Holistic hydro-economical approach to quantification and valuation of watershed and source protection benefits: A case study of Big Elm Creek Watershed, Texas, USA.

Pre-proposal submitted to the Texas Water Resources Institute for consideration under the USGS Research Program, 2018

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Abstract: *Proposed study aims at establishing the value of Water related Ecosystem Services (WrES) and the enhancements in the value of these services due to implementation of watershed and source protection (W&SP) measures in the Big Elm Creek watershed. In this study, an integrated hydro-ecological modelling and economic valuation approach will be applied to (i) determine the water yield, nutrient and sediment retained and the carbon stored by different parcels of the landscape, (ii) establish the value of WrES, (iii) identify high value parcels for priority management, (iv) investigate how management measures may enhance the functions provided by the watershed, and (v) relate the cost of implementing W&SP projects to the benefits realized. This study is part of the author's doctoral research which is focused on assessing the current W&SP framework and making the case for integrated economic valuation of benefits of W&SP measures to address the multifaceted issues typical of watersheds in Texas. By establishing an aggregated value that considers water quality, quantity and climate regulation benefits, its hoped that the study will spur increased investments on the supply side of water management this mitigating the impacts of climate change and human activities, improving water quality, quantity and climate regulation functions of landscapes, which are key research priorities for the Texas Water Resources Institute.*

Background and rationale for the study

Watersheds provide a variety of Water related Ecosystem Services (WrES) that are vital to humanity. Preventing impairments in watersheds ensures that upstream landscapes can ably filter, yield, store water and buffer river flows, spring discharges and ground water levels as well as storing and sequestrating carbon (Abell, et al., 2017; Vigerstol & Aukema, 2011), and thus sustainably providing good quality water for drinking, irrigation, hydropower, aquatic life, opportunities for recreation, drought and flood mitigation. Compromised or degraded landscapes mean that the societies that depend on them have either limited access to sustainable sources of water or consume contaminated water.

To abate this, several federal and state agencies and local organizations in the US are undertaking the implementation of Watershed and Source Protection (W&SP) measures directed at achieving the national goal of restoring and maintaining the physical, chemical, and biological integrity of the Nation's waters in line with the requirements of the Clean Water Act of 1972 and the safe Drinking Water Act of 1974 (EPA, 1995). In Texas, 20 Watershed Protection Plans (WPPs) developed under stewardship of Texas Commission on Environmental Quality, or Texas State Soil and Water Conservation Board, and Texas Water Resources Institute have been accepted by the US Environmental Protection Agency (EPA) as they met the agency's national guidelines for watershed-based plans (TCEQ, 2017). Many more plans and measures continue to be developed and implemented at local levels by water users and other third parties.

Despite this endeavor, studies and reviews have identified gaps in assessing the benefits accrued from the implementation of these source protection measures – a case that has led to less interest from private entities from investing in source protection measures (Sklenar, et al., 2012a). An EPA review determined that the most significant weakness of the formulated WPPs was the inability to simulate load reductions and provide a basis for monitoring the impact of measures implemented (EPA, 2011). Also, the development of WPPs & Source Water Assessment and Protection Plans in the US has been more directed at mitigating water quality issues. There is a growing consensus that the quantity of water in the U.S. is as much of a concern as is its quality and therefore it should be given utmost attention, especially by managing the supply side of the policy since the demand side continues to increase as water demand increases. This requires an integrated approach that establishes impacts of W&SP measures on the supply side, which forms the basis of this study.

The Problem.

Big Elm Creek and other tributaries of the Little River, itself a tributary of the Brazos River in Texas, U.S. have concerns of impaired habitats, chlorophyll-a, nitrate, depressed dissolved oxygen, ortho-phosphorus, and total phosphorus (Jonescu, et al., 2017). The Big Elm Creek is also listed as a category 5 waterbody with impaired and threatened waters for which management measures are yet to be undertaken as required under Sections 303(d) of the federal Clean Water Act (TCEQ, 2015). Reported annual sediment production rate of 5.02 ac-ft/mi^2 in some sections of the Creek is among the highest in the Brazos Basin; second only to the Brushy Creek in Williamsons County, TX (USDA, 1959). As shown in figure 1, the Creek's flows are highly intermittent, an occurrence that appears to be on the increase. The Big Elm Creek watershed, predominantly characterized by agricultural land use, is a typical example of watersheds in Texas and the U.S. that generally have a waterbody that is experiencing multi-faceted water issues that can be addressed by considering an integrated approach to watershed and water resources management.

Already, TCEQ has contracted TWRI to undertake the characterization of the tributaries of the Little River for future WPP development. This study will compliment these ongoing efforts by assessing and valuing the benefits accrued (on water quality, quantity and climate regulation) from the implementation of various W&SP measures in the watershed.

Research Objectives.

Aimed at assessing the enhancements in the value of WrES provided by the watershed as a result of implementing management measures with the ultimate goal of establishing the rationale and promoting investments on the supply side of water management, this case study will specifically;

1. Determine the relative water yield, the retention of nutrients and sediment from different parcels of the Big Elm Creek landscape, and the carbon stored and sequestrated by the watershed.
2. Determine the value of WrES provided by the watershed in regulating the quantity and quality of water and climate and identify high value parcels for priority management.
3. Investigate how W&SP measures may enhance landscape functions.
4. Relate the cost of implementing W&SP projects to the benefits realized.

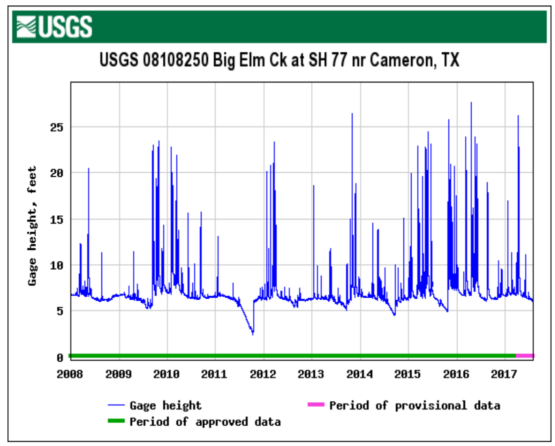

Figure 1. Recorded water levels of Big Elm Creek as measured near Cameron, TX

Project scope.

The proposed case study is part of Kikoyo's doctoral research study that is focused on assessing the current W&SP framework, valuing the benefits accrued from implementation of W&SP measures and making the case for a holistic and integrated approach for valuation of benefits of W&SP measures to address the multifaceted issues typical of watersheds in Texas. It is hoped that the study will spur increased investments on the supply side of water management, improving the water quality, quantity and the climate regulation functions of the landscapes, which are key research priorities for TWRI. It forms the second phase of the larger study, preceded by a study that reviews the hydrological tools and the framework for watershed management valuation. The third phase will involve a second case study in a different region of Texas with different meteorological and geophysical characteristics from the Big Elm Creek watershed

Methods and expected results

In this case study, hydro-ecological models that can simulate the WrES provided by the watershed, will be used to show how the Big Elm Creek watershed's current and future climate, land use and management practices have a bearing on the water quality, and quantity and climate regulation. Whereas currently a review of the different models that could be used to achieve this is ongoing, two specific models that could be used in combination, (i) Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and the (ii) Agricultural Policy / Environmental eXtender (APEX) are promising. Not only can InVEST simulate the economic value of water quality and quantity related ecosystem services provided by the watershed, it can also be helpful in determining the climate regulation function (carbon storage and sequestration) provided by the landscape. APEX is particularly strong in simulating impacts of management measures such as the use of buffers, pesticide management, cropping mechanisms, afforestation schemes on water resources at a smaller scale.

Water yield modeling will be aimed at determining the water yield from the watershed and the relative contribution of different parcels of the watershed. The modelling will simulate the impact of climatic and human activities on water yield. Nutrient and sediment retention modeling will involve identifying and mapping anthropogenic nutrient and sediment sources from watersheds and the nutrient / sediment retention functions provided by respective parcels in the landscape. Carbon sequestration modeling will involve estimating the amount of carbon currently stored in a landscape and the amount of carbon sequestered. Valuation of all these ecosystem services will involve the use of market or social value data (e.g. cost of water treatment and dredging to determine the avoided cost if the landscape provided the purification/retention service, cost of water provided by municipals less production costs to establish the value of water contributed per parcel, the value of a unit of carbon to determine the value of carbon sequestration over time) to value WrES to society. The revenue / costs saved will then be redistributed over the landscape, thus identifying the high value hotspot parcels in the landscape that require priority management. Scenario simulation will involve formulating and running scenarios of different management, land use and climatic parameters. The cost of management options will finally be compared with the enhancement in the ecosystem services attributed to implementation of such options.

Project schedule and budget requirements.

The tentative project schedule, budget requirements and the linkage of this case study to the dissertation research is as indicated in tables 1 and 2. This application for funding relates to only the italicized components in table 1.

Table 1. Tentative project schedule

Activity		**Output**	**Schedule**
Compilation of the concept note		Concept note	Sum. & Fall 2017
Framework review & evaluation of hydrologic tools for impact assessment of WSP measures		Research paper prepared	Sum, Fall 17, Spr. 2018
Valuation of WrES & benefits of implimenti ng SP measures - BigElm Creek watershed	*Funding proposal submitted*	*Approved proposal byTWRI*	*Fall 2017*
	(i)Data collection, (ii)Modelling, (iii)Economic valuation (iv)Scenario simulations	*(i) Report and (ii) Research paper prepared.*	*Spr., Sum.& Fall 2018*
Case study 2: Yet to be decided	Funding proposal approval by TWRI or TCEQ.		Fall 18
	Methods and deliverables same as in Case study 1		Entire 2019
Dissertation and Research paper compilation (Hydro-economical inferences from the implementation of watershed & source protection measures in TX, USA			Fall 2019

Table 2. Project budget requirements.

Funding requested under the USGS program			Matching Funds		
Category	Amount	Justification	Category	Amount	Justification
Travel - Student	*$642*	*Approx 1200 miles @ $0.534 / mile. (IRS rate)*	*Supervisor expenses and wages*	*$10,000*	*Field expenses, Travel costs and Salary to supervise the graduate student*
Field expenses, Meals, Lodging	*$2366*	*Per diem rate - Bell, Milam counties, 14days@$169. (Ref: www,gsa.gov)*			
Supplies, tools, software	*$1992*	*Field PPE, Photography, Computing,, Copying &Printing, Communication.*			
Total	*$5000*		*Total*	*10,000*	

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