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Abstract: Fragmented jurisdictions and decision making structures can result in destructive competition and/or a lack of systematic cooperation that can hamper effective resource management and environmental planning, although the value of local autonomy and stakeholder participations should not be underestimated. This study empirically examines if political fragmentation in local governance is a significant barrier to successful resource management. To test this hypothesis, the authors quantify the degree of political fragmentation at two different geographical scales – 1) site-level: 12-digit watersheds and 2) regional: metropolitan statistical areas or equivalent regions – and analyze how water resource management outcomes vary with the level of political fragmentation using nationwide land cover and stream gauge information in the United States. Regression analysis shows water quality declines (or slower quality improvements), measured in terms of total suspended solids, are associated with both site-level and regional political fragmentation indicators, suggesting that political fragmentation can make resource management more challenging.

Key words: Political Fragmentation, Local Governance, Destructive Competition, Water Resource Management, Environmental Planning

Highlights:

- The importance of local governance structures in resource management is discussed.
- Political fragmentation in local governance related to resource management is quantified using various metrics.
- Water quality changes are analyzed with explicit consideration of the potential influence of political fragmentation.
- Total suspended solids increase rates are found to be associated with both site-level and regional political fragmentation indicators.
- Findings suggest that political fragmentation can be a significant challenge to effective resource management.

Fragmented Local Governance and Water Resource Management Outcomes

1. Introduction

Water resource management is an extraordinarily challenging realm in which consideration should be given to the complex behaviors of both the natural environment and human settlements. While the challenges are often grand, managing water resource systems is critical and high on the priority lists of various organizations (ranging from grass-roots groups to international agencies) as it is essential for human well-being, although management contexts vary significantly by region or country (see e.g., Komatsu et al., 2010; Marsh, 2012; Martins et al., 2013). In the United States, the *FY2013 National Water Program Guidance* (U.S. Environmental Protection Agency, 2012a) highlights the critical value of successful water resource management, sets priorities based upon "sustainable communities" and "healthy watersheds", and clearly articulates various implementation strategies, but admittedly, how to effectively achieve these priorities is an on-going question.

Given that water resource management has to deal with complex "coupled natural and human systems", successful management largely depends not only on our understanding of the mechanisms of ecological systems but also on our institutional environments that can shape the way we perceive and respond to dynamic changes in the ecological systems (Berkes and Folke, 1998; Anderies et al., 2004; Ndubisi, 2008). The importance of institutional arrangements has been widely acknowledged in resource management and environmental planning (see e.g., Carlsson and Berkes, 2005; Lane and Robinson, 2009; Sternlieb et al., 2013). In particular, fragmented authorities and decision making structures (i.e., political fragmentation) have often been viewed as a significant challenge to effective resource management and environmental planning, although the "hometown advantages" and other benefits of disaggregated-local-government-initiated planning have also been recognized. For instance, according to Yaffee (1997), fragmentation of responsibilities and authorities is one of the main causes of recurrent failures in environmental planning and resource management. Moreover, it has been contended that political fragmentation can induce destructive competition as opposed to cooperation, and this can hamper successful management of valuable natural resources (Kim and Jurey, 2013). In other words, individual agents may not be able to see incentives enough to take a holistic strategy for resource management without an institutional arrangement that promotes systematic cooperation, and therefore may tend to have parochial, myopic views which in turn result in undesirable outcomes for everyone, as suggested by "the tragedy of the commons" (Hardin, 1968).

However, despite longstanding recognition of the importance of institutional structures in resource management, little is known about how political fragmentation really affects resource management efforts in the field, and thus the outcomes (i.e., quantity and quality of resources). Previous empirical research has typically looked at individual cases in a qualitative, descriptive manner, rather than testing the relationship between political fragmentation and the effectiveness of resource management using a large number of observations under various governance arrangements, although few exceptions exist (see e.g., Sigman, 2007; Kim and Hewings, 2013). To fill this gap, this study examines the potential effects of political fragmentation in local governance on water resource management by conducting a regression analysis with the use of information from more than five hundred stream gauges. More specifically, the present study quantifies the degree of political fragmentation at two different geographical scales – 1) site-level: 12-digit watersheds and 2) regional scale: metropolitan statistical areas (MSA) or equivalent regions – and analyzes how the water resource management outcomes, measured in terms of total suspended solids (TSS), vary with the level of political fragmentation. By doing so, it attempts to better understand the implications of fragmented local governance for water resource management, and eventually contribute to a more effective management of water resources, which is essential for public health, safety and welfare.

In the remainder of this article, attention is first directed to how water resource management outcomes can be influenced by local governance structures, particularly political fragmentation. Then, section 3 provides an empirical analysis (designed to examine if political fragmentation in local governance is a significant barrier to effective water resource management) and explains the model, metrics of political fragmentation, and the data utilized in this study. The empirical analysis outcomes are presented in section 4. Finally, section 5 discusses the main findings of the study and their policy implications with emphasis on some potential strategies for dealing with the challenges arising due to political fragmentation.

2. Political Fragmentation & Water Resource Management

There are multiple sources of complexities that make water resource management extremely challenging. Similar to all other types of planning or resource management practice, managing water resources has to deal with not only "environmental uncertainty – uncertainty for planning" but also "process uncertainty – uncertainty from planning" that create difficulties in identifying what will happen in the foreseeable future and how to cope with emerging problems (Abbott, 2005). In addition, both ecological and human systems involved in any management tasks of water resource are non-reducible, spontaneous, and sometimes chaotic in nature, thus they present largely unpredictable interactions (Dryzek, 1987; Huitema et al., 2009). Recently, this inherent unpredictability of system behaviors has been further compounded by the force of globalization which increases competition in various dimensions and densities of interactions across scales (see e.g., Cash et al., 2006; Young, 2006; Young et al., 2006). These complexities force us to confront unprecedented challenges to effective water resource management; for instance, in the U.S., a recent national summary of state reports to the U.S. Environmental Protection Agency seems to provide a warning by showing that a significant proportion of rivers, streams, lakes, reservoirs, and wetlands can be viewed as either impaired or threatened (U.S. Environmental Protection Agency, 2012b).

In accomplishing successful water resource management, the overarching and/or associated institutional arrangement is critical, as noted by Lepawsky (1950), Gerlak (2006), Nimmo (2006), Thiel and Egerton (2011), Larson et al. (2013), and many others.[1] Particularly, water quantity and/or quality changes can be significantly affected by the way local governance structures are organized (e.g., highly fragmented with a large number of municipalities vs. relatively more consolidated), since local governance systems largely shape how individual agencies interact with each other and further influence the behaviors of private agents including developers, businesses, and many other stakeholders. For instance, the local governments within highly fragmented settings may be under higher levels of interjurisdictional competition, so they may tend to be more favorable to new business and development projects (see e.g., Break, 1967; Cumberland, 1979; Kunce and Shogren, 2005). This pro-growth attitude (or "races to the

[1] See also Ndubisi (2002), Randolph (2004), Lane (2006), and Reed (2007) for the importance of institutional factors in the management of other types of resources and/or general environmental planning.

bottom" according to Verchick (2003)) can have a substantial impact on water resource management outcomes, as illustrated in figure 1.

<< Insert Figure 1 about here >>
Figure 1. Political Fragmentation & Water Resource Management Outcomes

More specifically, first, political fragmentation in local governance can modify land use patterns, and thus affect water quantity and quality changes.[2] This possibility is supported by a growing number of empirical studies which find political fragmentation can cause rapid land use conversion and sprawl. For instance, in their study of the counties in 14 states, Carruthers and Ulfarsson (2002) reported that development densities tended to be lower in more politically fragmented areas with a relatively greater number of local government units per residents.[3] More recently, Kim and Hewings (2013) conducted a micro-level analysis of small (1 mile × 1 mile) land areas within 82 Midwest metropolitan regions, and found that land use conversion rates were likely to be accelerated when the area was shared (or surrounded) by multiple jurisdictions.

Secondly, given interjurisdictional competition and pro-growth attitudes, land use in a more fragmented context may be less likely to be managed well. For instance, in such a context in which a large number of cities or towns seek new development to expand their tax bases, critical water bodies and/or land surfaces may not be systematically protected through

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[2] The 2008 National Research Council publication, *Urban Stormwater Management in the United States*, indicates "There is a direct relationship between land cover and the biological condition of downstream receiving waters. The possibility for the highest levels of aquatic biological condition exists only with very light urban transformation of the landscape. Conversely, the lowest levels of biological condition are inevitable with extensive urban transformation of the landscape, commonly seen after conversion of about one-third to one-half of a contributing watershed into impervious area" (p.5, National Research Council, 2008).

[3] The association between political fragmentation and sprawl (i.e., characterized as low density development) is also detected in the authors' other subsequent studies, such as Carruthers (2003) and Ulfarsson and Carruthers (2006). Also, see Lewis (1996) and Razin and Rosentraub (2000) for detailed explanations of why a fragmented local governance structure can induce a more sprawling pattern of land development.

appropriate zoning ordinances or other instruments, such as water quality protection setbacks and impact fees. If this is the case, the marginal negative impact of land use change on water quantity and quality will be greater in the areas with more fragmented governance structures than in cases with lower levels of fragmentation and/or with the presence of institutionalized entities (e.g., special districts for water resource management) which can mitigate or override destructive competition due to political fragmentation.

Third, even if land use and development processes can be properly controlled, water quality and quantity changes can be influenced by political fragmentation due to the limited effectiveness of other management practices, related to water resource protection. With a larger number of jurisdictions with their own interests, common resource management would be more challenging without an additional overarching authority (e.g., Murray-Darling Basin Authority, Australia), and may sometimes end up with an undesirable state due to the lack of consistent and cooperative efforts. In fragmented regions, it is also very likely that the water resource used by one jurisdiction is under the control of another jurisdiction. In this case (i.e., when water quantity and/or quality do not directly impact the residents of the managing jurisdictional area), the quality protection and other management practices may suffer due to lack of incentives.

In sum, political fragmentation in local governance can have a significant potential impact on water resource management processes and outcomes. In the following section, a statistical examination of potential impacts is provided to examine how political fragmentation actually affects water resource management outcomes in reality with the use of nationwide land cover and stream gauge information in the United States.

3. Empirical Analysis

3.1. Model

As noted, this study examines if political fragmentation in local governance is a significant barrier to successful water resource management. Such an examination may be accomplished in multiple ways. One could empirically test the hypothesis by performing a direct, qualitative evaluation of the quality of management practices under distinct governance structures (i.e., fragmented vs. more consolidated) through surveys and/or interviews, and then comparing the evaluation outcomes from the different governance contexts. An alternative approach is to assess a measureable resource management outcome (i.e., water quality and/or quantity) and investigate how its changes are associated with political fragmentation.

This study takes the latter approach. In other words, it analyzes the changes in a water quality variable with explicit consideration of the potential influence of political fragmentation. However, the present study does not focus on one or a few study areas to apply a water system modeling tool to the sites. Instead, it utilizes a large number of cross-sectional observations in the U.S. where a large degree of heterogeneity in political fragmentation exists, as done in some other water quality/quantity studies, such as Meador and Goldstein (2003), Dodds and Whiles (2004), and Horowitz and Stephens (2008). More specifically, the following regression model is employed here.

$$\ln\left(\frac{TSS_{i,t+1}}{TSS_{i,t}}\right) = \alpha \cdot \ln(TSS_{i,t}) + X_i \cdot \beta + G_{i,t} \cdot \theta + \varepsilon \qquad (1)$$

where $TSS_{i,t}$ is the average level of total suspended solids (mg/L) in site i at time t; X_i indicates a vector of major determinants of TSS variation, such as land use changes in the watershed; $G_{i,t}$

represents a vector of the governance variables (i.e., political fragmentation indicators); α , β , and θ are a single coefficient or a column vector of estimable coefficients that show the effects of the corresponding variables on TSS changes; and ε is an independent and identically distributed error.[4]

By estimating the above model with the use of a large number of observations, the empirical analysis is expected to check how political fragmentation ($G_{i,t}$) can influence TSS changes, a measureable water resource management outcome. Although this model does not fully describe the complex behaviors of water systems as shown in figure 1, it can provide meaningful estimates, drawn from many cross-sectional cases.

3.2. Study Period, Sites, and Data

This study focuses on the period: Year 1992–2001, in which a nationwide land cover dataset and a great number of TSS observations are available. TSS information is compiled by utilizing the Consortium of Universities for the Advancement of Hydrologic Science, Inc. Hydrologic Information System (CUAHSI-HIS: http://his.cuahsi.org/), a platform for sharing hydrologic data from a broad range of sources of information. It should be noted that all TSS observations available for six years (i.e., 1991, 1992, 1993, 2000, 2001, and 2002) in the conterminous U.S. are collected, and then 1991–1993 and 2000–2002 observations are used to calculate the average levels of TSS at the start and the end points of the study period (i.e., $TSS_{i,t}$ and $TSS_{i,t+1}$), respectively. The expanded time windows (i.e., 1991–1993 and 2000–2002, as opposed to 1992 and 2001) provides extra observations, which can help obtain more reliable average values for

[4] TSS is a widely used indicator of water quality, designed to measure the solid sediment particles suspended in the water column of interest and is a recognized water pollutant. In addition to the variable's popularity, it is employed in the present analysis, as data for TSS are available for a large number of stream gauge sites in the U.S.

each site. The additional observations also enable the analysis to include more sites with both $TSS_{i,t}$ and $TSS_{i,t+1}$ values.

There are 567 stream gauge sites across lower 48 states having data for both $TSS_{i,t}$ and $TSS_{i,t+1}$ values, required for the empirical analysis, as shown in figure 2. Although some data points only have few observations during 1991–1993 or 2000–2002, over 50% of the all sites have more than 10 observations in both 1991–1993 and 2000–2002.

<< Insert Figure 2 about here >>
Figure 2. Study Areas: 567 Sites across States

Since land use changes in the watershed may have a significant impact on TSS changes at a particular stream gauge site, this information is also gathered. More specifically, this study uses the National Land Cover Data (NLCD) 1992/2001 Retrofit Change Product provided by US Geological Survey, which identifies land use changes from 1992 to 2001 accurately by addressing the compatibility issue between the two (i.e. 1992 and 2001) datasets (US Geological Survey, 2008). The raster-based land cover information is processed, by executing the Tabulate Area function built in ArcGIS, to identify how land use had changed in each 12-digit watershed between 1992 and 2001.[5] Further, the percentages of land use categories, such as Urban and Forest, in 1992 and 2001 are calculated in preparation for the regression analysis. Figure 3 shows how the average level of TSS of each site in 1992 (*TSS92*) is associated with the percentage of forest land in the 12-digit watershed (*FOR92*) where the data point is located. As expected, the TSS levels are found to be significantly lower in the areas with a higher percentage of forest land.

<< Insert Figure 3 about here >>

[5] The entire U.S. is divided up into watersheds and sub-watersheds identified by a hierarchical Hydrologic Unit Code system. Among various scales, 12-digit watersheds are one of the most widely used units of analysis in water research. On average, the size of a 12-digit watershed is approximately 100 square kilometers.

Figure 3. Total Suspended Solids – Forest Land Relationship

3.3. Measurements of Political Fragmentation

A remaining critical task is to measure political fragmentation (i.e., to construct $G_{i,t}$ in the regression model, Equation 1). Whereas simple regional measurements, such as the number of municipalities per capita or per acre in each region, have been widely adopted by existing research in the social science literature dealing with political fragmentation, it is unclear whether these measurements on such a scale alone accurately capture the fragmented governance relevant to water resource management discussed previously. The regional indicators (i.e., state-, MSA-, or county-level metrics) may have limited usefulness in the examination of spatially-explicit resource management outcomes investigated in this study, since they do not consider the spatial variation of the fragmentation within each state, MSA, or county.

Therefore, this study quantifies the degree of political fragmentation at two different geographical scales – 1) site-level: 12-digit watersheds and 2) regional: metropolitan statistical areas or equivalent regions – by employing five metrics, explained in the following paragraphs. These indicators, collectively, can represent multiple aspects of political fragmentation, such as the number of jurisdictional areas involved in small watershed-level management and the presence of a viable governmental unit devoted to local water resource management as well as region-wide political circumstances. All these aspects can potentially affect water quantity and quality changes by modifying land use patterns and/or effectiveness of management practices in the field, as discussed in the previous section.

- 1-a. *NUMPL*: The first site-level metric used in this study is the number of local municipalities (i.e., cities and towns) sharing the 12-digit watershed in which each TSS observation site is located. This is calculated by overlaying 1990 jurisdictional boundaries and the watershed boundary shapefile, and then counting the municipalities intersected with each 12-digit watershed. Approximately 30% (170 out of 567) of the entire sites are found to be located in the watersheds shared by two or more jurisdictions. Furthermore, there are a few data points (e.g., Des Plaines River at Riverside, IL point in watershed # 071200040706) contained in the watersheds with more than 20 municipalities, as demonstrated in figure 4.

<< Insert Figure 4 about here >>
Figure 4. Watershed #071200040706 in IL

- 1-b. *MSMENT*: Another spatially-explicit metric used here is a modified entropy index, developed by Kim and Hewings (2013) to represent the micro-level political power distribution. This index utilizes the concept of entropy, originated from the field of thermodynamics and further used in urban and regional studies (see e.g., Wilson, 1970; Cervero, 1989; Krizek, 2003) to capture the level of the power balance among three nearest jurisdictions. It is designed to provide a value ranging from 0 (governed by a single jurisdiction) and 1 (under the influence of multiple jurisdictions with similar proximity – i.e., more fragmented setting). As done in Kim and Hewings (2013), first the modified entropy index is computed for individual sections (1 mile × 1 mile) covering the study areas. Then, the mean value of the sections' index in each 12-digit watershed is computed to construct the site-level metric, *MSMENT*.
- 1-c. WD100: The third site-level indicator is a dummy variable indicating the presence of a viable, formalized institution for the management of water resources, such as water management districts. To construct this indicator, 1992 Census of Governments is used, since relevant watershed-level information across states is not readily available. In detail,

first, special districts for water resource management are identified from the 1992 Census of Governments dataset which contain various types of government units along with their annual spending information and the counties in which the entities were based. Then, if a 12-digit watershed (or majority part of the watershed) is included in the counties with a water management district having $100,000+ annual spending, *WD100*=1 is assigned to the watershed, otherwise *WD100*=0.

- 2-a. R_PCGOV: To measure the region-wide degree of political fragmentation, this study also uses a traditional metric: the number of total government units per 1000 residents in each region, which is simple, but powerful in representing the variation of political fragmentation across regions. For the delineation of regional boundaries, 1993 Office of Management and Budget (OMB) definitions of the MSAs are employed, as the study examines the effects of political fragmentation in early 1990s on the changes in water resource management outcomes, measured in terms of the changes in TSS between 1992 and 2001.[6] Furthermore, the areas, which are not included in any metropolitan area, are grouped together in each state, and regarded as a metro equivalent region to assign the regional fragmentation indicator values to those rural places.
- 2-b. R_HHI: The last indicator employed in this study is the Hirschman-Herfindahl Index, which is employed by some recent studies in the social sciences investigating the consequences of political fragmentation, such as Grassmueck and Shields (2010) and Hendrick et al. (2011). As explained in Grassmueck and Shields (2010), this indicator, defined below, can have a value between $1/n$ (a more fragmented structure) and 1 (a

[6] In the cases of the New England region, the county-based New England metropolitan area boundaries provided by US Census are used to avoid the issue of the partially included counties, rather than adhering to the OMB MSA delineation.

consolidated setting) and effectively represent the level of power concentration based upon government expenditure information.

$$HHI_i = \sum_{j=1}^{n} \left(\frac{E_{ij}}{TE_i} \right)^2 \qquad (2)$$

where E_{ij} and TE_i represent the amount of expenditures of government unit *j* in region *i* and the total government spending in region *i,* respectively; *n* is the total number of governments in the region.

4. Analysis Results

Using the above political fragmentation indicators as well as the water quality and land use information explained in the previous section, robust regression is conducted to estimate the model (i.e., Equation 1) using the STATA's *rreg* command. This estimation technique can determine the influence of political fragmentation on water resource management outcomes, measured in terms of TSS change rates, by handling the outliers and associated statistical issues which can make ordinary least squares (OLS) estimators problematic. Table 1 presents descriptive statistics of the variables used in the analysis. The robust regression outcomes of the following four key specifications of the model are summarized in table 2, while OLS estimation results are provided in Appendix A for comparison purposes.

1) No consideration of political fragmentation
2) Inclusion of site-level political fragmentation indicators
3) Inclusion of regional political fragmentation indicators

4) Inclusion of both site-level and regional political fragmentation indicators

<< Insert Tables 1 and 2 about here >>
Table 1. Variables & Descriptive Statistics
Table 2. Regression Analysis Results

Above all, the regression analysis shows that one major determinant of the dependent variable (i.e., log of TSS change rates) is *LTSS92* (i.e., log of the average level of TSS in Year 1992) which consistently exhibits a significant, negative coefficient. The negative value of the estimated coefficient suggests that the sites which had a high TSS level in *t* (i.e., Year 1992) tend to experience a lower TSS change rate in the following years (i.e., Year 1992–2001). *LFOR9201R* (i.e., log of forest land change rates in the watershed) also has a negative effect on the TSS growth rates in models 2 and 4. This indicates the deterrent effect of forest land on TSS increases, which is consistent with our knowledge that forest land can contribute to preventing water quality deterioration. *LURB9201R* (log of urban land change rates in the watershed) turns out to be insignificant, although it comes up with an expected sign (i.e., positive – the average level of TSS is likely to rise, as the percentage of urban lands increases) in all four settings of the regression analysis. According to the estimation, *LPOPD90* (log of population density in the 12-digit watershed) is also found to have an insignificant impact on the TSS change rates in the sites investigated, although its coefficient turns out to be significant at 10%-level in model 2.

In addition, some physiographic division dummy variables are found to have significant effects on TSS change rates. For instance, the dummies for the Atlantic Plain, the Interior Highlands, and the Interior Plains exhibit significant, positive coefficients which suggest that these areas had experienced relatively more rapid TSS increases (or slower TSS declines) than comparable sites in other physiographic divisions between 1992 and 2001. In contrast, *PD6DUMMY*, a dummy representing the Laurentian Upland, shows a negative estimate that may indicate the relative improvement of the stream water quality in the division.

Regarding the effects of the local governance variables (i.e., the five political fragmentation indicators) which are of main interest in this study, the model estimation seems to provide some important findings. Among others, in Model 2, *NUMPL* (i.e., the number of the intersected municipalities in each 12-digit watershed) is found to have a significant, positive effect on the dependent variable. This suggests that the TSS level is more likely to increase (i.e., a lower water quality), if the watershed is shared by a greater number of jurisdictions and thus under a more fragmented institutional circumstance. The effect of this fragmentation variable remains significant in the case of Model 4, in which both site-level and regional political fragmentation indicators are included to control for the potential effects of various factors. The magnitude of the effect is quite substantial (i.e., +0.045 in Model 2 and +0.046 in Model 4), indicating that the TSS increase rate rises (i.e., water quality decreases) nearly by 5 percent when an additional municipality shares the 12-digit watershed area in the sample.

Similarly, *R_PCGOV* (i.e., the number of government units per 1000 residents in the region), a regional indicator of political fragmentation, shows a significant, positive coefficient in the two model specifications in which its effects are tested (with the magnitudes +0.177 and +0.185, respectively), while the Hirschman-Herfindahl index exhibits insignificant estimated coefficients. Like the case of *NUMPL*, the significant, positive coefficient shows that political fragmentation is associated with deteriorating stream water qualities. More specifically, the result suggests that water resource management outcomes can be poorer in a region with a higher degree of political fragmentation in terms of the region's overall governance structure. This finding indicates that resource management is an extraordinarily complex task which can be shaped not only by site-level conditions but also by higher-level circumstances.

Unlike *NUMPL* and *R_PCGOV,* the remaining three indicators of governance structures, including *WD100* (i.e., presence of water districts with $100,000+ annual spending), do not exhibit significant coefficients. The insignificance of *WD100* is particularly notable, as it may suggest that water quality improvement or protection is not always guaranteed by the presence of a water-related government unit with a sizable amount of spending in the area. Each agency's activities and its role in promoting effective local water resource management, as opposed to its spending size, would be a more important contributor, although this study has not been able to quantify and consider such details of individual agencies due to the limited data availability.

Overall, the present regression analysis seems to suggest that political fragmentation does matter. Although three out of five governance variables turn out to be insignificant, both site-level (*NUMPL*) and regional (*R_PCGOV*) fragmentation indications are found to have statically significant coefficients, which can be interpreted as a potential negative influence of fragmented governance on water resource management outcomes. This may imply political fragmentation can make water resource management more challenging. Erratic and widely fluctuating water quality and/or quantity can threaten human and environmental well-being.

5. Summary & Discussion

The present study 1) measures the spatially varying degree of political fragmentation by utilizing a set of numeric indicators, defined at both site- and regional scales; 2) analyzes how the changes in TSS between 1992 and 2001 is associated with the political fragmentation in 1992 by conducting a regression analysis; and 3) finds that TSS tends to increase more rapidly (or decline more slowly) in the areas where the structures of local governance are more fragmented. More specifically, stream water quality levels are found to decline more (or do not show significant improvement) in the areas where watersheds are shared by multiple jurisdictions. Furthermore, a regional scale governance variable also shows a significant impact on water quality change (i.e., more fragmented regions tend to exhibit relative TSS increases, even after the effects of land use changes are controlled for). In fragmented regions, the water resource managing authorities are less likely to be identical to those using the resource, and the discordance can raise the difficulties in establishing effective strategies and attaining water quality and quantity management objectives. The finding may also be attributable to pro-growth mentality and/or the lack of cooperation or incentive that are likely to be more prevalent in a highly fragmented region, although the verification of this conjecture requires a more rigorous examination which is beyond the scope of this study.

It must be acknowledged that the empirical analysis is not without limitations. Employing a large number of stream gauge sites results in somewhat incomplete consideration of detailed spatial configurations or other unique characteristics of individual sites which could be considered more thoroughly through case study research focused on one or few watershed areas. In addition, the results should be interpreted with caution, since the present regression analysis is limited in establishing causality, as are other cross-sectional studies. The analysis also may not control for the entire set of potential (and often regionally unique) determinants of TSS change due to the limited availability of 12-digit watershed-level data for all of the 567 cross-sectional observation points. Nevertheless, this study can be a meaningful supplement to existing case studies, as it examines the critical association between political fragmentation and resource management through a statistical analysis of the data for a number of watersheds across states.

Given the challenges arising due to fragmented governance, how can we effectively attain successful water resource management and thus promote public health and welfare? One could assert that a fundamental shift is needed from the current (fragmented) institutional arrangement to a more consolidated structure in local and regional governance. Another could contend that we need to improve the performance of existing water resource management districts and to create more special districts which can fulfill holistic and systematic resource management.

Admittedly, the above remedies may work, but they require long, careful deliberation (involving consideration of a full range of advantages and disadvantages of such institutional reforms) and sometimes incur significant costs for the reforms. Furthermore, the value of community-level initiatives and local authorities' significant contributions should not be underestimated. As Verchick (2003, p.472) articulated, local units are in a good position to carry out environmental planning and resource management, since "… local government resides closest to ecological effects, it holds the greatest potential for democracy, it is capable of flexible and innovative implementation, and it has the potential to protect local constituents from distributional imbalances on the regional scale. …"

Planners and other policy makers may want to consider alternative actions to overcome the challenges arising due to the fragmented governance, while maintaining the benefits of local authorities and the principle of subsidiarity. Utilizing growth management schemes, which have been developed over decades in many states, may be an alternative which deserves recognition, as the schemes involve some feasible approaches to intergovernmental cooperation and systematic management of development/protection processes (see e.g., Gale, 1992; Porter, 1996; Weitz, 1999, 2012). Water resource management practices can also be improved by promoting non-traditional (or less formalized) efforts to cope with the drawbacks of fragmented government units, such as establishing social networks and building trust among key actors in resource management, sharing information broadly through the networks or beyond to better support real management/physical practices in the field, and creating a more flexible collective action mechanism in which both public and private parties are actively engaged and strongly motivated to act for improvements (see e.g., Fraternali et al., 2012; Larson et al. 2013; Menzel et al. 2013). Future research that pays attention to the contribution of such alternative actions as well as the detailed mechanism of land/water system behaviors under various management settings will be valuable to advance this field of research.

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