

Comparison and evolution of water institutions in the U.S. Midwest

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Abstract: In the Midwest, climate change will lead to lower precipitation and increased variability, which may threaten water supplies. A better understanding of the current water institutions in Midwestern states can help policy makers face water scarcity and variability. This study focuses on five neighboring states enforcing three distinct water allocation doctrines; riparianism (Illinois and Missouri), regulated riparianism (Iowa), and prior appropriation (Kansas and Nebraska). We compare water institutions and implementation in these states and assess institutional adaptations.

Keywords: Climate change, institutional adaptation, riparian doctrine, regulated riparianism, prior appropriation, U.S. Midwest

1. Introduction

Modeling of the long term impacts of climate change reveals a warming tendency, with an obvious decrease in cold extremes and a remarkable increase in warm extremes, and changing precipitation subject to spatial and temporal uncertainty (van Vliet et al., 2013). According to a summary by IPCC (2014), while unanimous research findings predict warming, the temperature increase ranges from +3 to +6°C across the United States. Precipitation is expected to change, being modestly wetter in the north and modestly drier in the Southwest.

For the Midwest, relatively unanimous results based on projections derived from various models on different scales (Sinha & Cherkauer, 2010), indicate hotter summers with longer dry periods and milder, wetter winters will likely occur (EPA, 2014). Climate change will, therefore, have a significant influence on water supply and demand in the Midwest (Angel & Huff, 1997). It is expected that water withdrawals for farm irrigation will increase in this region (Maupin et al., 2014), and reductions in agricultural production may reach 50% (Rosenzweig et al., 2002). Thus new challenges are arising for water resources management in areas that traditionally have not been afflicted with water scarcity and related environmental stresses. This may create demand for changes to the institutions related to water use and allocation.

As a type of common pool resource (CPR), water resources are prone to the 'tragedy of the commons,' i.e., overuse (Dietz, Ostrom & Stern, 2003). To better manage water resources, appropriate water institutions that can adapt to changing circumstances are essential. Water institutions are composed of water law, policy, and administration (Saleth & Dinar, 2000; Saleth & Dinar, 2005). In the eastern U.S., water resources are dominated by the common law doctrine of riparian water rights, under which the right to use water belongs to the owner of the land. But seventeen states have adopted an emerging regime called regulated riparianism, under which the 'waters of the State' are owned by the State in trust for the public and subject to the State's regulatory power to protect the public interest' (Beck, 2000: p.118). The change responds to an imbalance in water supply and demand in eastern states, due to increases in population and water use per capita (Dellapenna, 2010).

Given the new challenges of climate change for water resources management in the Midwest, a better understanding of the current water institutions in Midwestern states can help policy makers in future policy design. We elaborate the differences and evolution of institutions in managing water resources in two Midwestern riparian states, i.e., Illinois and Missouri, through a comparison with Iowa, Kansas and Nebraska.

This paper proceeds as follows: in section 2, we discuss water management institutions and institutional change. In section 3, we present a review of the three major property rights regimes for water allocation in the U.S., and how they have evolved over time. In section 4, we compare the three water allocation doctrines in Illinois, Missouri, Iowa, Kansas, and Nebraska, focusing on comparing water laws, policies and administration of the three doctrines. The conclusion highlights issues of institutional change for water management in the Midwest.

2. Water management institutions and adaptation under climate change

2.1. Water resource management institutions: Recommendations from the literature

The varying magnitude and timing of precipitation along with warming temperatures and substantial evaporation creates potential uncertainty and variability for water

resources, which in turns creates challenges for water allocation, management and use (Sommer et al., 2013). Consequently, as ‘rules of the game’, water institutions and their changes are being increasingly paid attention to as a way forward for water management (Saravanan, 2008). Recent studies examining appropriate policy interventions in various parts of the world stress the importance of a holistic approach incorporating environmental and natural resource issues, agriculture and irrigation, and social factors (World Bank, 2012). Other studies stress the importance of incorporating various geographical scales (Huntjens et al., 2012). Identifying adaptation strategies at farm and policy levels, Bozzola and Swanson (2014) recommended a focus on both spatial (water trading) and temporal (water storage) interventions to deal with changing variability of water resources. Given the nature of common pool resources, improvements to water institutions should take account of social, economic, and political settings (Ostrom, Janssen & Anderies, 2007). Path dependence implies that new water policies cannot be devised without appropriately considering their institutional history and cultural environment (Meinzen-Dick, 2007).

2.2. Adaptation to climate change in water management

Two strands of institutional adaptation strategies are important¹. The first strand is related to the enhancement of adaptive capacity (van Vliet et al., 2013). For instance, Engle and Lemos (2010) emphasized that institutions were critical determinants of adaptive capacity and resilience building, and explored the relationship between the governance indicators and adaptive capacity of river basins to climate change.

The other strand is related to the polycentric governance of natural resources to cope with climate change (Ostrom, 2014) and multiple evaluation principles (Adger, 2001). Huntjens et al. (2012) used the eight design principles developed by Ostrom (1990) for common pool resources to capture structural, agency and learning dimensions of the adaptation challenge, and found empirical support for the institutional design propositions for adaptation in water governance systems. Adger, Arnell and Tompkins (2005) pointed out that criteria of effectiveness, efficiency, equity and legitimacy were important in judging successful adaptation strategies, and suggested criteria selection should be context specific.

2.3. Institutional change

In the past 50 years, driven by urbanization, industrialization and drought emergency, the primary issues that need to be addressed in water allocation are third party effects, compensation for users, and public responses (Meinzen-Dick & Ringler, 2008). Institutional changes within the water sector occur due to the influence of both endogenous and exogenous factors, which ‘raise the opportunity costs of institutional change, reduce the corresponding transaction costs, and create a pro-reform climate’ (Saleth & Dinar, 2000: p.166).

Water management has followed three broad, overlapping trends, namely, focusing on ‘the central role of the state’ (public action), ‘the scope for organized user management’ (collective action), and ‘larger role for market institutions’ (enabling private action) (Meinzen-Dick, 2007: p.15200). Livingston (2005) referred to the collective action level as the micro level analysis of institutional change. In addition, according to a stage-based perspective proposed by Saleth and Dinar (2005), the water institutional change process can be divided into ‘mind change, political

¹ In addition, there is research looking at developing adaptation technologies, such as better irrigation methods, drought-resistant crop varieties, etc. But that is beyond the scope of this paper.

articulation, institutional change and actual impact' (p.6). Their framework acknowledges the linkage between various theories and explains the dynamics in different stages of the change process.

Similarly, Livingston (2005) discussed meso-level evaluation as addressing 'the structure and sequencing of actual change' (p.21), in particular, concepts of nesting, subjective perception, objective elements, path dependency and transactions cost. Others have used transaction cost theory to explain change related to both water institutions and the institutional environment (McCann & Garrick, 2014).

3. U.S. institutions for managing water resources

This section presents the evolution of major water allocation doctrines in U.S. and their corresponding water right regimes.

3.1. Water allocation doctrines in the U.S.²

One institution that has developed to deal with market failure for water resources is property rights regimes for water. There are three water allocation doctrines existing in the U.S. in addition to state property rights for some waters. Roughly separated by Kansas City (Dellapenna, 2006) or the 100th meridian (Wilkinson, 1984), riparian doctrine dominated most of the eastern states, including Illinois and Missouri. Riparian rights are obtained based on ownership of riparian land, bordering or underlying watercourses or covering a groundwater aquifer. To comply with this doctrine, each individual landowner is entitled to use and manage the water on or beneath his land so long as his withdrawal and management don't harm other riparians. The riparian rights are 'usufructuary' rights, indicating the right to use and benefit from using water, rather than ownership of the water itself, and the permissible usage of water is limited to *reasonable use* (Missouri Department of Natural Resources, 2000). Under the riparian doctrine, transference of individual water rights follows the transfer of title to riparian property.

In contrast, the prior appropriation doctrine, which was developed and prevails in western states, establishes the principle of 'first in time, first in right', that is, the first user has the senior right to water resources (Wilkinson, 1984). Under this doctrine, water rights are specifically defined as to quantity, time, place, and manner of use, and most importantly according to their priority relative to other uses (Dellapenna, 2011). When water supply is in shortage, the early allocations (senior users) would be satisfied first, and junior users have to reduce or even cut off their withdrawal. The principle of *beneficial use* of water resources applies, giving priority to residential, agricultural and industrial uses.

In the past 60 years, some eastern states, e.g., Iowa and Wisconsin, have adopted regulated riparianism to regulate allocation of water resources that are becoming increasingly scarce due to increased demand (Beck, 2000; Dellapenna, 2011). Under this system, permits³ need to be obtained to practice the *reasonable use* of water resources. Table 1 presents the allocation rights with underlying rules and state examples as mentioned above.

This trend of changing water institutions can be driven by water shortages, water conflict resolution, water use efficiency, impacts of climate change and variability, socio-economic and political significance, etc. A general evolutionary path of water

² Water allocation is generally governed by state law rather than federal law in the United States (Dellapenna, 2011).

³ Permits are a type of time-limited license issued by a state agency on the basis of the reasonableness of the proposed use (Dellapenna, 2011).

doctrines in U.S. can be depicted by figure 1. By 2006, '... riparian rights is in decline, with more and more states embracing regulated riparianism. Regulated riparianism has been enacted in 17 eastern states [and Mississippi] and Hawaii for all waters in the state, and in another three states for groundwater — all enacted within the past 50 years. Traditional riparian rights continue as the primary body of water law in 14 eastern states, two of which have enacted regulated riparian systems for their groundwater and several more of which are considering enacted [sic] some form of regulated riparianism. Appropriative rights are the predominant body of water law for the quantitative allocation of water in the 18 States between Kansas City [and] the Pacific Ocean, including one (Arizona) that has enacted a regulated riparian statute for its groundwater.' (Dellapenna, 2006: p.3)

3.2. Property rights and water institutional changes

Different water allocation doctrines can be compared regarding their underlying property rights. A comparison of different property rights corresponding to varying doctrines is presented in table 1. Under the riparian doctrine (in Missouri and Illinois), water is deemed as a common property (Dellapenna, 2006), which has the characteristics of a high cost of excluding potential users from enjoying benefits from its use, and thus one concern is overwithdrawal of water resources. This is the oldest type of water rights in the U.S.

In contrast, the traditional riparian rights were abandoned when facing chronic short supply in the relatively dry western states (Dellapenna, 2011). The prior appropriation doctrine (as in Kansas and Nebraska) represents private property, which can be traded separately from land. Typically a state agency administers the water rights and the sole purpose is to enforce the clearly defined property rights. One problem that has arisen is that in some cases the rights were overallocated.

The case of regulated riparianism in Iowa exhibits characteristics of public property⁴. To enforce license terms and conditions, disputes between competing water users may be resolved by a state agency or by a court.

Comparing property rights under the three doctrines reveals they correspond to the evolution of water institutions from common property rights to private property, and public property rights (Meinzen-Dick, 2007). Both private and public property rights are deemed appropriate to better govern CPRs than common property (Dellapenna, 2011). To better understand the water allocation institutions in the Midwest, the following section compares water institutions in five states in some detail.

4. Comparison of water institutions and institutional changes

4.1. Water law, policy and administration

Table 2 presents a comparison of water allocation institutions in Missouri, Illinois, Iowa, Kansas and Nebraska under the three distinct doctrines. At the state level, formal laws⁵ have been enacted to govern water allocation and use in each state,

⁴ For definitions of various property rights and their comparisons, see McKean (1992) and Dellapenna (2011).

⁵ In general, 'statute' refers to an act or law passed by a legislative body, and 'regulation' means a rule or standard that has the force of law once promulgated by an administrative agency within its statutory authority (Missouri DNR).

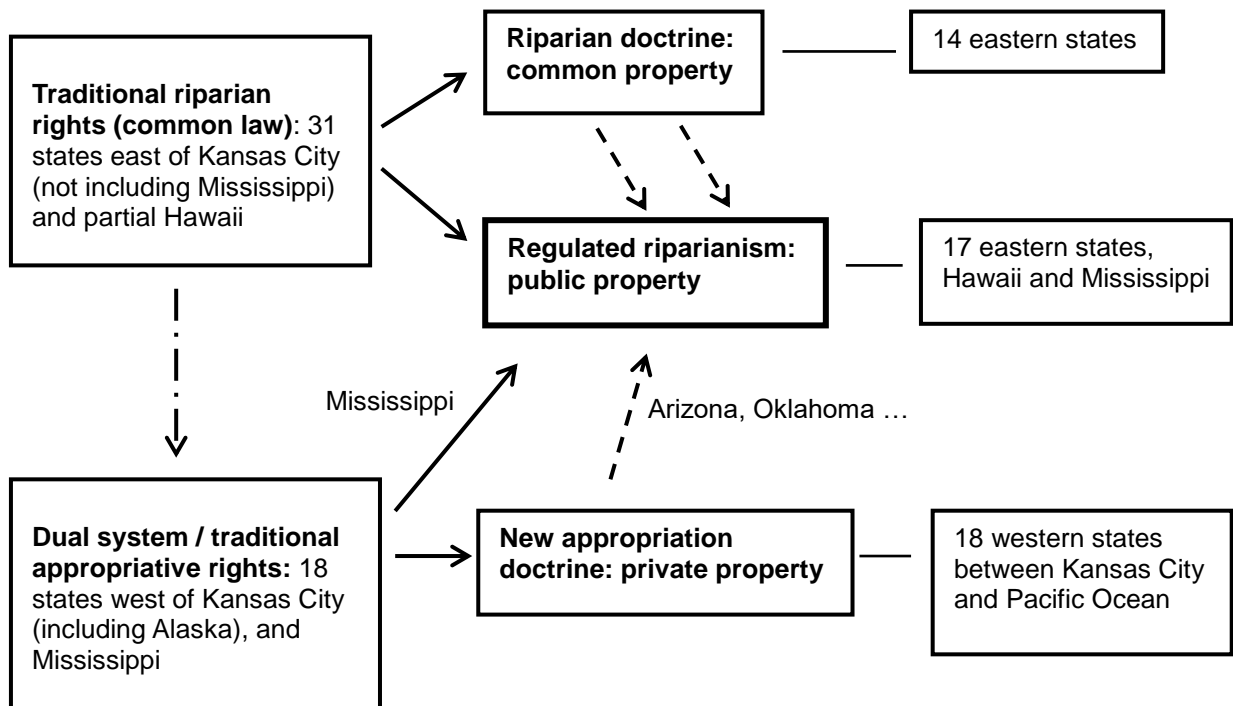


Figure 1 Evolution of water allocation rights in U.S.

Notes: 1. Hawaii previously adopted both riparian rights and aboriginal water law, and now follows regulated riparianism. Mississippi previously adopted appropriative rights, and now follows regulated riparianism. More states following the riparian doctrine are adopting regulated riparianism for groundwater management and some states (e.g., Arizona) are also partially adopting regulated riparianism for groundwater management.

2. The regulated riparianism and the new appropriative doctrine can be distinguished from the traditional riparian rights and the traditional appropriative rights based on the modifications, specifications and regulations in the *Regulated Riparian Model Water Code* (American Society of Civil Engineers (ASCE) 2003) and the *Appropriative Rights Model Water Code* (ASCE 2006). But in nature, the traditional and new appropriative doctrines are identical regarding the private property rights, 'beneficial use' principle, and 'first in time and first in right' rule. The traditional and new riparian rights are also alike in the respects of common law rights, 'reasonable use' principle, and in the sense of using water legally only for riparian lands.

Sources: Adopted from Beck (2000); Dellapenna (1994); Dellapenna (2001); Dellapenna (2006); Dellapenna (2010); Dellapenna (2011). For the evolution of the dual system in the West, see Dellapenna (1990). For the evolution of western appropriative doctrine, see Johnson and DuMars (1989).

Table 1 Comparison of water allocation rights/doctrines in U.S.

Allocation rights	Description	Nature of right	Enforcement	Underlying rules	States
Riparian rights	Allocate the right to use water to the owners of land abutting a water source	Common property	Courts	Reasonable use	Illinois, Missouri, etc.
Regulated riparianism	Allocate water according to the reasonableness of the proposed use without limitation regarding the location or the sequence of use.	Public property	Administrative agency	Reasonable use with time-limited permits	Iowa, Wisconsin, etc.
Appropriative rights (prior appropriation)	Water should be 'appropriated' and applied to a 'beneficial use' in order for one to acquire the right to use the water.	Private property	Administrative agencies and courts	Beneficial use, 'first in time, first in right', use it or lose it	Kansas, Nebraska (surface water), etc.

Sources: Adopted from Dellapenna (2006); Dellapenna (2011).

for example, Illinois Compiled Statutes, Illinois Environmental Protection Act, Kansas Water Appropriation Act, etc. Meanwhile, each state has its own specific policies, regulations, codes, and rules regulating water use in conjunction with the formal laws. Some of these rules are implemented by the state-level department of natural resources (DNR) and bureau or commission within each DNR as mentioned below. Regarding the state-level administration, water resources are governed and managed by offices of water programs, or water centers within the DNR of each state, but the Division of Water Resources is affiliated with the Department of Agriculture in Kansas. Oftentimes, there can be one water administration in one state working on all water management issues, like the Integrated Water Management Division in Nebraska, or more than one administration, but focusing on different aspects of water management and/or working together, like the Clean Water Commission and Safe Drinking Water Commission in Missouri. In addition, there are multiple coordinating agencies in each state, for instance, the Illinois State Geological Survey, and other agencies at the state level, association of water agencies, water centers and extension programs within universities, and so on. In short, collaboration between water management administrations, and between administrations and other coordinating agencies assures adequate implementation of water laws and regulations in each state (Huntjens et al., 2012; Mukhtarov et al., 2015).

4.2. Evolution of water institutions

Evolution of water institutions in these states can be accessed chronologically and functionally. The Illinois Department of Natural Resources was founded from the former Illinois Department of Conservation according to an executive order in 1995, and codified into state law by Public Act 89-50. Within the department, the Division of Water Resources Management under the Office of Water Resources Programs regulates public waters, and statewide water use allocation and monitoring, along with other responsibilities (Illinois Department of Natural Resources, 2014).

Under the Omnibus State Reorganization Act, the Missouri Department of Natural Resources was created on July 1, 1974. Among different commissions, the soil and water conservation program with Missouri DNR provides farmers and landowners with soil and water conservation assistance and educational workshops about farm irrigation, nutrient management, ground and surface water use, soil erosion, etc (Missouri Department of Natural Resources, 2014). Regulations are employed primarily to major water users who may withdraw or divert water, as discussed below.

In order to manage water and protect its surface and ground water resources, Iowa's General Assembly created the Iowa Natural Resources Council (INRC) in 1949. In 1957, the Council's duties were expanded to include supervision of all floodplain activities. A permit system for regulating water use was established and the Council was in charge of issuing or renewing the permit. In 1963, the Council's duties were expanded again to include controlling oil and gas conservation. Early on in its existence, the Council and its staff became national leaders in floodplain management, regarding conservation and use of water, as well as approval of any structure, dam, deposit or excavation in or on any floodway. However, from 1983, many state agencies merged, and the Council's floodplain management responsibilities were transferred to the Environmental Protection Commission. In 1986, the Iowa DNR was established to conserve and enhance natural resources management in cooperation with individuals and organizations. Within the department, the Conservation and Recreation Division and Natural Resource

Table 2 Comparison of water allocation institutions in Missouri, Illinois, Iowa, Kansas and Nebraska.

Doctrines State	Riparian doctrine		Regulated riparianism	Prior appropriation doctrine	
	Illinois	Missouri	Iowa	Kansas	Nebraska
Law	Illinois Compiled Statutes Illinois Environmental Protection Act Groundwater Protection Act	Missouri Revised Statutes -Water Resources Law (1989)	Iowa Statute Iowa Recreational Use Statute (1993)	Kansas Water Appropriation Act	Nebraska Revised Statutes for -Surface Water -Groundwater -Water Data Collection
Regulation/rule/policy	Illinois water resource regulations	Missouri Code of State Regulations	Iowa Water Regulations	Kansas water rules and regulations	DNR Rules for -Surface Water -Integrated Management Plans
Administration	Illinois Department of Natural Resources -Office of Water Resources Programs -Division of Water Resource Management	Missouri Department of Natural Resources -Water Resources Center -Clean Water Commission -Safe Drinking Water Commission	Iowa Department of Natural Resources -Natural Resource Commission - Conservation and Recreation Division -Water Quality Bureau	Kansas Department of Agriculture -Division of Water Resources	Nebraska Department of Natural Resources -Integrated Water Management Division
Coordinating agency	U.S. Army Corps of Engineers Illinois Environmental Protection Agency Illinois State Water Survey Illinois State Geological Survey	USGS Water Resources of Missouri	US Army Corps of Engineers Iowa Department of Agriculture Iowa Association of Water Agencies Iowa Geological and Water Survey Iowa Water Center, Iowa State University	Kansas Water Office Bureau of Water at Kansas Department of Health and Environment Kansas Geological Survey of the University of Kansas	USGS Water Resources of Nebraska Nebraska Water Resources Association Nebraska Water Center, University of Nebraska-Lincoln

Sources: Adopted from various sources, including:
 Missouri Department of Natural Resources: <http://www.dnr.mo.gov/>
 Illinois Department of Natural Resources: <http://www.dnr.illinois.gov/>
 Iowa Department of Natural Resources: <http://www.iowadnr.gov/>
 Kansas Department of Agriculture: <http://agriculture.ks.gov/>
 Nebraska Department of Natural Resources: <http://www.dnr.ne.gov/>

Commission oversee water use and law enforcement, among other issues (Iowa Department of Natural Resources, 2014).

In Kansas, the Kansas State Agricultural Society was initially organized in 1862 to guide agricultural work statewide. In 1994, the Society was renamed the Kansas Department of Agriculture comprised of multiple divisions and programs. The Division of Water Resources within the department executes statutes governing construction of water projects, laws and responsibilities regulating water allocation and use, and compacts related to interstate rivers (Kansas Department of Agriculture, 2014).

In Nebraska, the surface water use has been overseen by an administrative system since 1895. Authorized by Nebraska statutes, the state DNR issues surface water permits, called appropriations. All water wells drilled after September 9, 1993 must be registered according to the current Nebraska laws. The Integrated Water Management Division is the provider of technical expertise, and the planner and coordinator for implementing an integrated management process. The goals of the process are to ensure a balance between water demands and supplies and to protect the rights of existing water users (Nebraska Department of Natural Resources, 2014).

In summary, the main objectives of water management in each state are to:

Illinois: mitigate uncertainties, and protect the public rights;

Missouri: manage storm water and wastewater, manage water wells and public water, and regulate commercial use of water;

Iowa: ensure clean water, and improve management of water resources;

Kansas: protect individual's water rights and public interest, and guarantee minimum desirable streamflows; and

Nebraska: regulate the withdrawal of water especially under uncertainties.

4.3. Permit systems under different doctrines

As mentioned above, a new trend in water institutions is using permits to regulate water withdrawals. A comparison of the permit system in the five states is presented in table 3. Regulating water use with a permit system is fundamentally the same with major procedures of obtaining a right to use water, including specifying the type of water, water amount, dates to have access to water / duration of using water, transferability and renewability of water rights, etc (Dellapenna, 2011; Missouri Department of Natural Resources, 2000).

To regulate and manage surface and/or groundwater withdrawals, a permit may be required before a water user can withdraw water, and written applications are oftentimes needed to obtain the permit. Given the varying water availability in the five states, the type of permits and withdrawal rates are different. Illinois and Missouri are traditionally water sufficient states, and thus only groundwater withdrawals greater than 100,000 gallons per day (gpd) are required to obtain a permit in Illinois, and similarly only major water users with withdrawals greater than 100,000 gpd need a permit in Missouri. Comparatively, Iowa DNR requires water users withdrawing water greater than 25,000 gpd to obtain a permit. In Kansas, a term permit is required for any non-domestic water uses, and the withdrawal amount cannot exceed 4,000,000 gallons for any temporary permits (up to 6 months) within the same water system. In Nebraska, a natural flow permit or rural domestic groundwater withdrawal permit is required, and the diversion of water is limited to one-seventieth of a cubic foot per second (cfs) per acre for farm irrigation.

Some important dates and processes to obtain the permit in each state highlight the differences of the three doctrines. In Illinois, a general permit was initially issued on July 13, 1983, and later a regional permit issued on July 25, 1990. Similarly,

Table 3 Comparison of permit systems regulating water withdrawal under different dominating doctrines.

	Illinois	Missouri	Iowa	Kansas	Nebraska
Purpose	Regulate groundwater withdrawal	Manage surface and groundwater withdrawals	Manage diversion, storage and withdrawal of surface and groundwater	Manage surface and groundwater withdrawals	Manage surface water and groundwater withdrawals
Type	Statewide, regional and general permits	Registration permit	Surface and groundwater use permits	Surface and groundwater term permits and temporary permits for beneficial use	Natural flow permits and rural domestic groundwater withdrawal permits
Regulated withdrawal amount/ rate	Groundwater withdrawal >100,000 gpd	Major water users, >100,000 gpd	>25,000 gpd	Term permit for any non-domestic uses; temporary permits < 4,000,000 gallons	Diversion rate for irrigation < one-seventieth of a cubic foot per second (cfs) per acre.
Important date	General permit was issued on July 13, 1983 Regional permit was issued on July 25, 1990	File a registration document after September 28, 1983.	Permit system was established in 1957	Applications for permits, after April 12, 1984, are subject to any minimum desirable streamflow requirements.	Anyone who, prior to April 23, 1993, has withdrawn ground water for industrial purposes may apply for a permit.
Process to obtain	Application with equal rights and ladder-type application fees	Application with equal rights and ladder-type application fees	Application with equal rights and varying application fees	Application with varying priorities and certain field inspections with fees	Priority was set based on the dates of application, and application fees
Duration	< 5 yrs	< 5 yrs	< 10 yrs	Term permit < 5 yrs, temporary permits < 6 months	As long as the use is deemed beneficial.
Transferable	No	Yes but limited to project changes	No	Yes but limited to 4,000,000 gallons within the same water system	Yes but limited to the transfer of lands
Renewable	Yes	Application for permit renewal prior to its expiration	Yes	Application for extension prior to the original expiration date	Yes
Expiration/cancellation	As modified, suspended, or revoked by the Department	End of permitted time	End of permitted time	Abandonment with five successive years of nonuse.	Subject to cancellation if not following permitted uses for more than five consecutive years.

Sources: Adopted from various sources, including Missouri DNR, Illinois DNR, Iowa DNR, Kansas DA, and Nebraska DNR, as well as State Water Withdrawal Regulations: <http://www.ncsl.org/research/environment-and-natural-resources/state-water-withdrawal-regulations.aspx>

a registration document needs be filed for applying for a water permit starting from September 28, 1983. Iowa established a permit system in 1957, which marked the transition from riparian rights to regulated riparianism. In contrast, Kansas and Nebraska have more restrictions on the permit system. Kansas requires applications for permits after April 12, 1984, and they are also subject to any minimum desirable streamflow requirements. Nebraska also asks anyone who has withdrawn ground water for industrial purposes prior to April 23, 1993 to apply for a permit. In addition, applications for water permits have equals rights under both riparian and regulated riparian doctrines, and applicants need to pay ladder-type application fees in Illinois and Missouri, and varying fees in Iowa. However, the prior appropriation doctrine assures a higher priority for early applications, as shown in Kansas and Nebraska. In these cases, certain field inspections are necessary along with application fees paid by applicants.

Furthermore, the duration and transferability of permits mark the relative flexibility of the doctrines. The withdrawal permits are valid for no more than 5 years in Illinois and Missouri, and no more than 10 years in Iowa. In Kansas, the duration is up to 5 years for a term permit, and 6 months for a temporary permit. In Nebraska, a permit is valid as long as it's considered a beneficial use. The permits are minimally transferable in Illinois and Iowa; transfers are limited to the transfer of the property. Conversely, the permits are allowed to be transferred within the limit of permitted water withdrawal in Kansas, and limited to the transfer of the land in Nebraska. A similar requirement is found regarding the renewability across the five states. Water withdrawal permits are renewable, but renewal applications may need to be submitted before the expiration date. The expiration date is typically the end of the permitted time, but may be modified or suspended by the state DNR as required in Illinois. In both Kansas and Nebraska, cancellation of a permit can be induced if the permitted uses are abandoned for five consecutive years, i.e., *'use it or lose it.'*

5. Conclusion and implications for water policy design in the Midwest

Midwestern states are characterized by intensive agricultural activities, high water availability and variation, and potentially high fluctuation of temperature, precipitation, and evaporation. This research looks at the potential impacts of climate change on incentives for changes to institutions that manage and govern water resources. A thorough comparison is conducted on water institutions in five neighboring states under the three major water allocation doctrines.

As discussed above, a switch from traditional riparian to regulated riparian doctrine in some eastern states indicates water is considered to be public or state property rather than common property. Both public and private property rights can be possible solutions for common pool resource problems (Dellapenna, 2011). The transition from riparian rights to regulated riparian rights may have lower transaction costs than a switch to private property rights due to path dependence. Path dependence directs the evolution of water institutions and ensures new policy is a good fit with local, physical and cultural context. For instance, though water permits have been adopted in Iowa, the fundamental riparian nature means water use is only permitted if the user owns the land over the aquifer or adjacent to the waterbody.

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