Open Journal of Soil Science, 2022, 12, 242-252
https://www.scirp.org/journal/ojss
ISSN Online: 2162-5379
ISSN Print: 2162-5360

Value of Water Based upon Retail Sales Tax Revenue

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How to cite this paper: Wright, J. (2022) Value of Water Based upon Retail Sales Tax Revenue. *Open Journal of Soil Science*, **12**, 242-252.
https://doi.org/10.4236/ojss.2022.126011

Received: June 1, 2022
Accepted: June 26, 2022
Published: June 29, 2022

Abstract

In quantifying the benefits of compost amendments to soils for agricultural and urban use in terms of water conservation, there are many difficulties in conveying "value" of water due to the many different aspects of value to individuals and organizations. Perhaps the most universal metric for value is through the net monetary impact of water. Therefore, it is necessary to quantify the benefits by placing a dollar value on the amount of water conserved by amending soils with compost. In most of the literature, the value of water is rarely defined, and when it is the value presented is actually the "cost" of water production or reclamation. However, to truly understand the impacts of water conservation, a fuller vision of the value of water is needed beyond the costs of water. In this paper, the value of water is developed for the Rapid City, South Dakota area. With a value of water established, the benefits of soil compost amendments are calculated by evaluating the reduction of irrigation water needed for comparable crops and the value of the conserved water. In developing a value of water for Rapid City, South Dakota, the direct costs for water production are compared with the retail value of water and the economic activity enabled by a water supply. The average cost of water production for South Dakota cities averaged $0.004 per gallon ($0.001/Liter). The analysis of retail value and economic impact showed that water is valued at $0.71 per gallon ($0.19/Liter) for Rapid City and nine other South Dakota communities when calculated using the community's retail sales records and economic reports. Efforts to find similar findings for the US were not found. With the value of water established for Rapid City and other South Dakota communities, the value benefits of compost amendments on water conservation are shown in direct monetary terms.

Keywords

Water, Value, Dollar, Benefit, Compost

1. Introduction

"We never know the worth of water till the well is dry."

Thomas Fuller, English churchman and historian, 1608-1661 [1]

"Higher organic matter content means the soil can store more water, which improves the crop's ability to resist drought and to fully take advantage of genetic enhancements, …In addition, greater water retention means less runoff and, therefore, less environmental impact…" [2].

Precipitation falls upon the Black Hills of South Dakota and Wyoming as part of the hydrologic cycle to replenish the needed essence of life. The hydrologic cycle occurs throughout the year, at times in the form of snow, with varying frequency. Precipitation is the only means of re-supplying the water resources in the Black Hills and makes the conservation and wise use of water extremely important. Soil moisture can be in abundance or short of supply when drought becomes reality. The hydrologic cycle is an event of nature that humans cannot control. With the potential of climatic changes in the future should society better manage water resources by implementing water protection and conservation?

Can we protect or manage the availability, quality, and safety of our necessary water? In discussing potential management options regarding the conservation and wise use of water, a value of water is needed. Practical and affordable solutions to conserve water are crucial in the search for water sustainability. Strategic decisions and management are needed at the local, regional, national, tribal and international level. Conservation of water must show benefits in terms that are understood and the most understood comparative method is money.

With water being a resource and the supply un-predictable, research to determine the potential for conservation of irrigation water through the use of compost as a soil amendment was completed in early 2019. The research project collected data on the water content of soils with and without compost amendment. The research needed a dollar value of water to evaluate the cost-benefit ratio of compost use. One potential water management practice is utilizing solid waste currently being composted for use as a soil amendment. Compost as a soil amendment improves the soil's structure and health [3] [4] [5]. Improved soil structure provides better water infiltration, storage, availability, and conservation. Use of compost provides a market for the composted fraction of solid waste. Use of compost supports the development of composting as a viable solid waste management option. For a waste reduction program, such as municipal solid waste composting, to be viable, there must be a use and benefit for the use of compost. Water conservation is a much sought-after goal in water resource management. By determining a value of water, an economic analysis is possible and meaningful.

2. Water Usage

The United States Geological Survey publishes a water usage report to the Nation every five years [6]. **Table 1** is a summary by category of use from the 2018 report and shows that irrigation uses 37% of the water used in the United States.

Water producing utilities determine rates for the sale of water based upon the cost of acquisition, treatment, distribution, delivery, collection and treatment of said water. In South Dakota, the production, delivery and treatment cost of water is in the range of $0.004 per gallon [7]. The value of water to the community's economic activity is another basis for determining the retail value of water. The cost of production and delivery of water does not show the water's value, only its cost. Economic activity created because of water being available can be seen as a realistic value of water.

If a soil is amended with compost, will there be a significant savings of irrigation water? If there are savings, an acceptable value of water is needed. A value of water based on a community's economic activity will encourage meaningful conservation and protection of local water resources. Research at the South Dakota School of Mines showed that compost improves soil structure with one of the benefits being water conservation [7]. Increased use of compost to conserve water will encourage more composting of municipal solid waste and less landfilling.

"Management of public water in the western United States has been managed by the Bureau of Reclamation. With the development of the west and its water demands, the Bureau is now at a time where a new management approach is needed. Cost benefit analysis, conservation, prioritization, best utilization are all terms that need inclusion in a modern western United States water management policy" [8].

The book "Cadillac Desert the American West and Its Disappearing Water" by Marc Reisner, [9] suggests it may be desirable that a new water policy be developed including who administers the water program. The issue of water rights is complicated and variable. A review of and probable changes of water law and policy are discussed in current literature and recommended in order to achieve water resource management for the 21st Century and beyond.

Table 1. Categories of water use in the United States [6].

Public Water Supply	12%
Irrigation	37%
Aquaculture	2%
Mining	1%
Domestic	1%
Livestock	1%
Industrial	5%
Thermo-electric power	41% non-consumptive
Total	100%

Water is a necessity for life and a community asset. The definition of community varies, but certainly will involve cities, counties, states, tribes and the nation. In the case of international water boundaries, national and international interests will be involved. Boundaries will be defined by watersheds, shore boundaries or aquifers. The need for international agreements respectful of all needs is an absolute necessity. A nation simply cannot consume the entire flow of a river and damage or destroy a downstream nation. International water, as well as national and local water, must be protected, managed, and conserved [10].

The search for adequate water policies, because of history, culture, politics, and geography is elusive [11]. Jane Lubchenco's observations [12], certainly characterize the elusive search for policies that would stretch the world's effective supply of water by promoting water conservation in irrigated agriculture [13]. The idea that the supply of water will someday be the issue that petroleum is today is a reasonable perspective as presented in the following quote:

> "Water promises to be to the 21st century what oil was to the 20th century: the precious commodity that determines wealth of nations."
>
> —Fortune Magazine, May 2000 [14]

An analysis of the value of water to one community, Rapid City, South Dakota, is the beta site for this discussion. The source, quantity, cost, and use of the water are what make it possible for this relatively small urban area to survive.

3. Rapid City, South Dakota

Rapid City, South Dakota and its local stream Rapid Creek, provide a system for comparative analysis. The stream's surface water contribution and recharging functions to local aquifers, provides water to Rapid City. Rapid City had an estimated 2017 population of 75,488, and a county population of 110,141 [15].

As Rapid City has grown, the demand for domestic, commercial, industrial, and residential irrigation water has increased. **Table 2** shows the growth of the City and County population volume of water produced, and cost of production. Rapid City is approximately 68% of the county's population. The water sources were stream flow, infiltration galleries, and deep wells all in the Rapid Creek watershed.

4. Rapid Creek

Rapid Creek has a watershed of approximately 710 square miles and originates within outcrops of the Madison Limestone, Englewood Formation, and Deadwood Formation, approximately 40 miles west of Rapid City. [18] Numerous headwater springs near the base of the Madison Limestone provide a steady stable discharge. The base flow enters the Deerfield and Pactola Reservoirs providing a stable supply of water. The reservoirs serve as flood control structures, storage for run off, and as reserve water sources for municipal, defense, and irrigation. Normal annual precipitation varies with an average of 17.04 inches for Rapid City, and 19.58 inches for Pactola Reservoir [18].

Table 2. Historical record of population and water production for Rapid City, South Dakota.

Year	City Population	County Population	City Water (MGY)	Annual Water Cost
1900	1342	5610		
1910	3454	12,453		
1920	5777	12,720		
1930	10,464	20,079		
1940	13,844	23,799		
1950	25,312	34,053		
1960	42,390	58,195	2,215,379,625	
1970	43,486	59,349	3,560,000,000	
1980	46,492	70,361	3,510,000,000	$1,340,499
1990	54,523	81,343	3,270,000,000	$10,656,664
2000	59,607	88,565	4,508,584,300	$7,316,033
2010	67,956	100,948	3,990,225,263	$11,403,244
2017	75,488 (a)	110,141 (b)	3,995,951,700 (c)	$12,465,315 (c)

(a) Rapid City Planning Department, [15]. (b) Rapid City Economic Development Office, [16]. (c) 2017 Rapid City Water Department Annual Report, [17].

The average stream flow for Rapid Creek in Rapid City is stated at 59.3 cubic feet per second [18]. Flows are managed to keep wildlife, especially fisheries, alive and healthy, to meet irrigation demands during summer periods, to meet surface water needs of the city, and to maintain appropriate reservoir elevations and minimize extreme storm or peak seasonal induced flow. The average annual flow is calculated to be approximately 14 billion gallons. The City of Rapid City processes approximately 3.9 billion gallons per year or approximately one fourth of the stream's annual flow.

The map of **Figure 1** is of the entire watershed, with significant geographical points noted.

5. Irrigation

The Rapid Valley Water Conservancy District manages approximately 150 square miles or @96,000 acres of irrigated property. The first development and use of water by settlers in the Rapid Creek Basin began in the late 1870's, with the first water right granted in 1877 for agricultural purposes. The first municipal water right in the Basin was secured by Rapid City in 1885 [18]. Irrigation demand as well as water needs of the City generally determines the summer release from Pactola Reservoir. **Table 3** summarizes irrigation demands on the Rapid Creek watershed.

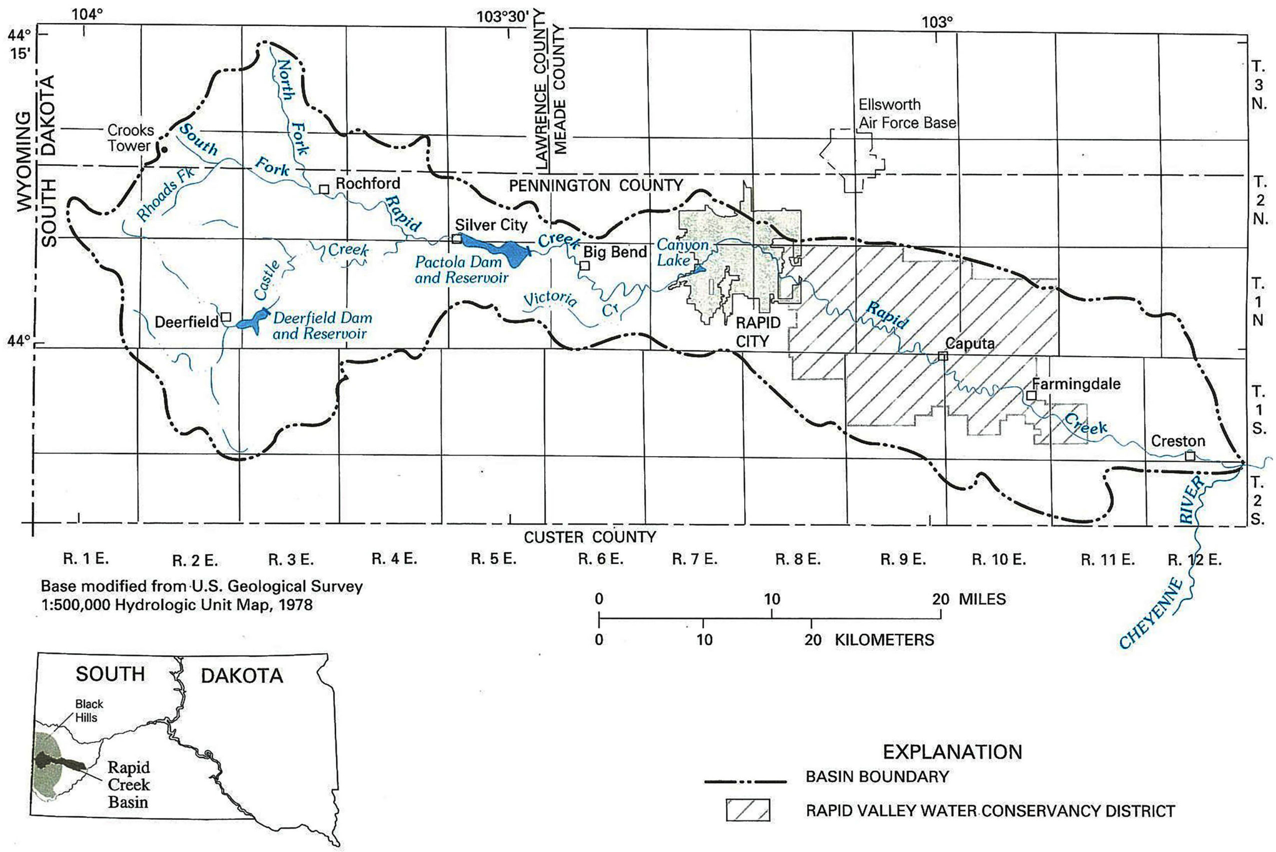

Figure 1. Rapid creek watershed.

Table 3. Irrigation demands on rapid creek.

Bennet Ditch, Leedy Ditch, and Storybook Ditch < 2 cfs each
Arrowhead Golf Course—@52,000,000 gallon/year, Meadowbrook Golf Course @70,000,000 gallon/year
Executive Golf Course @11,000,000 gallon/year
Irrigation Interests Deerfield Reservoir—any excess of 7000 in storage acre feet/year
Irrigation Interests Pactola Reservoir—7000 in storage acre feet/year

6. Methods

Rapid City provides a community with good records on water production, retail activity with City sales tax, and good water source data. The USGS Water, Resources Investigations Report 98-4214, entitled "Ground-Water and Surface-Water Interactions along Rapid Creek near Rapid City, South Dakota" [18] provides base flow information for Rapid Creek. Comparison of available water and water demands encourage sound practices in water protection and conservation.

The Rapid City Water Division, Production Group, Department of Public Works provided records of water production and costs.

The City Finance Office provided economic records showing the revenue from the 2% city retail sales tax which allowed calculation of the total retail sales subject to the 2% city sales tax.

In June of 2018 the seventeen first class municipalities of South Dakota were sent a questionnaire on quantity of water production, cost of water production and retail sales tax revenue. Responses provided an average of water production, water cost and total retail sales.

The availability of state-wide information provides an average cost of production and an economic based water value that was comparable to Rapid City's. The value of water based upon retail activity was relatively consistent across the state.

The economic value of the community's retail sales is used to determine a value of water [7].

7. Findings

The Rapid City economy is based on tourism, agriculture, medical, education, and hospitality industries. A good indicator of economic value, on a monetary basis, is the annual revenue that the City of Rapid City receives through its 2% city sales tax. Tax records are excellent data as they are carefully recorded, audited and evaluated [19]. **Table 4** summarizes the annual receipts received by the City of Rapid City since 2000.

2017 data shows that the City of Rapid City has a $2.8 billion-dollar economy made possible by the availability of water. If the current water supply were to diminish in quality and or quantity, a reasonable conclusion would be that the economy would adjust accordingly. Protection of the quantity and quality of the City's water source is in their interest.

Table 5 shows the five-year average for ten South Dakota municipalities at $0.71 per gallon based upon retail sales, and $0.004 per gallon based upon production and distribution cost.

Table 4. City of Rapid city annual sales tax revenue [20].

Year	2% Revenue	Total Retail Sales	Year	2% Revenue	Total Retail Sales
2000	$25,839,119	$1,291,950,000	2010	$42,959,552	$2,147,977,600
2001	$27,381,804	$1,369,090,200	2011	$45,677,756	$2,283,887,800
2002	$27,805,157	$1,390,257,800	2012	$48,075,091	$2,403,754,500
2003	$29,310,824	$1,465,541,200	2013	$49,636,875	$2,481,843,700
2004	$32,118,161	$1,605,908,000	2014	$51,837,716	$2,591,885,800
2005	$35,066,889	$1,753,344,400	2015	$53,861,089	$2,693,054,450
2006	$38,210,295	$1,910,514,700	2016	$54,200,133	$2,710,006,650
2007	$40,474,405	$2,023,720,200	2017	$55,510,536	$2,775,526,800
2008	$42,869,134	$2,143,456,700			
2009	$41,487,017	$2,074,350,800			

Table 5. Average retail value of water in South Dakota cities 2013-2017 [7].

City	Gallons	Gross	water value	Production
	water produced	retail sales	Retail	Cost
Brookings	909,334,935	$637,518,430	$0.70	$0.003
Huron	870,355,640	$321,658,920	$0.37	$0.003
Box Elder	300,600,000	$75,000,000	$0.25	$0.006
Mitchell	710,443,200	$542,540,450	$0.76	$0.001
Rapid City	3,663,740,282	$2,630,463,490	$0.72	$0.005
Sioux Falls	7,255,470,800	$5,714,668,360	$0.79	$0.003
Vermillion	376,048,408	$277,354,030	$0.74	$0.004
Yankton	816,010,000	$429,623,200	$0.53	$0.010
Aberdeen	1,208,640,800	$833,431,350	$0.69	$0.004
Spearfish	479,817,961	$365,038,740	$0.76	$0.004
Total	16,590,462,026	$11,827,296,970		
		average	$0.71	$0.004

Agricultural value of irrigation water is estimated by the value of the crop produced by the irrigated lands in the Rapid Valley Conservancy District. The district is estimated at 96,000 irrigated acres, producing an estimated 2 ton per acre of hay at an estimated market value of $75/ton. Therefore, 96,000 production acres, yielding 2 ton/acres, at the in the field cost of $75/ton, provides an estimated economic value of $14,400,000 per year. In an average year, the Rapid Valley Conservancy District has the potential to use 14,979-acre feet of water pg. 16 [18]. The irrigation district's accessibility to the irrigation water provides an estimated economic value of $14,400,000 divided by 14,979-acre feet of water. This equates to a value of $961/acre foot of water, or $0.003/gallon of water.

A community's value of water can be estimated by what the community is willing to pay for it, what it costs to produce and deliver, or what it allows economically. **Table 5** displays that an average value in South Dakota for realized retail economic activity, water is worth $0.71 per gallon. **Table 5** shows the average cost of water production and delivery is $0.004 per gallon.

A telephonic survey of several Rapid City retail stores in November of 2018 found examples of the price for retail prices of water. For example, if one buys a 20 oz. bottle of drinking water at a retail convenience store for $0.89 to $1.39 each the water is worth $5.70 to $8.90 per gallon. A gallon of drinking water at a local grocery store costs $1.00, the water is worth $1.00 per gallon. Rapid City office cooler water costs a $1.30 per gallon. The retail value of water is estimated at $1.00 to $8.90 per gallon according to this survey. It is apparent that the retail price depends on the vendor, packaging and size, but significantly higher than the price of economic value as calculated at $0.71 per gallon [7].

8. Discussion

The following statement is from "Determining the Economic Value of Water" by Robert Young

> "The analysis presented in this book demonstrates several key points. First, rather than valuing water per se, resource and environmental economists performing nonmarket valuations actually develop monetary measures of individuals' preferences for consequences of policy proposals or events. Such consequences might be improved supply, or reliability for off-stream users. Others include water's role as public goods, such as environmental or habitat preservation. Likewise, economists develop monetary measures of the gains in well-being that result from policies that reduce water degradation or those that address excessive or inadequate water supply. Using money as the measuring rod for valuing inputs and outputs enables economists to compare benefits with money costs of investments or with forgone values in alternative uses." [21]

Data shows that the Rapid City community is willing to pay $0.004 per gallon for the treatment and delivery of their municipally supplied water and between a $1.00 to $8.90 per gallon for convenient drinking water at a grocery or convenience store.

To cover current and future water costs an October 2017 Rapid City council decision would have taken the fee charged for municipal water to approximately $0.008 per gallon. The City Council's action was referred and defeated by the citizens three months later. In August of 2018, the city council reconsidered the rate increase and raised the rates to an average of $0.008 per gallon, with no opposition.

The City of Rapid City conducts billions of dollars worth of retail sales. If the City's water were not available at its current level, or if the water quality was decreased by drought or contamination, it can be assumed community activities would have to be adjusted and economic activity would be impacted. The adjustment would likely require a compensatory adjustment in water and therefore a compensatory adjustment in economic activity, such as retail sales. The compensatory adjustment could be very expensive including reduced economic activity, water importation, or treatment of waste water to drinking water standards.

In the interest of stability and sustainability of the finite resource of water, the city must embark on a meaningful water conservation and protection plan. The use of compost as a soil amendment to the irrigated soils within the city would conserve a significant amount of their water production that goes to irrigation. The findings of the research on the conservation of irrigation water through the use of compost as a soil amendment show that a 10% savings of water are possible with compost amended soils.

Approximately 35% of the City's water production is for irrigation. If the city were to incorporate compost into its green space, significant water savings will occur. A 10% savings in irrigation water would be possible resulting in approximately 136 million gallons of water conserved per year. The savings of 136 million gallons of irrigation water and production costs of $0.008 per gallon provides an annual $1 million cost savings. 136 million gallons of conserved water equates to a retail economic value of $95 million per year when valued at $0.71/gallon.

9. Conclusions

Water is a finite resource we must protect; we get no more. Economic activity that is dependent on water availability, justifies an investment by the community in active and investment orientated water conservation measures. The City is the only entity that can protect its finite supply of water. Incorporation of community-based compost reduces landfill costs and allows the community to amend the irrigated soils to conserve their precious water and save precious landfill space.

Cost of the delivery and incorporation will require an investment by the city. The investment could be in the delivery of compost to agricultural users or to their own irrigated city properties. The city properties would be public and private, and would include public spaces such as parks, golf courses, cemeteries, and residential and commercial private properties. An economic value of $0.71 per gallon, would more than help finance and justify the investment. The verification of a retail value to the water demonstrated that water is more valuable than the cost of production and delivery.

Acknowledgements

A special thank you is extended to the Finance, Planning and Water Production Departments, City of Rapid City, Rapid City, South Dakota, USA for their material and resource support. Their support allowed detailed study and observation possible. Ten South Dakota municipalities contributed water production volumes and cost and sales tax revenue and to them, a grateful thank you is extended.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Fuller, T. (2015) The History of the Worthies of England. Vol. 1. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781316136270

[2] Clay, D. (2015) Higher Organic Matter Content.

[3] Curtis, M.J. and Claassen, V.P. (2009) Regenerating Topsoil Functionality in Four Drastically Disturbed Soil Types by Compost Incorporation. *Restoration Ecology*,

17, 24-32. https://doi.org/10.1111/j.1526-100X.2007.00329.x

[4] Hudson, B.D. (1994) Soil Organic Matter and Available Water Capacity. *Journal of Soil and Water Conservation*, **49**, 189-194.

[5] Dalal, R. (1998) Soil Microbial Biomass—What Do the Numbers Really Mean? *Australian Journal of Experimental Agriculture*, **38**, 649-665. https://doi.org/10.1071/EA97142

[6] Dieter, C.A., *et al*. (2018) Estimated Use of Water in the United States in 2015. US Geological Survey.

[7] Wright, J.T. (2019) Conservation of Irrigation Water through the Use of Compost as a Soil Amendment in Department of Civil and Environmental Engineering. South Dakota School of Mines and Technology, Rapid City, 126.

[8] Moore, M.R. (1991) The Bureau of Reclamation's New Mandate for Irrigation Water Conservation: Purposes and Policy Alternatives. *Water Resources Research*, **27**, 145-155. https://doi.org/10.1029/90WR02403

[9] Reisner, M. (1993) Cadillac Desert: The American West and Its Disappearing Water. Penguin, London.

[10] Barlow, M. and Clarke, T. (2002) Who Owns Water? *The Nation*, **2**, 11-14.

[11] Ward, F.A. and Pulido-Velazquez, M. (2008) Water Conservation in Irrigation Can Increase Water Use. *Proceedings of the National Academy of Sciences*, **105**, 18215-18220. https://doi.org/10.1073/pnas.0805554105

[12] Lubchenco, J. (1998) Entering the Century of the Environment: A New Social Contract for Science. *Science*, **279**, 491-497. https://doi.org/10.1126/science.279.5350.491

[13] Ward, F.A. and Michelsen, A. (2002) The Economic Value of Water in Agriculture: Concepts and Policy Applications. *Water Policy*, **4**, 423-446. https://doi.org/10.1016/S1366-7017(02)00039-9

[14] Selby, J. (2005) Oil and Water: The Contrasting Anatomies of Resource Conflicts. *Government and Opposition*, **40**, 200-224. https://doi.org/10.1111/j.1477-7053.2005.00150.x

[15] Department, C.o.R.C.P. (2018) Population Data.

[16] Rapid City Economic Development Office (2016) Population and Economic Data.

[17] City of Rapid City, Department of Public Works, Tim Weber, Rapid City Water Division and Water Production Supervisor (2017) Rapid City Water Division Group Production Report, 2018.

[18] Anderson, D.W. (1999) Ground-Water and Surface-Water Interactions along Rapid Creek near Rapid City, South Dakota. 99.

[19] Olaoye, F.O. and Akinola, A.A. (2019) Tax Revenue and Budget Implementation in Nigeria. *American Journal of Industrial and Business Management*, **9**, 1219. https://doi.org/10.4236/ajibm.2019.95082

[20] City of Rapid City, Department of Finance, Pauline Sumption, Finance Officer, Financial Data (2018) Sales Tax Revenue.

[21] Young, R.A. and Loomis, J.B. (2014) Determining the Economic Value of Water: Concepts and Methods. Routledge, New York. https://doi.org/10.4324/9780203784112