Water Prevails: Research in Water Resource Management Approaches Applied in British Columbia, Canada

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Abstract. Numerous human daily activities required the water resources as the fundamental natural resources. Hence, the appropriate and efficient sustainable approaches should be analyzed to reach sustainable water resource management targets. Therefore, this Paper introduced the overall status quo of freshwater resources, then focused on identifying water resource status in British Columbia, the West Coastal Province of Canada near the Pacific Ocean. With analysis regarding water resource management approaches from climatology, scientific and sociological perspectives. Furthermore, the interpretation of the relations between water resources and human activities revealed the four principles that were adopted by the provincial government to determine appropriate water resource management approaches. Water reusing, water quality monitoring and pricing strategies were identified as potential scientific instruments to reveal the efficiency of current water resource management proposals. Besides adjusting the water parameter standards, indigenous knowledge and public participation should be concluded to revise current water management strategies. Furthermore, the integration of the analysis with the actual and practical water requirements and patterns in British Columbia revealed the coherency of current water management approaches with sustainable water usage goals. Through these analyses accompanied with multiple case studies and research, the goals toward sustainable water resource allocation and methods to improve current water resource management plans were clarified.

Keywords: Water Resource Management; Natural Resource; Natural Resource Economics; Water Resource; Environmental Sociology.

1. Introduction

Water resource was considered one of the most critical natural resources that the majority of human activities would be relied on. However, its scarcity is the most critical issue that human society faces now. Approximately 2.5% of the overall water resource on Earth was freshwater, while the proportion of available freshwater was even less [1]. Agriculture would consume about 70% of the overall available freshwater resource in the matter of crop irrigation to maintain growth. Since agriculture was one of the critical foundations of society, failure of either perspective would ultimately social collapse and insecurity [2, 3]. Moreover, the water resource provided based on ecology equilibrium, became gradually critical under the background of climate change. In the matter of water quality requirement to maintain populations of specific species, the water quality would significantly influence regional ecology health and stability majorly reflected in biodiversity [4, 5]. Therefore, these factors revealed the necessity of water resources, and the proper management approaches should be adopted to resolve the allocation issues and to determine an appropriate demand-consumption equilibrium pattern. In the long term, the management approaches would provide sustainable potentials and solutions regarding solving freshwater quality, quantity, allocation, and security issues [2, 5, and 6].

While proposing appropriate and efficient water resource management methods, two dominant study areas were mainly focused on. Some revealed the necessity to improve infrastructures, accompanied by the improvement of scientific techniques. For instance, to secure freshwater resource quality, a critical scientific improvement was to minimize water pollution to ensure the potential for reusing through establishing purification networks to reduce chemical pollutants present in water [7]. Even though scientific techniques improvement often requires economic considerations, its efficiency

would be reflected in relatively short time periods. Besides scientific approaches, other studies considered appropriate water resource management methods from sociological perspectives. Studies indicated that participation from various levels would justify and enhance water resource allocation decisions. Various proposals regarding water decisions from different water resource stakeholders should be adopted based on their knowledge and interests. Despite the negative effects brought by potential interest conflict between water stakeholders and governments, the overall water resource management approach was efficient and could be supplied based on various participatory programs that promote democratic public participation [8]. The purpose of this paper was to analyze the water resource management approaches applied in British Columbia, Canada. Considering the origins of the water resource status quo, various applied methods with future expectations.

2. Status Quo of Water Resource in British Columbia

Climate change events, especially global warming, facilitated the melting process of mountain snow. Additionally, global warming generally resulted in more frequent precipitation in all seasons. Even though this could facilitate water resource circulation in short time periods, eventually the water brought by precipitation would unlikely be restored in the pattern of snow as the increase in temperature. Moreover, since the mountain snow was considered to replenish limited freshwater resources as inferred, rapid melting of freshwater would cause increasing risks of flood and freshwater inaccessibility. Focused on British Columbia, the western coastal province of Canada, which was considered an available water-resource-nourished region compared to the rest majority of provinces of Canada. Its natural geographic features provided a solid base regarding water resource preservation and storage. Some hydrology and topographic features, especially the flowing or discharging pattern of rivers associated with elevation variance, would determine the river water resource distribution intra-provincially. Most frequently in British Columbia, river streams reached maximum flow in early to middle spring in the matter of melting snow from eastern Rocky Mountain Valley regions. Approximately 90% of the freshwater system provided 90% of the total population in British Columbia lived in urban regions [2]. Moreover, the precipitation of British Columbia brought replenishment of water resources. Southern regions, including the Fraser River Basin and Pacific Coastal communities, received relatively higher precipitation levels. Annual and seasonal precipitation varied significantly. During summer months, the precipitation was approximately 50 mm, while during winter months the precipitation would increase to about 550 mm. Regardless of the impacts of certain climate events (El Nino or La Nina which brought significant variation in precipitation compared to regular seasons). This pattern leads to inconstant water resource replenishment during the summer season, with facing potential risk of water shortage if inadequate water resource management approaches are applied [1, 2].

Appropriate and efficient water resource management methods were facing challenges from geographical features and significant variance in seasonal precipitations that greatly impacted the provincial water resource distribution, allocation, and consumption. Therefore, constructing adequate water resource management approaches based on various natural geographic features and from national, provincial, or regional scales was substantial regarding water resource usage and allocation.

As implied previously, Strategies for water resource management in British Columbia required improvements to provide more solid provincial solutions regarding water resource issues. The dominant issue that the province facing now is missing a balanced standard to quantify water supply based on regional consumption or usage, especially considerations and decisions to solve the supply conflict between urban and rural regions in British Columbia. For instance, Whistler, the city of British Columbia, had increased the average water usage to 425L / Day which was greatly higher than the national average usage of 329 L / Day [9]. This draws an example of a status quo regarding the overusing of water among urban regions, while rural and suburban regions would struggle with water shortage. In addition, another issue presented in current water resource management strategies was the deficiencies of current water resource system designations. Since water resource management

includes water quality monitoring, while current management system demonstrated its disadvantages in water quality assessment, as it was constructed based on conventional and unspecific Hydrological practices. Hence, new advanced and specific approaches were required to reestablish water quality monitoring.

3. Canadian Water Resource Management Principles and Approaches

3.1. Principles and Methods Researched

In the matter of scarcity and relatively fragile sustainable potential as the two most critical natural attributes of water resources, the management methods were unique from other natural resources. Various research from national and provincial or regional scales have demonstrated current sustainable approaches to solving water resource management issues. Based on a report listing the principles of water management in Canada proposed by the Canadian Water Resource Association around the 1990s, the sustainable approaches to solving related issues would be interpreted from several perspectives [10].

Those perspectives concentrated on 4 principles. Firstly, establishing linkage between water resources and other natural related natural resources. Moreover, satisfying fundamental consumption needs. Additionally, enhancing ecology diversity with integrity. Lastly, planning for future and integrating the issue with economic basis. It revealed a national agreement regarding sustainable water resource management approaches. With the main principles introduced federally, national and provincial governments would comply with these as guidelines when scheduling sustainable water resource management projects. For instance, since the instability of replenishment of underground water resources that deeply depended on seasonal precipitations and melting snow during spring months, a scientific approach could be applied was water recycling to achieve the target of sustainable water resource management [10].

The current majority of Canadian water resource reusing originated from agricultural and landscape irrigation and industrial usage, while the stormwater and rainwater were relatively less rarely recycled[4,11]. It was noted that water recycling in Canada is dependent on the contamination level of wastewater after the first use or consumption, therefore the wastewater requires various advanced treatments (including reverse osmosis, sedimentation and extra nutrient removal and UV light disinfection [7]) to satisfy the criteria of Category 1 and 2 (which referred to criteria that satisfied water reuse standard without major hazardous effects to human bodies) for refusing to achieve the goal of sustainable usage[12,13]. Vernon, the city of British Columbia, had started water reuse since 1977, it focused on agricultural irrigation, effluent irrigation and recreational purposes wastewater during the irrigation periods from April to October. Despite this program reducing the heavy water reliance and shortage during agricultural irrigation seasons, it demonstrated the importance and necessity for annual water reusing besides irrigation periods. Through establishing an annual water reusing network, the water shortage in Vernon would be efficiently resolved.

Another current scientific and sustainable approach regarding water resource management had been applied in British Columbia was determining water quality through monitoring micro-organism presence, minimizing the contagious factors would be critical for reusing water as they would propose biohazard that had potentially destructive effects on the ecology system and public health[5,14]. Therefore, the microbial risk assessment system of freshwater bodies was constructed with variations from different provinces. It also indicated that for British Columbia, the fresh drinking water quality was not defined by legislative imperative [5]. Moreover, the quantification of water resource allocation under four principles mentioned previously would contribute to sustainable water management efficiently. Therefore, economic policies presented by the British Columbia provincial government demonstrated water pricing strategies to satisfy the sustainable water resource management goals.

3.2. Status Quo with Examples

All the above scientific and sustainable approaches the principles mentioned, with multiple principles and approaches that had been applied by the Canadian federal or British Columbia provincial government, the cases associated with each approach would reflect the effectiveness. For instance, regarding the water recycling approach in British Columbia, the Vancouver Convention Center (VVC) West Building and the University of British Columbia Center for Interactive Research in Sustainability (CIRS) were representative examples that had already applied wastewater reuse system. While the specific mechanism for each building worked differently. For the CIRS building, it collected the rainwater and maintains stored for in-site treating to facilitate further toilet flushing or internal irrigation inside the building. While VVC West building the reusing of wastewater, especially black water (wastewater from sanitary resources which had gray or black color with a pungent scent) was applied for flushing toilets and irrigation. These examples explored the potential that the discrete water reuse networks and mechanisms could provide to reduce the reliance on freshwater practices [10].

Another research in British Columbia would reflect the efficiency of microbial risk assessment to achieve sustainable water resource management. Studies were mainly focused on Fraser River Valley and Capital Regional Watershed regions to determine the microbial impact on freshwater watershed health and quality. It was studied that E.coli or fecal coliforms were within the regulated quantities, which were undetectable per 100mL for all three research sites, with the population-based method. However the study indicated that even though from numerical result did not reflect potential negative impacts on current drinking freshwater bodies brought by the microbial among this region and Part 5 of BC Drinking Water Protection Act promoted associated Water Act could be proved based on regulatory tools, British Columbia had management issues regarding microbial risk assessment and proper management regimes. Missing risk abatement methodologies regarding ecosystem health and Inconsistent legislative imperative to convert regulations into actual conduction [3, 7].

As indicated previously, water price adjustment would also be a critical factor contributing to sustainable water resource management. One study revealed the present water pricing strategies in South East Kelowna significantly impacted the irrigation water demand when the block rate increased. For instance, in 2004, the approximated water charge price was $0.02 per cubic meter, if the irrigator increased the allotment that was accompanied by a volumetric charge of $0.1 / 1000 Gallons, then it would ultimately result the water price to $0.17 per cubic meter. Therefore in order to sustain the regular daily water consumption without violating water pricing regulations, some irrigators were required to pay the bills of previous years before the beginning of new charging period [9]. From this example it could be concluded that for Agricultural regions in British Columbia, the manipulation of demand and supply relation of water resource allocation was greatly impacted. Compared to agricultural usage, it was concluded that for Industrial water demand management techniques, it may require tax incentives to allocate and to coordinate industrial water consumption [9]. All these above examples provided a broad view regarding current water resource management in British Columbia that were coherent with the national water management principles, majority examples demonstrated the successful aspects and results of current management approaches. However for some cases, the disadvantages of current approaches had been identified and could be improved for future implementations.

4. Management could go Beyond: Future Expectations

Despite the deficiencies of recent water resource management approaches from the scientific and sustainable aspects had applied in British Columbia, the sociological perspective water resource management should be considered in the future studies.

For example, in the context of Canadian society, the indigenous right was considered a significant component to maintain social stability. One study revealed that the dominant conflict between Indigenous groups and Provincial government was the right of excavating natural resources. While

the indigenous communities regarded themselves as a stewardship owning them, failing in simply recognizing indigenous communities as the stakeholder while participating the self-oriented natural resource management would eventually lead to federal level of collaborative management inefficiencies. The depth and broadness of indigenous traditions and knowledge covered numerous perspectives of natural resources, including the ecosystem health, aquifer status and sustainable fishing or hunting. Therefore in the further research and improvement studies, the traditional knowledge and recognition regarding the water resource should be emerged with current scientific sustainable approaches to solve related issues to guarantee social stability simultaneously [15].

Moreover, increasing in public participation in sustainable water resource management. Unlike from the indigenous community involvement, it was more concentrated in the formation of social norm and values regarding management approaches. However, public participation required multiple elements to maximize its efficiency, whereas some elements were generated from provincial government. For instance, the accessibility transparency of the information; legislation solidified base; proper applied social resources and Public conflict resolution methods. Public participation should be legislated with the complete and symmetry information provided from the government to meet the principle of sustainable water resource management. When emerging with sustainable water resource management approaches, these elements could assist public to establish well-constructed, understandable information web regarding multiple water management parameters: consumption, demand, allocation, and supply. Therefore, the importance of promoting public participation would indirectly unify the target of the public with the government's goal to improve current water management approaches [15]. Further water resource management improvement could be concentrated on the reformation of the water tax, which was an economic tool to quantify water resource allocation and consumption patterns among various water users. Taxing is based on specific water usage instead of straightforward consumption level pricing, in this case the urban and rural residents would pay less compared to agricultural activities and industrial production consumers. Public Participation secured the reliability and promoted public awareness of scheduling appropriate water resource management plans, further facilitating the sustainable usage of freshwater resources [15, 16].

5. Conclusion

This paper revealed the status quo of water resources in British Columbia, with several studied examples to demonstrate major principles and approaches that the government of British Columbia had selected to schedule appropriate water resource management approaches. Further expectations were concluded to improve current water resource management methods. It was studied that the water resource management approaches selected by British Columbia greatly relied on seasonal and topographical factors, especially the refilling of underground freshwater resources from seasonal precipitation and melting snow. The dominant methods that were applied and researched included water quality parameter monitoring and regulating water consumption patterns based on usage types. All studies revealed their coherence degrees with four principles that the provincial government had selected to determine adequate water resource management plans, accompanied by little variances based on actual local circumstances to achieve the sustainable usage of water resources. Despite the success that these studies had revealed, some shortcomes were demonstrated on the basis of efficiency and regulation transparency for long-term practicing and implementations. Therefore, further improvements regarding current water management approaches in British Columbia would embrace more of indigenous knowledge or perspectives to make those approaches more comprehensive and practical. Additionally, increasing public participation should also be considered to promote transparency of implemented water resource management approaches, multiple monitoring elements would boost the democracy among water resource management engagement to make management and allocation more efficient.

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