the land cover are being described in Table 2.

Table 1. Data and their source

Sl. No.	*Data*	*Data source*
1	Topographic Data	Topographic Maps (1:250,000, 1:50,000 Scales), Ground Surveys, Aerial Photographs (1:50,000 Scale), Satellite Data products (FCC at 1:250,000, 1:50,000 Scales)
2	Physiographic	
3	Natural Resources	
4	Soil Characteristics	Conventional data sources, Ground Surveys, Aerial Photographs (1:50,000 Scale), Satellite Data products (FCC at 1:250,000, 1:50,000 Scales)
5	Land Use/Land Cover	
6	Land Capability	
7	Ambient Environmental Setup	
8	Socioeconomics	

Table 2. Remote sensing application to study land cover changes

Sl. No.	Activity causing changes	Type of land transformation	Scope of remote sensing applications	Approach of study
1.	Agricultural practices	The soil changes its physical and chemical properties. The topsoil is easily eroded and land becomes saline/alkaline or acidic. In the areas surrounding rural settlements natural vegetation cover is also lost due to exploitation, for firewood and grass. Wind storms easily carry away top soil during dry season when there is no vegetation and soil is loose and dry.	Mapping of land use and land cover in agricultural areas along with monitoring of ecological factors.	Analysis satellite data product 1:50,000 or larger scale.
2.	Excessive irrigation and repeated cultivation	Due to excess water, land becomes saline/ alkaline due to presence of dissolved salts in water.	Mapping of irrigated field, soil salinity/ alkalinity	Analysis of satellite data products at 1:50,000 scale or larger
3.	Urbanisation	Due to increase in population urban areas are rapidly growing and encroaching agricultural land and forested areas as a result, natural ecosystem is degraded.	Monitoring of urban sprawl.	Analysis of satellite data products at 1:50,000 scale or larger
4.	Industrialization	Large amount of natural lands are converted into industrial area destroying natural ecology. Waste materials like ash, chemicals, etc. are dumped on land causing pollution of land. Degradation of forest and vegetation leading to deforestation and spread of desertification. Increased soil erosion because there is no vegetation to hold the soil.	Monitoring of industrial land use patterns, pollution and its effects on ecology and vegetation. Estimation of land being converted into industrial areas. Mapping of forest types, extent, density and changes	1:50,000 or 1:250,000 scales.
5.	Overgrazing	Grasslands are converted into thorn lands and land becomes barren leading to desertification and erosion. In hilly terrain overgrazing can cause land slips and landslides.	Monitoring of vegetation cover and soil characteristics. Mapping of topography and vegetation cover	Landsat MSS/TN data in 1:100,000 scale or higher scale. Aerial photographic surveys for mapping topography.
6.	Heavy rains and floods	The soil is washed away and deposited elsewhere causing soil erosion due to formation of ravines and gullies. Land slides occur in hilly areas. Water logging and submergence of land causing soil degradation due to rise of water table resulting in salinity/alkalinity. Silting of lakes, tanks and ponds with eroded soil. This causes overflow of water during rains.	Flood plain mapping river system and river course monitoring. Mapping of drainage characteristics. Mapping of land topography in flood prone areas. Mapping of watershed areas and drainage characteristics. Mapping and monitoring of characteristics of watershed and water-bodies.	Visual and computer aided interpretation at 1:250,000 scale for flood plain mapping. Landsat MSS/TN data of bands 3 & 4 in 1: 250,000 or higher scale for monitoring drainage characteristics. Photogrammetric surveys using aerial photographics data. Landsat TN data in 1:50,000 scale for field level applications.
7.	Excessive heat and lack of rainfall (droughts)	Increase in acidity and degradation of soil due to lack of moisture. Destruction of vegetation cover leading to soil erosion and degradation.	Mapping of soils. Mapping of vegetation cover	Visual and computer aided analysis of data of band 2,364 combinations in 1:50,000 scale; 1:250,000 scale can be used for regional studies. Visual and computer aided vegetation index analysis of satellite data.

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