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WATER, LAW, SCIENCE

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Abstract

In a world with water resources severely impacted by technology, science must actively contribute to water law. To this end, this paper is an earth scientist's attempt to comprehend essential elements of water law, and to examine their connections to science. Science and law share a common logical framework of starting with *a priori* prescribed tenets, and drawing consistent inferences. In science, observationally established physical laws constitute the tenets, while in law, they stem from social values. The foundations of modern water law in Europe and the New World were formulated nearly two thousand years ago by Roman jurists who were inspired by Greek philosophy of reason. Recognizing that vital natural elements such as water, air, and the sea were governed by immutable natural laws, they reasoned that these elements belonged to all humans, and therefore cannot be owned as private property. Legally, such public property was to be governed by *jus gentium*, the law of all people or the law of all nations. In contrast, *jus civile* or civil law governed private property. Remarkably, *jus gentium* continues to be relevant in our contemporary society in which science plays a pivotal role in exploiting vital resources common to all. This paper examines the historical roots of modern water law, follows their evolution through the centuries, and examines how the spirit of science inherent in *jus gentium* is profoundly influencing evolving water and environmental laws in Europe, the United States and elsewhere. In a technological world, scientific knowledge has to lie at the core of water law. Yet, science cannot formulate law. It is hoped that a philosophical understanding of the relationships between science and law will contribute to their constructively coming together in the service of society.

INTRODUCTION

In the cosmos, the Earth is a very small object among giant planets, the sun, the stars, and the galaxies. Yet, it is remarkably unique. Life, as we know it, does not appear to exist anywhere else in the cosmos except planet Earth. Among the many reasons for this uniqueness, water occupies a preeminent position. As the ancients intuitively recognized, and as modern science has rationally established, life originated in water in the distant past due to causes as yet unknown, and has proliferated and flourished over geological time because of water. From the cytoplasm to blood, vital fluids of all living things are made of water. And, through the phenomenon of the hydrological cycle, water controls all geological and biological processes necessary for life's sustenance. Throughout history, water has awed and challenged the imagination of mystics, poets, philosophers, scientists, and engineers. To fully understand water, one has to delve into every branch of human knowledge, an overwhelming task.

At the beginning of the twenty-first century, the world faces a water crisis, both of quantity and quality, caused by massive human intrusion into the functioning of the hydrological cycle through technological innovations. Overcoming the crisis by means of wise water management poses formidable challenges. For their resolution, these challenges require a constructive, coordinated effort of diverse expertise ranging from the sciences to the humanities. It is becoming increasingly clear that science and society must come together in unprecedented ways to achieve a civilized sharing and a wise management of the world's finite water resources. In this context, it behooves earth scientists to reach beyond their science and comprehend water's human dimensions. Accordingly, this paper is an attempt by an earth scientist to decipher philosophical connections between water law and science.

Historically, the core concern of law has been to assure the rights of the individual (Sandars, 1917, p. 5; Birks and Mcleod, 1987, p. 37). Property, ownership, and rights to enjoy private possessions have played such an important role in society that law is mostly devoted to relationships among persons, groups of persons, and the state. The notion of duty mainly evokes a mental image of responsibility in relation to human transactions. This mind-set might have been reasonable prior to the industrial revolution, when populations were small and human technology had marginal impacts on the human habitat. However, in the modern technological world, survival of human civilization demands a notion of duty that transcends mere human-human relations, to address human-Nature

interactions. Remarkably, the concept of duty in relation to Nature was thoughtfully addressed by the Roman legal scholars commissioned by Emperor Justinian of Constantinople who authored the Institutes, a comprehensive codification of jurisprudence, during the sixth century A.D. They fundamentally distinguished between law of state (*jus civile*) and law of all peoples or law of all nations (*jus gentium*). The former was particular to the state with whose name it was associated, and focused on inter-human relations. The latter, applicable to all nations, including the particular state, pertained to appropriate human conduct compatible with Nature's laws that transcend human control. This broad notion inspired the doctrine of public trust (that is, public property held in trust for the people by the sate) which has played an important role in water law over the centuries in Europe and the Unites States.

A rational understanding of connections between science and water law has to start therefore with a history of Roman law, and its influence through the centuries on modern western civilization. The doctrine of public trust, stemming from *jus gentium*, has historically proved to be a thread that has united civil law in Europe as well as common law in England and the United States. Meanwhile, contemporary imperative for sustainable water management is necessitating a move toward the watershed as the unit of water management, a unit that invariably crosses boundaries among states and nations. Watersheds have to be managed based on scientific principles. Accordingly, this paper starts with a brief look at the history of Roman law, follows its evolution through the centuries into modern water law in Europe and the United States, and ends with a discussion of the philosophical connections between science and water law.

From time immemorial, humans have intuitively felt the importance of water deeply enough to treat water and Nature almost synonymously. Water was considered the source from which life began, and water was essential all forms of religious worship. Even Thales of sixth century B.C. in Greece who departed from theistic notion of Nature, considered water to be the source of everything. Modern science, based on observational experience, tells us that water is an extraordinary substance, with unusual physical and chemical properties which endow it with the ability to be an awesome geological and biological agent, eroding, depositing, dissolving, transporting, and nourishing.

Thus, religion and science are unanimous in considering water to be a unique, awe-inspiring phenomenon. Understanding water, either merely to satisfy human curiosity, or to devise ways of sustaining from it, challenges every branch of human knowledge from secular science, to aesthetics and art, to morality and faith. Just at a time when science and technology induce us to believe in our

ability to control Nature at will, water demands of us the need for humility in our perception of Nature. Understanding water, for curiosity or for survival, requires a collective effort in pooling our knowledge from the sciences to the humanities, and developing the skills to make judgements and decisions that will be equitable and civilized for individuals and for the community at large. This notion of pooling knowledge for common good lies at the core of what connects science and law in relation to water.

It is presumptuous for a single person to attempt to review and assimilate the vast literature on water in the sciences and in law. Yet, the complex modern world requires a broad comprehension of connections among widely disparate fields of knowledge. Accordingly, the overall ambition of this work is to present diverse ideas and connections on matters related to water, and leave it to the reader to reflect on them.

FROM THE ANCIENTS TO JUSTINIAN'S INSTITUTES

Nature, Gods, and Law

All ancient civilizations were awed by Nature, and recognized an imperative to subordinate social organization to its order. Living within Nature's bounds was identified with morality and law. Natural order was associated with one or more gods with super-natural powers. Gods conveyed norms of behavior to humans through chosen agents such as sages, priests, kings, and prophets. Prescribed religious rites helped to please the gods to assure prosperity and avoid calamities. Duty and morality therefore went hand in hand with religious rituals.

Jackson (1975) summarizes how ancient civilizations in the Near East and India perceived morality and law. In ancient Egypt, *ma'at* stood for 'order, right, righteousness, truth, or justice', although there was no specific word for law. In that society, *ma'at* was the substance on which the gods fed, and it was the king's daily offering to the gods. In Babylon no specific word denoted law. The sum of eternal truths on which the cosmos was founded was referred to as *kuttum*, while equity or the process by which the king secured equity, was referred to as *mesharum*. The king was divinely commissioned to formulate rules to implement *kittum*. In the Bible, God is the author of *torah*. *Torah* has a non-legal moral authority as indicated by the etymology of the word itself; the noun *torah* means to instruct or to teach. In Hinduism, the word *dharma* is defined as the duty to conform to the natural order of things. *Dharma* as revealed by the sages, has no constraining power, except

its own moral authority. It could become legally binding only through the instrument of custom or royal ordinance.

It is remarkable that these diverse civilizations shared a common value of adapting to Nature, a philosophy that is as valid today as it was in past millenniums. Nevertheless, the ancients' notion of natural order differs from the secular one based on science. The seeds of this departure from god-oriented perceptions were sown by Greek philosophers, starting with Thales. Rather than accepting laws meted out by gods, these philosophers conceptualized the behavior of the natural world in terms of cause and effect associated with impersonal forces. Matter was conceived as being made of indivisible atoms of different kinds, the combinations of which were responsible for all observed phenomena. This philosophy crystallized during the fourth century B.C. with Aristotle's logic and reasoning, laying the foundations of modern scientific thought. Over the next hundred years, Aristotle's logic was given a novel interpretation by the stoics, whose philosophy rested on a foundation of materialistic physics, with Aristotle's logic providing the theoretical method. The material universe was considered to be governed by absolute reason, identified with God. Consequently, virtue was life lived according to reason, and morality was rational action.

THE INSTITUTES OF EMPEROR JUSTINIAN

By the turn of Christian Era, Rome had accumulated an enormous body of legal decisions over more than thousand years. These early laws were founded on custom, and were referred to as *jus civile,* or Roman Law. Many commentaries were written through the centuries. According to Cicero (first century B.C.), divinity-oriented natural order was supplanted by *lex naturae* or law of Nature, inspired by the materialistic stoic philosophy of third-century B.C., notably Chrysippus (Sandars, 1917, p. xxiii).

The secular natural philosophy influenced Gaius in the second century A.D. who summarized and organized existing knowledge into a new concise literary form of *Institutionum* (or, the Institutes) to harness voluminous legal information into a simple form to facilitate comprehension and teaching of law. Gaius divided 'things' according to *in nostro patrimonio* (capable of private ownership), or *extra nostrum patrimonium* (not capable of private ownership). The latter belonged to all people (*communes*), the state (*publicae*), to no one (*nullus*), or groups of persons (*universitatis*). Of things that are common to all, for example, any person may inhale the air or float his ship in any part of the

sea (Sandars, 1917, p. 90-91).

During the sixth century A.D., Emperor Justinian of the Byzantium, with its capital at Constantinople, drew upon the genius of his minister Tribonian to save and transform the Roman law library. Aided by professors Theophilus and Cratinus of the Constantinople law school and professors Dorotheus and Anatolius of the Berytus (modern Beirut) and twelve other legal scholars, the Tribonian commission produced a three-volume work, collectively known as *Corpus Juris Civilis* (Body of Roman Law). The shortest, but the most celebrated of these was *Institutionum sive Elementorum* (The Institutes or Elements) known widely as the Institutes of Justinian, promulgated in 533 A.D. The Institutes, following the format of Gaius' second century work of the same name, was a concise and systematic overview of the complex voluminous body of Roman law. Justinian's vision was that the Institutes might serve as the first elements of the whole science of law (Sandars, 1917, p. 2). Through the centuries, the Institutes has proved to be the most influential law book ever written (Birks and Mcleod, 1987).

The Institutes start with the premise that justice is the perpetual wish to render everyone his due (Institutes, I.1.1). In keeping with its goal of portraying the elements of the whole science of law, classification was central to the organization of the Institutes. Public law concerned itself with the governance of the Roman Empire, while the concerns of private law were the interests of individuals (Institutes, I.1.4). Private law, in turn, consisted of three elements, namely, natural law (*lex naturae*), law of all peoples (*jus gentium*), and law of the state (*jus civile*). Here, natural law is the expression of right reason inherent in nature and man, having a binding force of law. *Jus gentium* is the law that is common to all nations including Rome, stemming from the fact that all men have to abide by right reason inherent in natural law. For this reason, law of nature and *jus gentium* can be grouped together (Sandars, 1917, p.7).

Law is about persons, things, and actions. Here, a fundamental distinction is made between things that can be privately owned from those that cannot. In section II.1.1 the Institutes declares,

> *"By the law of nature these things are common to mankind – the air, running water, the sea, and consequently, the shore of the sea. No one, therefore is forbidden to approach the seashore, provided that he respects habitations, monuments, and buildings, which are not like the sea, subject only to the law of nations."* (Sandars, 1917, p.90).

Here, 'law of nations' is *jus gentium*, also translated as law of all peoples (Birks and Mcleod, 1987, p.55). It is clear that law of Nature dictates what things common to mankind are. In sixth century Europe, navigation and fishing were important to all humans, and hence the Institutes proclaimed that navigation in rivers and the seas, fishing, and using the sea coast and the banks of rivers were common to all by *jus gentium* (Institutes, II.1.2-5).

Usufruct (*de usufructu*) is an important concept introduced in the Institutes. It is the right to use and enjoy things belonging to others, provided that the substance of the things used remains unimpaired. It is a right over a *corporeal* (or, material) thing. Usufruct perishes when the *corporeal* thing perishes (Sandars, 1917, Institutes II.4, p.125).

At a practical level of water management, Roman legislation gave consideration to different forms of surface water and groundwater, as shown in the following excerpt (Balis, 1934; excerpt translated by Panos Panagopoulos, personal communication, 2007). The general presumption regarding inland waters was that *aqua profluens res communis omnium est* (flowing water as well as river banks) belonged to all and cannot be appropriated. However, a distinction was made between *flumina publica* or public rivers, which had permanent flow, and *flumina privata*, or private streams, which had intermittent flow. This was done to protect the ownership of the (often dry) riverbed. Lakes in public rivers were considered public, as well as their banks; but artificial lakes or reservoirs would be private, if the owner had the right to use the water. Likewise the seacoast, defined as the part of the coast "up to the reach of the greatest winter wave", that is, the highest runup (because in the Mediterranean the highest waves generally occurred in the winter), was considered as common property and accessible to all – a clause that is still in force in Greek law. Groundwater was regarded as part of the subsoil, and hence owned by the owner of the property. It could be used even if it created deficits in lower properties, unless it was done on purpose (*animo vicino nocendi)*. Springs were considered as part of the subsoil and was the property of the and land owner. The owner had the right to use them, but if the water was left to flow freely (*aqua profluens*), it then fell under the provisions for surface water. Runoff water was appropriated by the owner of the land on which it took place, even if it formed a stream of intermittent flow. In the absence of other provisions, flow between adjacent fields was determined by the nature of the terrain (*natura agrorum*); the lower field is obliged to accept the flow from the upper field, and therefore actions in the upper field intensifying the flow downstream, or actions in the lower field obstructing the flow, were not permitted. As will be seen later, some of these concepts have been part of Spanish and French water codes until

recently, while others continue to exist even today.

From the foregoing, it is clear that at a philosophical level, the tenets of Roman Law, summarized below, serve as an inspiration as modern world strives to adapt to the constraints of a finite Earth.

- Inanimate Nature is amenable to comprehension by reason
- Human laws change with time, in accordance with changing social values
- Humans must adapt social organization to Nature's constraints.
- Interaction between Nature's laws and human laws necessitates a hierarchical division of legal systems into private law, public law, state law, and law of all peoples (law of nations; *jus gentium*).
- By embracing Aristotle's 'rational' Nature, the Institutes achieved a profound unification of science and law.
- On a practical level of water management, Roman Law showed a remarkable grasp of the nature of perennial and intermittent rivers, groundwater, springs, and irrigation.

Soon after publication of the Institutes in Latin, Theophilus published a paraphrase in Greek. The law school at Constantinople was closed in 717 A.D. and remained so until 866 A.D. The Roman Empire was lost to the passage of history when it was conquered by the Ottomans in 1453 A. D. In the west, knowledge of Justinian's legislation waned over the succeeding centuries, although it never completely died out.

PUBLIC TRUST AND ITS INFLUENCE

In a secular intellectual environment, the twelfth century witnessed a revival of interest in the Institutes in the universities of Italy, especially Bologna (established 1088 A.D.). The philosophical influence of Roman Law spread throughout Europe. *Jus gentium* attracted wide attention in regard to rights of the public in navigation, fisheries, and tidal lands,. The principle that such rights were superior even to that of the Crown, and that the Crown owned common property in trust for the people came to be known as public trust.

Through the following centuries, two great systems of law became established. Throughout

Europe, civil law, in the Roman sense of 'law of state' was followed, while in England common law was the tradition. Here 'common law' implies law common to all of England in contrast to local laws of shires. The difference between the two is that civil law starts with a set of abstract rules or tenets which form the basis of legal decisions, while common law relies on prior judicial decisions (precedents).

Twelfth and Thirteenth Centuries

Early in the twelfth century, Justinian's Institutes were translated into French (Althaus, 1978, p.10). Vacarius, who had taught at Bologna, taught law in England by 1150 A. D. (Birks and Mcleod, 1987, p.7). Prior to these, an eleventh century regional French law declared,

> *"the public highways and byways, running water and springs, meadows, pastures, forests, heaths and rocks ... are not to be held by lords .... nor are they to be maintained ... in any other way than that their people may always be able to use them."* (Sax, 1980, p.189).

The continuation of Roman Law philosophy is apparent. Meanwhile, the Norman kings of England had been levying tolls upon navigation users, and were exploiting fisheries. In 1215 A.D., King John responded to the petition of rebellious barons and granted at Runnymede the first Magna Charta, which limited certain rights enjoyed by the king, and forced the Crown follow certain legal procedures. As part of these, the royal exploitation of navigation and fisheries were abolished (Althaus, 1978, p. 24).

The first great book on English law, written in Latin, was Bracton's 'On the laws and customs of England' published during the middle of the thirteenth century. He stated,

> *"We have now spoken of the law of nature, the law of all peoples, and the law of the state. Since all the law of which we propose to treat concerns persons, things or actions under English laws and customs, and since <u>persons are the most important of these three in that it was for persons that all laws were made,</u> we must turn to persons first, starting with their various conditions and then giving the law applicable to them."* (Birks and Mcleod, 1987, p. 26, emphasis added).

This statement is revealing. It shows that law, by tradition, has placed the human person at its center. Therefore, it is understandable that *jus gentium*, which addresses natural laws that are beyond human control has not received as much attention as *jus civile*.

Roman Law spread to Spain from Bologna during the thirteenth century. Commissioned by Alfonso the Wise, a digest of Castilian-Spanish law known as *Las Siete Partidas* (the seven-part code) was compiled (Althaus, 1978). The *Partidas* stated,

> *"Everyman has a right to use the rivers for commerce and fisheries, to tie up to the banks, and to land cargo and fish on them."* (Stevens, 1980, p. 197).

Seventeenth to Early Twentieth Century

In a climate of enlightenment and reason, the seventeenth and the eighteenth centuries witnessed a strengthening of the influence of Roman Law in western Europe. In many law schools, its framework helped describe and teach civil law. Many text books were written whose influence has extended to modern legal thought. In England, the influence of Roman Law waned after the mid-eighteenth century, except for the establishment of public rights in tidelands. Public trust entered America through British common law and through French and Spanish influence.

Holland

In Holland, Grotius published *Inleiding tot de Hollandsche Rechtsgeleertheyd* (Introduction to the jurisprudence of Holland) in 1631. He showed that Roman Law was an authoritative source of many Dutch legal decisions. In 1642, Arnoldus Vinnius of the University of Leyden published *In quatuor libris Institutionum imperialium Commentarius academicus et forsensis* (known in short as Academic and Forensic Commentary). Vinnius' work was widely read in France and contributed significantly to the survival of the Institutes (Birks and Mcleod, 1987).

France

During the seventeenth century, the Ordinances of Louis XIV did much to foster a growing impression of the existence of a law common to all of France. Notable among these was the Edict of 1669 which institutionalized the distinction between navigable and non-navigable rivers,

and incorporated the former into the Public Domain of the State (FAO, 1975, p. 55). Soon, French law began to be taught at Avignon, Aix-en-Provence and other centers, based on the familiar scheme of the Institutes. François Boutaric published in 1738, *Instituts de l'empereur Justinien conférés avec le droit français,* He believed that the Justinian framework, duly accounting for the variations of national laws, was well suited for teaching. Later, Jean-Joseph published in 1785 *Eléments de Jurisprudence sur les loix romaine et celles du royaume* in which he followed the Institute's framework less rigorously. As a result of these developments, when Napoleon established a commission to draw up a comprehensive civil code (*Code Civile,* 1804*)*, the structure of Justinian's Institutes was adopted (Birks and Mcleod, 1987). As for groundwater, the civil code deemed it to be the property of the overlying land owner, as in Roman Law. Later, however, other laws were promulgated to limit this right (FAO, 1985, p.55). France continued to update its water laws starting from the late nineteenth century. Notable among these were the act of 1898 which constituted the first attempt towards an integrated water law, the Public Health law of 1902 which, for the first time, regulated the quality of groundwater for drinking purposes, the law of 1919 on the production and use of hydro-electric power, and law of 1935 which transferred deep aquifers in many areas of the Paris Basin to the Public Domain (FAO, 1985).

It is to be noted that France adapted the Roman concept of public trust in running water in an abridged manner. Thus, private ownership of water in non-navigable streams was permitted, except under special conditions of public interest. However, private ownership of water was subject to administrative control (Teclaff, 1985, p. 36).

United Kingdom

In Scotland, Sir George Mckenzie's *Institutions of the Law of Scotland* published in 1684 was the leading introductory text on Scottish law, until John Erskine of the University of Edinburgh published his celebrated text, *Principles of the Law of Scotland* in 1754, the twenty-first edition of which appeared in 1911. This text book and *An Institute of the Law of Scotland* published by Erskine in 1773 were both structured in the form of the Justinian Institutes (Birks and Mcleod, 1987).

In England, the common law system did not forge a strong connection with Roman Law. The last work of significance to discuss Roman Law was *Commentaries on the Laws of England* published between 1765 and 1769 by William Blackstone of Oxford University. However,

interest continued in public trust in tidal lands, with roots in Roman Law. In 1811, the trial court (Exchequer) held that the soil under the salt water between high-water mark and low-water mark was the property of the Crown, being always subservient to the public rights of the King's subjects. This public right could not be alienated even by the King (Althaus, 1978, p. 33).

By the middle of the nineteenth century, Britain had begun to experience the environmental impacts of rapid urbanization, industrialization, and unsanitary living conditions, especially in poor neighborhoods. Between 1831 and 1850, epidemics of water-borne diseases, including cholera, typhus and typhoid caused many deaths. In 1854, John Snow, a physician, traced a London cholera recurrence to a single well contaminated by nearby privy vaults (toilet facilities). Pollution of groundwater and surface water caused by unsanitary living conditions was a matter of great public concern. This led to the passage of what may be considered the first environmental protection legislations in the modern sense in England. Notable among these were the Public Health Act of 1875, and the Rivers Pollution Act of 1876.

Spain

In Spain, the second half of the nineteenth century was notable for the adoption of two water acts, one in 1866 and another in 1879. Both were incorporated into the country's Civil Code in 1889. Although much influenced in spirit by the thirteenth century *Partidas*, the Spanish Acts provided for some accommodation of private property rights. According to these Acts, two principles guided water regulation. The broad Roman Law notion that rivers, rain water, lakes, groundwater, springs and fountains, waters issuing from public drains, and waters flowing from private property were all recognized as being in the public domain was accepted. However, waters flowing along private lands were considered to be private property (as in Roman Law), as were waters from irrigation channels. The Civil Code distinguished between discovered and undiscovered groundwater. Discovered groundwater was private property if it occurred underneath private land, and public property otherwise. Undiscovered groundwater was considered *res nullius* (belongs to anyone). That is, it belonged to the discoverer, regardless of ownership of land. The Civil Code, with its provisions for private ownership for water would be in effect for nearly a century until the passage of the 1985 Water Act (Costejà et. al, 2002, p.7-8).

Germany

In Germany, water law did not evolve directly from Roman Law as it did in Spain and France. During the middle ages, German property law was rooted in the concept of *Regalien*, that nobility owned many natural goods in which citizens had a usufructuary interest. During the eighteenth and nineteenth centuries, Roman Law influence gave rise to property laws combining Germanic and Roman concepts, strengthening private property rights, and the concept of compensation for takings. But, common weal required that the medieval concept of *Regalien* be sustained. For example, the Constitution of Frankfurt declared in 1849 that roads, navigable streams, the shores of the sea and harbors are common property of the state. The priority of common weal over private rights was asserted in the Weimar Constitution of 1919 which stated that property obliges, and therefore its use shall equally serve the public weal (Kube, 1997).

At the turn of the twentieth century, natural resource laws and statutes reflecting these general principles governed the administration of various territories or states (Länder). There was no unified law for the nation as whole, until the promulgation of the Federal Water Code in 1957 (Kube, 1997).

United States

The influence of public trust entered the United States in three different ways. Following English common law traditions, public interest in navigable waters was made part of the Northwest Ordinance passed by the Confederate Congress in 1787. Article IV of the Ordinance provided that,

> *"The navigable waters leading into the Mississippi and Saint Lawrence, and the carrying places between the same, shall be common highways, and for ever free, as well to the inhabitants of the said territory as to the citizens of the United States, and those of any other States that may be admitted to the Confederacy without any tax, impost, or duty therefor."* (Althaus, 1978, p.98-99).

Inspired by this ordinance, public trust became part of the Constitution of many states west of the Mississippi that subsequently joined the Union. Additionally, English common law tradition also established that the beds of navigable waters and the rights to fish in them were part of public trust interests, and their sovereign attributes were inalienable in nature (Stevens, 1980, p. 200).

During the nineteenth century, the doctrine of riparian rights, which asserts that those who own lands adjacent to a stream have the rights to the flow of water became part of the law of various states of the Union. Although it is commonly assumed that riparian rights in the United States has its origin in English common law traditions, there is evidence that French Civil Law of early nineteenth century has also had its influence. Riparian rights in France is limited to non-navigable streams, while in the United States no such distinction is made (Teclaff, 1985, p.6,7)..

Independent of English common law, Roman legal influence and liberal notions of public interest in common resources was brought to Louisiana by the French, and into Arizona, New Mexico, Texas, and California by the Spanish via Mexico. By tradition, these laws are respected along with common law in these states.

Unlike Europe, a land that had experienced continuous habitation for millenniums, America was at this time a land, rich in natural resources, being settled by an energetic immigrant population aided by a technological revolution. Having displaced the pre-existing native peoples, the settlers saw possibilities of unlimited prosperity through conquest of land, water, and natural resources. To fully achieve the perceived economic potential, favorable laws had to be created to exploit natural resources justifiable beyond the scope of common law traditions. This need gave rise to a new form of "rights" to water, referred to as appropriation rights. Sometimes referred to as the Colorado doctrine, the general principle is that water rights are not associated with land ownership. A person who uses water beneficially from a water source has a right to a prescribed quantity of water. The first person to so use the water enjoys seniority in rights over later users. These rights can be sold or mortgaged, and are presumably granted in perpetuity. Although this philosophy runs counter to public trust, legal recognition of appropriation rights was the result of several contributing factors including economic good of the people, rights to property, trust or mistrust in governmental regulation, and faith in market forces. For these reasons, water laws in the western United States have evolved in unique ways during the second half of the nineteenth century to accommodate the spirit of public trust in public ownership of water, as well as to confer rights to ownership of water. In these states the government's administration of the public trust is more accurately described as a fiduciary relationship for conservation of the water resource to prevent waste and pollution and foster beneficial use of the public's water resource by as many users as possible.

However, over a span of a few decades, aggressive exploitation of water resources began to

seriously impact the environment. For example, in California, sediments generated by hydraulic mining choked stream channels of major rivers, exacerbating flood damage. Wasteful exercise of riparian rights stood in the way of hydro-electric power development. By the turn of the twentieth century, Californians realized that water could not be owned and exploited privately without serious detriment to public interests. To conserve water, avoid wastage and promote beneficial use, the voters of California approved a code in 1914 through a referendum, asserting State sovereignty over water, giving municipalities priority for water over agriculture and mining. A State Water Commission was established. All water users were required to obtain permits from the Commission. Unlike water rights which were granted in perpetuity, permits were issued for specific quantities of water for finite periods of time. In 1928, the voters of California went further and amended the state's Constitution, again through a referendum, declaring that water use must be reasonable and beneficial, and prohibiting wasteful and unreasonable use.

Tort

In law, the concept of 'tort' or civil wrong complements that of 'right'. While 'right' asserts a person's privilege to enjoyment, 'tort' enables a person to sue for legal remedy should the right to enjoyment be impaired. In common law, one of the oldest causes for action is 'nuisance', which denotes unreasonable impairment of right to quiet enjoyment. If the aggrieved party is the public, the result is public nuisance. Pollution of natural waters and harm to public health and safety constitute grounds for legal remedy on the basis of nuisance. Such remedy may either be in the form of compensatory monetary damages or in the form of injunction prohibiting the nuisance activity. Whether nuisance is established as fact by a jury or by a judge, determination of appropriate remedy involve value judgements. Two examples are instructive. In 1886, a Pennsylvania court held that a coal mining company whose runoff effluents adversely impacted drinking water, killed fish, and damaged downstream water uses in other ways was not liable for those damages on the grounds the coal company's benefit to the community was great compared with the trifling inconveniences to the others (Pennsylvania Coal Co. v. Sanderson 113 Pa. 126, 1886). In contrast, in 1913, a New York court shut down a major paper factory at the request of a down-stream riparian farmer who had demonstrated that he was adversely affected by the factory effluents (Whalen v. New York Bag and Paper Company, 208 N.Y. 1, 101 N.E. 805, 1913). During the 1980s, many companies discharging waste effluents into the Hudson river in the state of New York were successfully sued on grounds of public nuisance caused by pollution and impacts on aesthetic values (Cronin and Kennedy, 1997).

Incipient Environmental Movement

The second half of the nineteenth century witnessed a unique movement in the United States which led to the recognition that aesthetics, in addition to material benefits, is a public good. The first step in this direction was the creation by an Act of the Congress of the Yellowstone National Park in 1872, signifying that public lands were to be set aside and administered by the federal government for the benefit and enjoyment of the people. In 1908, when the federal government was ready to grant permit to the City of San Francisco to dam the Tuolomne River at the scenic Hetch Hetchy Valley in the high Sierra Nevada mountains, John Muir passionately opposed the project on grounds that sites of great natural beauty were national assets that belonged to the whole country, and hence must be preserved as such and protected from commercial exploitation. Muir conceded that human life was indeed more sacred than even great natural wonderlands, and that he would not object to the project if the Hetch Hetchy Valley constituted the only source of water supply to the city. He therefore argued that the public interest of the entire country must be protected until the City of San Francisco can demonstrate that Hetch Hetchy valley is the sole source of its water supply (Muir, 1908). Although Muir did not succeed in preventing the construction of the Hetch Hetchy project, his action pioneered an environmental protection movement that would strengthen five decades later.

Misconceptions about Groundwater

Until the beginning of the twentieth century, when groundwater hydrology became established as a scientific discipline, groundwater was regarded by courts as a mysterious and occult phenomenon (Frazier v. Brown, 1861) with little connection to surface water. These perceptions supported a nineteenth century American legal view that public trust is restricted to navigable waters and tidal lands. However, the concept of navigable waters was extended to include streams and rivers, beyond the common law limits of tidal waters. In the absence of scientific support, riparian concepts were extended to groundwater when neighboring lands owners experienced a general decline in available groundwater. In a 1903 decision, the California Supreme Court allotted to each owner a fair and just portion. These ‘correlative rights’ are mutual and reciprocal (Katz v. Wilkinshaw, 1903).

THE SECOND HALF OF TWENTIETH CENTURY

It seems likely that the second half of the twentieth century will be remembered as a period of major transition in regard to human attitudes concerning the Earth. Starting from the Industrial revolution two centuries earlier, humans had nurtured a hope that the Earth and its resources could be controlled at will through science and technology to enable accumulation of unlimited wealth. However, growing scientific evidence during the first half of the twentieth century began casting serious doubts on this hope. By the 1960s, a vigorous environmental movement was born in the United States with far reaching consequences on societal notions of well-being, common good, governance, and law. Within a decade, the emerging environmental consciousness had spread to Europe. The beginning of the twenty-first century is witnessing a concerted move to protect the Earth's natural resources such as air, water, biological habitats, and the land from human actions. The central notion of *jus gentium* that certain things belonged to all people (Institutes, II.1) is being generalized to accommodate emerging new scientific knowledge about the Earth and its biological systems.

United States

Although anticipated by John Muir a half century earlier, the vigor of the new movement in the United States was catalyzed by Rachel Carson's 1962 publication, Silent Spring, which, based on careful field observations, argued persuasively that the use of pesticides such as DDT to control mosquito-driven malaria had led to unacceptable destruction of bird-life. Over the next decade, many federal laws were enacted in the United States, designed to protect public resources such as air, water, wild rivers, and biological habitats. Soon thereafter, various states enacted similar laws to suite their individual needs.

A broad national framework for protecting the nation's environment was established by the National Environmental Policy Act passed by the Congress in 1969, with a goal of declaring a national policy to encourage productive and enjoyable harmony between man and his environment. The Act required that all branches of the federal government give proper care to the environment prior to undertaking any major project. An upshot was that all agencies were mandated to carry out Environmental Assessments and prepare Environmental Impact Statements for any contemplated project of significance. A year later, in 1970, the Environmental Protection Agency was created with a mission of establishing and enforcing environmental protection

standards, conducting environmental research, and providing assistance to others in combating environmental pollution. Among the many other federal legislations that were soon enacted, the following merit mention:

- wild and scenic rivers act of 1968,
- the federal water pollution control act of 1972, which, together with its 1977 amendment has come to be known as the Clean Water Act,
- the Endangered Species Act of 1973,
- the Safe Drinking Water Act of 1974,
- the Resource Conservation and Recovery Act of 1976, and
- the Pollution Prevention Act of 1990.

The Clean Water Act is the cornerstone of surface water quality protection in the United States. It does not deal directly with ground water nor with water quantity issues. The statute employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. The broader goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish and wildlife, and recreation in and on the water.

In the United States, development and management of water resources is a responsibility mostly vested with the state governments, with certain exceptions. These exceptions include waters associated with the lands reserved for the Native American people whose lands are held trust by the federal government with fiduciary responsibilities to act in their interests, water related to national parks, national forests, and military bases. In addition, several statutes such as Federal Power Act, Clean Water Act, and Endangered Species Act intrude on state responsibilities. Over the past two centuries, each state has developed its own water codes and statutes to complement common law precedents in regard to water rights. In so far as access to navigation and tidal lands are concerned, public trust is part of the Constitution of some states, and part of statutes of others. In many states, the legal status of groundwater is different from that of surface water. Whereas the use of surface water is strictly regulated with a permit system, groundwater is not subject to such a control. Groundwater is still deemed by many to be private property.

To meet the needs of adaptive, scientific management of water resources, the legislative

mechanism is used by the states to set in place appropriate statutes and water codes. Such legislative actions are supported by the Constitutional recognition in many states that all water within a state, above ground and below ground, belongs to the people, for whom the government holds it in trust. Such a trust carries with it a fiduciary responsibility of encouraging beneficial use of water without wastage, while simultaneously protecting the resource from damage so that its integrity can be preserved for the future. In keeping with this, there is a gradual move among states towards water management integrated over watersheds and groundwater basins.

It seems reasonable to state that the arid states of the western United States (e.g., Arizona, California, New Mexico, Texas) are now in a state of transition from a mind-set of vigorous exploitation to one of controlled development, conservation, and management. This transition, as one may expect, is a difficult one, requiring adjustment of attitudes towards water by various segments of society. Specifically, the expectation of 'rights' to water has to be balanced by responsibility demanded by common good. A consequence is that the courts in various jurisdictions are gradually expanding the scope of public trust to other beneficial values beyond navigability and fishing rights. The following three examples serve as illustrations.

Historically, the courts have restricted public trust benefits to commerce, navigation, and fisheries. But, in 1971, the California Supreme Court took an expanded view and extended public trust benefits to ecological preservation of tidelands, the rationale being that water law has to evolve to accommodate evolving scientific knowledge. It observed,

> *".... in administering the trust the state is not burdened with an outmoded classification favoring one mode of utilization over another .....The public uses to which tidelands are subject are sufficiently flexible to encompass changing public needs. There is a growing public recognition that one of the most important public uses of the tidelands– a use encompassed within the tideland trust–is the preservation of those lands in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area."* (Marks v. Whitney, 1971).

Perhaps the most celebrated public trust case relating to water is that of Mono Lake, a fully land-locked water body in the Sierras of California, with its highly saline water supporting a rare ecosystem. During the 1940s, the City of Los Angeles acquired lands bordering the feeders of

Mono Lake, and obtained appropriative rights to the waters of those feeders through a state permit issued in 1940. Exercising those rights, the City diverted all the waters bound for the lake to meet urban water needs. The resulting precipitous fall in the lake water level gravely threatened the fragile ecosystem of Mono Lake during the 1970s. The City of Los Angeles was sued. In its ensuing historic decision, the Supreme Court of California applied a rule previously suggested by a number of other courts that public trust is not merely a passive doctrine, but that there is affirmative duty on the part of the government to take public trust into account in the planning and allocation of water resources and to protect public trust uses whenever feasible. The court found that Mono Lake was a navigable water body, and extended public trust interests to the lake's non-navigable feeders. The court opined that the appropriative rights systems and the public trust system must be accommodated, implying that the appropriative rights system must be supported if feasible (Audubon Society v. Superior Court,1983).

In 2000, the Hawaiian Supreme Court took an even stronger position in favor of public trust than California. In the matter of Waihole Ditch water permit, the Court held that restriction of public trust to navigable and tidal waters offers only a partial picture of the water resources trust of Hawaii. Under the Hawaiian Constitution, the state has both the authority and duty to preserve the rights of present and future generations in the waters of the state. While recognizing the state's duty to strike a balance between private and public uses, the Court asserted that such a balance begins with a presumption in favor of public use, access, and enjoyment (Waiahole Ditch 94 Hawaii 97, 2000).

In summary, during the nineteenth and the first half of the twentieth century, water resources in the United States were generally perceived as a means of supporting vigorous economic growth, supported by legal rights to water exploitation. By virtue of federal statutes and court decisions, state law determines what a water right is, and state and federal constitutions prevent the conversion of private use rights to public purposes without the payment of just compensation Adverse impacts of water resources exploitation on the environment and ecosystems has led, during the second half of the twentieth century, to a reexamination of water policies and law. From the perspective of protecting water quality, conserving available water resources, and recognizing the public's interests in water, the government's public trust responsibilities are receiving increased attention. Responding to emerging scientific knowledge about the Earth and its biological systems, the courts are moving towards expanding the scope of public trust to benefits transcending the traditional commercial ones of navigability, fisheries, and tidelands.

American water law is in a state of transition in regard to natural resources and the environment.

Europe

Germany

Kube (1997) provides a lucid summary of the current status of water law in Germany. A milestone in Germany's water law history was the promulgation of the Federal Water Code in 1957. Prior to this, there were 19 different water regimes in Germany, substantially differing in attribution of ownership in surface water and groundwater, and rights to use water. In Germany, the responsibility for providing a framework for water legislation is vested with the federal government, while the executive responsibility of resource management and protection lies with Länder (States). The states, in turn, harmonize their functions with a coordinating group.

The objective of the Federal Water Code was, and continues to be,

> "*The attainment of a sensible and useful distribution of the surface water and of the groundwater regarding quantity and quality in the whole of the Federal Republic.*"

This aim, it was perceived, could be attained,

> "*If the free disposition by private owners is restricted and if the consideration of the public weal is the starting point of all action.*"

Underlying the water code are the principles of *Öffenliche Sache* (public good or public matter), *Sozialpflichtigkeit* (social obligation or social responsibility), and *widmung* (dedication to the public). The authority of the federal parliament to enact natural resources legislation is based on the recognition that the scarcity of publicly valued natural goods implies a parliamentary right to assume responsibility to distribute and manage the resources. In this spirit, the Federal Constitutional Court observed (Kube, 1997, p. 863),

> "*The impossibility to increase the area of land as well as its absolute importance to everybody prohibit leaving its use completely to the management through market forces.*"

In 1976, the Water Code was amended by adding several provisions. Among these were the prohibition of any administrative action that would lead to a deterioration of water, the use of water for the highest possible benefit for the public, and an explicit clarification that ownership of land does not entitle a land owner to the use of surface water or groundwater. The landowner must obtain individual approval from the administration for water use.

During the 1980s, Germany responded to emerging ecological knowledge such as adverse impacts of acid-rain on forests by further amending the Water Code requiring water administrators to consider water to be part of an integrated ecosystem.

From the foregoing, it is apparent that water law in Germany is aimed at achieving a science-based management of interconnected water resources and ecosystems so as to maximize benefit to the public. The basic value judgement underlying this approach is that common weal (analogous to public trust in the United States) supersedes private interests in so far as things that constitute common good.

France

The outline given below of the modern water law situation in France is based on an overview by Food and Agricultural Organization (1975). Following the Second World War, problems of public health and water pollution associated with urbanization and industrialzation necessitated a modernization of French water law. Responding to recommendations by an inter-ministerial water commission set up in 1959, a unified water legislation, the Water Law of 1964 was promulgated in December of that year. This law, supported by many subsequent sectorial regulations, constitutes the framework for current French water policy. At the core of this framework is the recognition that water has to be scientifically managed. Accordingly, water administration is structured around six river basins, namely, Artois-Picardy, Rhine-Meuse, Seine-Normandy, Loire-Brittany, Adour-Garonne, and Rhone-Mediterranean-Corsica basins. Over these basins, surface water, springs, and groundwater are to be managed together with the goal of maximizing benefits to the people.

Within this framework, both surface water and groundwater could be owned privately, subject to the issuance of appropriate permits and administrative supervision of private water use. The nineteenth century provision of non-navigability associated with private ownership was repealed.

All surface waters, except those that have not been classified as State property, are the property of the State. Groundwater is the property of the overlying land owner, but the rights to its use is subject to administrative control.

The core scientific underpinning of the 1964 Water Law was augmented by a hierarchical administrative structure comprised of national, basin, regional, and local levels. In addition, an international level exists to enable interaction with the neighbors with whom France shares riparian rights. The hierarchical framework includes duly empowered autonomous agencies at various levels, and financial institutions to achieve integrated water management. At all levels of management, citizens and water users have legal rights to participate in decision making.

In 1992, the 1964 Water Law was amended to render conservation of biological diversity an integral part of water management of aquatic environments. In doing so, the Law gave recognition to the fact that water is a part of the nation's common heritage. In addition, it incorporated the European Commission's Directive on Protection of Waters against Pollution caused by Nitrates.

Spain

During the twentieth century, Spain underwent many political upheavals, culminating in its becoming a Constitutional monarchy in 1978. Through the tumultuous years, water resources development was governed by the Water Acts of 1866 and 1879. As early as 1926, work was initiated towards water planning based on river basins with the creation of *Confederaciones Hidrográficas* or River Boards. In 1933, a National Hydrological Plan was drafted by an engineer, Manuel Lorenzo Pardo. Administration of water based on hydrological basins began twenty years later. Currently, forty percent of Spain's water resources are controlled by hydraulic engineering (Embid, 2007).

Spain's Constitution addresses water under Article 45 (Environment), Article 132 (Public Property), and Article 149 (State Competence). In Article 45.2, public authorities are required to concern themselves with the rational use of all natural resources, and be united in protecting and restoring the environment. All waters, including those located off-shore, the beaches, and the continental shelf are deemed to be public domain. According to Article 132.1, property in the public domain shall be regulated by law under the principles of inalienability, imprescribility,

non-seizure, and unencumbrance. While the Autonomous Communities (analogous to states) are responsible for management of water in watersheds entirely within their territorial boundaries, Article 149.22 vests with the State the power of managing river basins that span more than one autonomous territory.

Spains' Water Act 29/1985, recognizes at its core, the logical consequences of the principle of the hydrological cycle, of which groundwater is an inherent part (Articles 1 and 2). Article 1.3 declares that hydrological planning, founded on river basins, shall be the key to water management. To facilitate coordinated water management, the Act provided for appropriate institutions, in which citizens and water users will actively participate in decision-making (Embid, 2007).

Over the past two decades, Spain has faced a number of challenges in implementing the spirit and the provisions of Water Act 29/1985. A Draft National Hydrological Plan, prepared in 1993 conceived of hydraulically inter-linking river basins. As part of this, plans were drawn to transfer significant quantities of water annually from the Ebro basin, located in the north eastern part of the country, to the arid Mediterranean coast in the south. After vigorous debate, this plan was repealed in 2004. In the meantime, the European Union, of which Spain is a member, issued its Water Framework Directive (European Commission, 2000), requiring that member countries enact laws to facilitate water management centered around water basins. Spain is currently in the process of balancing its national water plans and policies with those of the European Union (Embid, 2007).

European Union

With its current membership of 27 nations, the European Union is an intergovernmental body, intended to protect, preserve, and enhance the members' common interests. During the 1970s, the Union began prescribing standards for improving and maintaining the quality of water in rivers and lakes, and strict standards for drinking waters that all members would abide by. This was soon followed by directives on urban waste-water treatment, control of agricultural nitrate pollution, and integrated pollution prevention and control. By the middle of the 1990s, an imperative arose for a more global approach to water resources management that involved active community participation. After intense collaborative work among the members, the European Parliament and the Council of the European Union adopted, in October 2000, the Water

Framework Directive which established a common vision of water management. The Directive required the member states to suitably modify their laws, statutes, and policies within deadlines to achieve the common vision.

The principal aims of the Directive were (European Commission, 2000),

- expanding the scope of water protection to all waters, surface waters and groundwater
- achieving 'good status' for all waters by a set deadline
- water management based on river basins
- "combined approach" of emission limit values and quality standards
- getting the prices right
- getting the citizen involved more closely, and
- streamlining legislation

Declaring that

> "*water is not a commercial product like any other but, rather, a heritage which must be protected and defended.....*",

the Directive took a holistic view of water resources, integrating fresh-water resources as well as aquatic ecosystems, including those of inland waters and coastal waters, estuaries, gulfs and closed seas. As conceived here, appropriate strategies of water management are to be based on a scientific understanding of the nature and behavior of these earth and biological systems. Since these systems are characterized by complex mutual interactions that often cannot be quantified in detail, and since their behavior often cannot be foreseen reliably, management strategies have to be adaptive. Adaptive strategies entail continuous and sustained monitoring of various system attributes of relevance, timely recognition of potentially adverse impacts, and modifying management strategies.

Water resources are finite and have to be shared among all segments of society and other living things. The finiteness of the resource and the need to share it equitably requires that humans make judgements, compromises, sacrifices, and choices. To this end, science can but make the best physical knowledge of the systems available. The choice of the 'best' strategy of sharing has to be made by the community, be it a village, a city, a state, a nation, or a collection of nations.

Much remains to be learned about constructively bringing together scientific understanding and societal decisions.

Already, the members of the European Union have taken actions to comply with the Water Framework Directive. France is positioned well to readily comply with the Directive because its 1964 Water Law had already established a water management plan based on river basins, which divided the country into six well-defined basins. In addition, the 1992, the amended Law implemented the European Commission's Directives on water pollution control and nitrate abatement (Bongaerts, 2002). In Germany, compliance with the Directive involves organizational challenges. German water management responsibilities are vested with 16 Länder which are administrative territories. At present, inter-basin management is achieved through cooperative Länder working groups. Changing this over to a river-basin structure would pose and organizational challenge. Additionally, community participation in decision-making is not at present part of the German process. Spain, like Germany, manages water through Autonomous Communities. According to Spanish law, when a river basin spans more than one Autonomous Community, the State has the responsibility for water management. For Germany and Spain, changing from administrative divisions to the watershed as a unit of water management poses special challenges.

Elsewhere in the World

Towards the close of the twentieth century, New Zealand and South Africa enthusiastically embraced the spirit of public trust to modernize their natural resources and water laws. In 1991, New Zealand enacted a Resource Management Act, which replaced common law with a renewable water permit system (New Zealand., 2006). The central theme of the Act was sustainable management of natural resources to meet reasonably foreseeable needs of future generations, safe-guarding life-supporting capacity of air, water, soil, and ecosystem, and avoiding adverse impacts of human activities on natural resources. South Africa's National Water Act 34 of 1998 (South Africa, 2006) explicitly designates the Government as the Trustee of the nation's water resources. The Act also vests the Government with the responsibility of judicious and equitable use of water resources, with the recognition of justifiable economic and social growth and international responsibilities. The preamble to the act specifically recognizes the role of the hydrological cycle in a finite earth by stating, '...water is a scarce and unevenly distributed national resource which occurs in many forms which are all part of an interdependent

unitary cycle...'.

WATER, LAW, SCIENCE

Jus gentium and Science

From ancient times, humans have intuitively recognized the central position occupied by water in the natural world, and their own dependence on it for survival. Therefore, they believed that the essence of morality and law is to abide by natural order. Remarkably, this imperative to abide by natural order is also recognized by modern science, although from a different perspective. Whereas the ancients attributed natural order to actions by various gods, modern science perceives natural order in terms of a relatively small number of observationally established physical laws. During the late eighteenth century, Scottish geologist James Hutton proposed his revolutionary concept of 'uniformitarianism', arguing that the earth's geological processes have been active through infinite times past. The intuitive basis for Hutton's reasoning was that physical laws of nature have remained unchanged through geologic time, a perception that the Roman Law jurists had astutely anticipated a millennium earlier when they considered nature's laws to be immutable.

By formally setting in place the concept of *jus gentium*, Roman Law became philosophically integrated with science. In keeping with contemporary needs of society, it focused attention on air, running water, navigability, and fisheries, the public ownership of which is widely known as the doctrine of public trust. This doctrine has endured over the centuries in Europe and the United States. However, explosive developments in science, and aggressive technological exploitation of water and natural resources during the twentieth century have led to world-wide depletion of vital freshwater resources, accompanied by alarming environmental and ecological damage. These technological impacts on public property indicate that *jus gentium* needs to be reconsidered from a modern perspective, and its scope expanded beyond the traditional public trust limits of navigation, fisheries, and tidelands. This need for rethinking has already been anticipated in the public trust judgments by the California Supreme Court in Marks and Whitney (1971) and Mono Lake (Audubon Society, 1983), and the judgment of the Hawaiian Supreme Court in the matter of Waiahole Ditch (Hawaii, 2000). It is also evident in the preamble of the Water Framework Directive of the European Union, and the water legislations of New Zealand and South Aferica.

Science and Modern Water Law

Modern water law cannot exist without science. The best available scientific knowledge of water and natural resources has to lie at the core of water law. Yet, science does not have authority to set policy. That authority is vested with the legislature and appropriate governmental bodies with statutory powers. Ideally, science and water law share a common goal of working together to assure an efficient and equitable use of water resources in the best interest of society. In achieving this common goal, they have strengths as well as weaknesses.

The methodology of science consists in drawing inferences from a small number of laws elicited from observational experience. These laws of science do not change with time. In law, judgements in litigations are based on the application of certain fundamental legal tenets or principles, laid down on the basis of social values. Unlike the laws of science, these tenets are subject to change with time, as social values change. In common law, such tenets are abstracted from previous judicial decisions, while in civil law, they are *a priori* prescribed as statutes. Science is neutral to moral values in that scientific knowledge can be used constructively or destructively. It is in this regard that the tenets of law are critical, having the duty of assuring that scientific knowledge is channelized towards constructive social ends. The hope is that science, duly informed about social values, will focus attention on identifying constructive strategies from which optimal social choices can be made. In collectively pursuing this goal, science and law are constrained by inevitable limitations.

Expectations and Uncertainties

Inherently, science seeks to describe things precisely, to predict their future behavior, and to control such behavior to benefit humans. Analogously, the goal of law is to provide stability of enjoyment of citizens' rights, either private or public. The desire for stability and certitude of expectation is common to science and law. Unfortunately, such stability of expectation is an ideal that neither science nor law can attain when dealing with water and natural resource systems.

Human activities such as urbanization, agriculture, forestry, industries, navigation, mining, and so on progressively degrade the landscape and the water-scape on a time scale of decades to centuries. Unfortunately, the details of such degradations cannot be predicted with confidence

because earth systems are difficult to access for observation, and are characterized by complex geometry and heterogeneity. At best, their behavioral patterns may be semi-quantitatively foreseen over relatively short periods of time. Superposed on this uncertainty about future behavior is the uncertainty associated with climate, which drives the hydrological cycle.

At present, democracy is the preferred form of governance the world over. In the aftermath of political oppression in many parts of the world prior to the Second World War, democracy is presently identified with human rights to freedom of health, education, religion, private property, and prosperity. While the world's poor assert their rights to clean water, sanitation, shelter, and livelihood, the affluent wish to exercise their right to accumulating wealth through exploitation of natural resources, including water. Both the poor and the affluent aspire to be assured of stability in the enjoyment of their rights. The difficulty is that exercising the right to these privileges cannot be handled purely as a legal matter. In relating to natural systems that are governed by laws that are beyond human control, human aspirations to rights have to be subordinated to constraints imposed by Nature. Insistence on rights that ignore limits imposed by Nature will inevitably lead to serious social consequences. In an expanded view of *jus gentium* necessitated by modern science and technology, water raises profound questions about human relationship with Nature. In order to handle such human-nature questions, democracy has to evolve beyond "rights", and recognize the importance of responsibility to society stemming from constraints imposed by Nature's laws.

Evolution of Water Law with Time

The turn of the twentieth century witnessed spectacular, unprecedented developments in hydrological sciences and hydraulic engineering. The understanding of the hydrological cycle, especially its lithospheric component, was greatly advanced through contributions from hydrology, soil physics, soil mechanics, hydrogeology, petroleum engineering, and economic geology. Human ability to manipulate surface water and groundwater were elevated to hitherto un-imagined levels though the construction of large multi-purpose dams, the invention of the deep-well turbine pump, and the transmission of electric current over long distances with alternating current. Aggressive water exploitation through these inventions has led to disappearance of artesian wells, groundwater mining, land subsidence, salt-water intrusion, triggered earthquakes, and other impacts. The pre-twentieth century water laws were totally inadequate to deal with this new generation of problems impacting society in unprecedented

ways. These laws had to be revised, giving due credence to evolving scientific knowledge, and identifying appropriate new tenets. The birth of the new field of environmental law during the second half of the twentieth century attests to the modernization of pre-twentieth century water law, in response to evolving scientific knowledge. Clearly, a time lag between new science knowledge and its accommodation into law is inevitable.

One example of the incompatibility between science and law merits mention. It is now widely recognized that surface water and groundwater constitute a single interconnected resource. Riparian habitats and wetlands vitally depend on this interconnected lithospheric water system. Thus, groundwater and surface water have to be subject to water laws that account for their interconnection. Yet, it is quite common to find that surface water and groundwater are treated differently in law. In arid parts of the western Unites States, for example, surface water is treated within the scope of public trust, while groundwater is treated as private property. Part of the reason for this contradiction lies in the fact that nineteenth century legal misconceptions about groundwater as a mysterious phenomenon have not yet been modernized. Another reason is that many land owners do not want to give up water rights granted to them on the basis of out-dated notions about groundwater.

That science evolves in time, and that law has to adapt to science implies that water rights and allocations cannot be granted in perpetuity. Yet, any water user must have a reasonable stability in expectation over some finite period of time. What this reasonable stability is, and how it may be assured in the context of evolving scientific knowledge are challenging questions of jurisprudence.

Adapting to Nature and Water Conflicts

The most important knowledge that has emerged from earth and biological sciences over the past fifty years is that the Earth is finite, and life-sustaining earth and biological systems are delicately interconnected. To survive in this finite Earth in a civilized way, humans have to understand Nature's laws, and devise sustainable strategies for utilizing available water resources, and preserve the integrity of the resource systems for future generations. It is imperative that humans adapt to Nature.

Three decades ago, the Committee on Geosciences and Man of the International Union of

Geological Sciences reflected on the future welfare of mankind, based on a knowledge of the world's energy and mineral resources, and a consideration of the environment, ecosystems, and water resources. In their report on Earth Resources Time and Man (von Engelhardt et al., 1975), the committee concluded that mankind is in a state of transition from a brief interlude of exponential growth to a much longer period characterized by very low growth or non-growth. Although the transition posed no insuperable scientific or technological difficulties, the committee opined that a revision of contemporary economic and social thinking of indefinite economic growth was needed. Failure to respond promptly to the impending changes, they concluded, could lead to a catastrophic collapse of our global technological civilization.

The skepticism of the committee brings to focus a profound human issue. That rare gift we call the human mind, is for ever making choices between opposites: good and bad, love and hate, sharing and coveting, compassion and violence, generosity and greed, sacrifice and selfishness, rationality and irrationality. When subjected to significant stress, the choices that an individual, a community, or even a nation make between pairs of opposites cannot often be predicted.

Because it plays a vital role in the sustenance of all life, water is a source of economic and political power. Water conflicts are common among various segments of society within a nation, and among neighboring nations that share water bodies. Examples of the former include the desire of nations to provide clean water to satisfy domestic and sanitary needs of the poor, protecting the water rights of aborginal people to enable them to pursue their traditional life styles, and the displacement of large populations to accommodate the construction of large hydraulic projects that benefit urban populations and industry. In these cases, it is commonly the case that economic benefits to certain segments of society that prevail in decision making. Trans-national rivers are often sources of international conflicts. Examples include the sharing of waters of the Colorado and the Rio Grande between the United States and Mexico, the sharing of the Hooghly between India and Bangladesh, and the sharing of the Euphrates among Turkey, Syria, and Iraq. These conflicts are commonly handled through international agreements. But such agreements could be stressed, if prolonged droughts or over development severely limit availability of water. Despite international agreements, violent conflicts cannot be ruled out.

In this context, the Water Framework Directive of the European Union is an encouraging development. What is novel about this approach is that rather than having individual nations forging agreements among themselves to share water, the Directive requires the 27 member

nations to enact laws for water management that conform to the same philosophical principles. When implemented successfully, Europe's water will be managed throughout the Union, based on scientific knowledge , uniform legal principles, and active participation by the public. This approach of the European Union comes as close to the ideals of *jus gentium* as one could hope for. If the world's nations genuinely desire peace and equity, there is no reason why they cannot be inspired by *jus gentium* and work towards a water law that is common to all people, and to all nations.

CONCLUDING REMARK

This paper is an attempt by an earth scientist to comprehend the interconnections between science and law in the context of water. The motive is to constructively contribute to a coordination between science and law. The most exciting finding of this study is that Roman jurists, inspired by Greek philosophy of reason, were able to distinguish between the law of state (*jus civile*) from the law of all people or law of all nations (*jus gentium*). This distinction, remarkably, was a consequence of a scientific view of 'natural order', and is as timely today as it was visionary then.

The Earth has become small due to a technological civilization. Because of the interconnectedness of human activities and earth systems, civilized survival of humankind requires that we evolve beyond the traditional notion of autonomous nations to one of community of nations with a common with common understanding that we are vitally dependent on Nature's order. This vision is not as utopian or unrealistic as it may seem. The fact that the Water Framework Directive has come about and is embraced by many nations is encouraging. Indeed, the Water Framework Directive is merely an expression of the remarkable concept of *jus gentium* that has endured for more than fifteen centuries through the rise and fall of empires and civilizations. Nature is teaching us that democracy, the preferred form of self-governance of modern times, has to evolve from its aspirations based on "rights" of various kinds to the next stage of rights balanced by an equal measure of responsibilities.

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