Title: Developing indicators of watershed health through public consultations and positing the use of ecological place-based approach in watershed management planning

Marilou B. Montemayor[a] (corresponding author) and Beverly Smith[b]

Affiliated with the Red Deer River Watershed Alliance, Red Deer, Alberta, Canada, as Watershed Management Planning Manager[a], and Executive Director[b], at the time of this study

Email: mbmontemayor@hotmail.com

Abstract

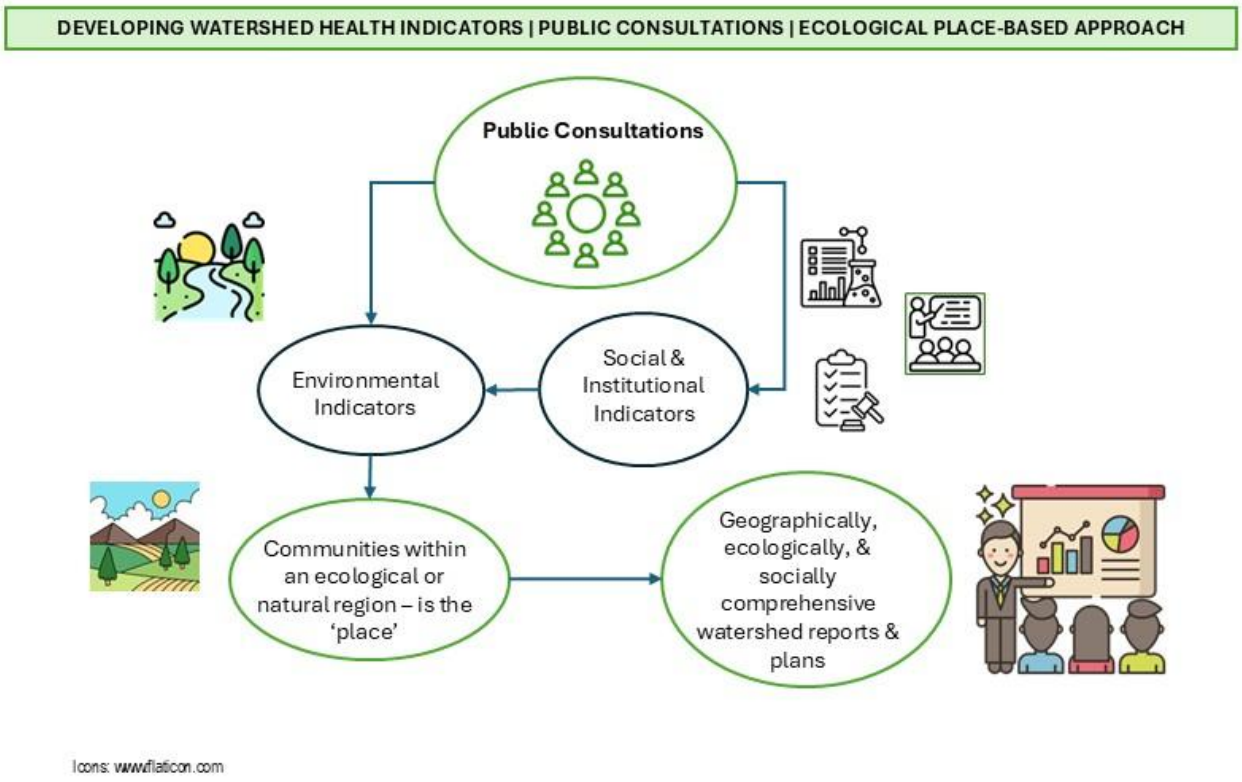
Watershed health assessment is essential in the identification of issues and in the development of a plan to find solutions to issues. Watershed health is assessed based on a suite of watershed health indicators (WHI) often selected by technical experts. Stakeholders' input into the selection of WHIs is necessary. Additionally, the importance of each indicator varies in different areas of a large watershed due to differences in ecological factors. The Red Deer River Watershed Alliance (RDRWA) conducted public consultation workshops at three locations that corresponded to natural regions (ecological land units) within the Red Deer River watershed, Alberta, Canada. Participants were asked, "What are your watershed issues?" Similar issues were grouped together and placed under a corresponding group of watershed health environmental indicators used by the RDRWA and the Government of Alberta. Non- environmental issues turned out to be social and institutional issues and these were classified based on the subject or topic that emerged from the process of grouping similar issues together. Issues were analyzed and comparisons were made between locations. Nine environmental indicator groups, three of which were new, and a new set of eight social and institutional indicator groups were identified. Natural regions influenced environmental indicators and, to a lesser extent, social and institutional indicators. Using natural regions within a large watershed is an ecological place-based approach that groups together land areas and their communities that have similar environmental issues. This approach, in combination with the use of WHIs developed by stakeholders, will provide the basis of a comprehensive watershed health report and a management plan in the future. This approach can be replicated in other places in the world that practice participatory watershed management planning.

Key Policy Highlights

- Watershed health indicators (WHI) should include both environmental, and social and institutional indicators.
- The development of WHIs should include consultation with stakeholders to access local knowledge and expertise and potentially gain their trust and support.
- Natural regions or ecological land units within a large watershed should form the basis for the place-based approach in watershed management planning.

Keywords: Ecoregions; Environmental indicators; Participatory process; Place-based approach; Social indicators; Water; Watershed

Graphical Abstract



Introduction

The Red Deer River (RDR) watershed is one of the major watersheds in Alberta, Canada (Figure 1). It has a total area of 5,023,063 ha and consists of five natural regions, Rocky Mountain, Foothills, Boreal, Parkland, and Grassland (Figure 2). The watershed, an area of land that drains into a waterbody, is a geographic hydrological unit commonly used for the management of the environmental aspects of land and water resources or watershed management (Alberta Environment and Sustainable Resource Development (AESRD) 2015; Heal 2017).

The Government of Alberta designated a Watershed Planning and Advisory Council (WPAC) for each of the major watersheds in the province (AWC 2008b). The Red Deer River Watershed Alliance (RDRWA) is the WPAC for the RDR watershed. WPACs are multi-sector, volunteer-based, not-for-profit organizations. WPACs are expected to produce a State of the Watershed (SOW) report that identifies issues in the watershed and develop collaboratively a Watershed Management Plan (WMP) periodically as needed. The development of a WMP is participatory process involving citizens or stakeholders (those who live, work, and do recreation within the watershed). A WMP recommends how stakeholders should address agreed-upon watershed issues, what actions should be taken and by whom (AESRD 2015; Heathcote 2009). Watershed issues are usually related to the impacts of human activities on land and water resources. A SOW is an assessment of watershed health that is based on a suite of watershed health indicators (WHI). The selection of WHIs is often recommended by technical experts (for example, biologists, environmental scientists, water scientists) and lack social science experts. Stakeholders may view this as inadequate, which could lead to lack of trust in the results of a SOW and the and WMP (Coelho et al. 2022). The lack of socio-economic considerations in a

technically focused plan discourages collaboration by stakeholders (see, e.g., Adams et al. 2005; Cheng and Daniels 2005).

A healthy watershed consists of numerous natural components (biological, chemical, physical) and processes, with complex interactions, and it performs many functions that benefit people and the environment (Alberta Environment (AE) 2008). A WHI, for example, surface water quality, includes several parameters (for example, dissolved oxygen, nutrients, bacteria, etc.). Commonly used WHIs and their parameters are found in the Red Deer River Watershed Alliance (RDRWA) (2009) and AE (2008).

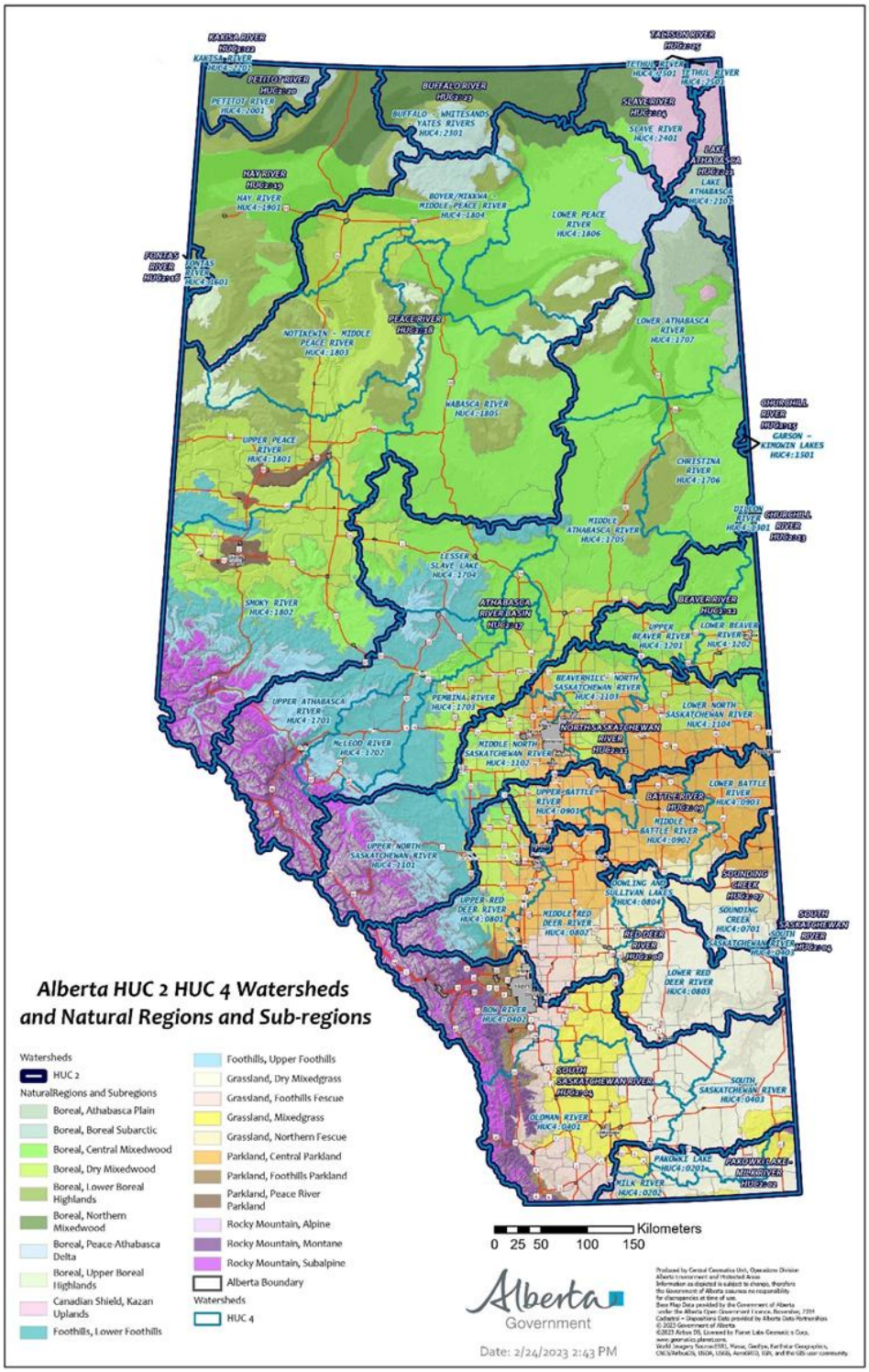
Watershed management involves the combination of concepts from various disciplines (for example, hydrology, physical geography, ecology, environmental science, and social science). Concepts used in this paper are briefly presented below.

Large watersheds (Figure 1) can span different ecological regions (ecoregions). These are areas of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables (Petersen 1999). Ecoregions influence environmental factors and are used as management units worldwide for environmental assessments, biodiversity monitoring, nature conservation, and natural resource management (see, e.g., Smith et al. 2018; Funk 2020). Alberta uses natural regions and subregions (Natural Regions Committee (NRC), 2006), which correspond to ecoprovinces and ecoregions, respectively, that are used by Statistics Canada (StatCan) (2017) for biodiversity monitoring and reporting. Alberta's park management framework is based on natural regions (Alberta Tourism, Parks, and Recreation (ATPR) 2015) and therefore, environmental, and social data are collected for each natural region. It would be useful to include data from parks into a SOW, and a WMP could include recommendations for

89 parks as well as among other sources of issues. Parks have environmental impacts such as
90 deterioration of surface water quality (see, e.g., Cooke and Xia 2020).

91 The place-based approach is based on the concept of a ‘sense of place' that is generated
92 within people from how they experience their environment and consequently the desire to protect
93 it (Norton and Hannon 1997). It has been used in the promotion of local development and in the
94 delivery of social services using local administrative authorities or communities as ‘places’
95 (Bradford 2005; Keller and Virag 2022), and recommended for environmental policy alignments
96 in indigenous lands (Kobluk et al. 2024). It was conceptually adapted to watershed management
97 planning, stating that 'people in the place are the best to identify and find solutions to their
98 problems' (Alberta Water Council (AWC) 2008a). Therefore, a ‘place’ depends on the spatial
99 context of an issue experienced by a community which can be influenced by natural regions or
100 ecoregions.

101 Consultation is one of the stages of public participation (Callahan 2007; Ross et al. 2016).
102 Perspectives from stakeholders are useful in the identification of watershed issues (Liu et al.
103 2008). Initiatives that involve the well-being of a community should be supported by local
104 knowledge, expertise, and partnership collaboration (Sung and Phillips 2018). A semi structured
105 interview study of 70 people involved in water management in a watershed by Garin et al. (2002)
106 found that viewpoints of experts and stakeholders differed as to the nature and origin of water
107 management problems. Coelho et al. (2022) used a workshop-based approach for the selection of
108 environmental indicators by stakeholders. The literature on public participation is extensive,
109 even when narrowed down to watershed, environmental, and natural resource management (see,
110 e.g., Reed 2008).



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112 Figure 1 The Red Deer River watershed and other major watersheds (hydrologic unit code

113 (HUC) 2) in Alberta, and natural regions and subregions

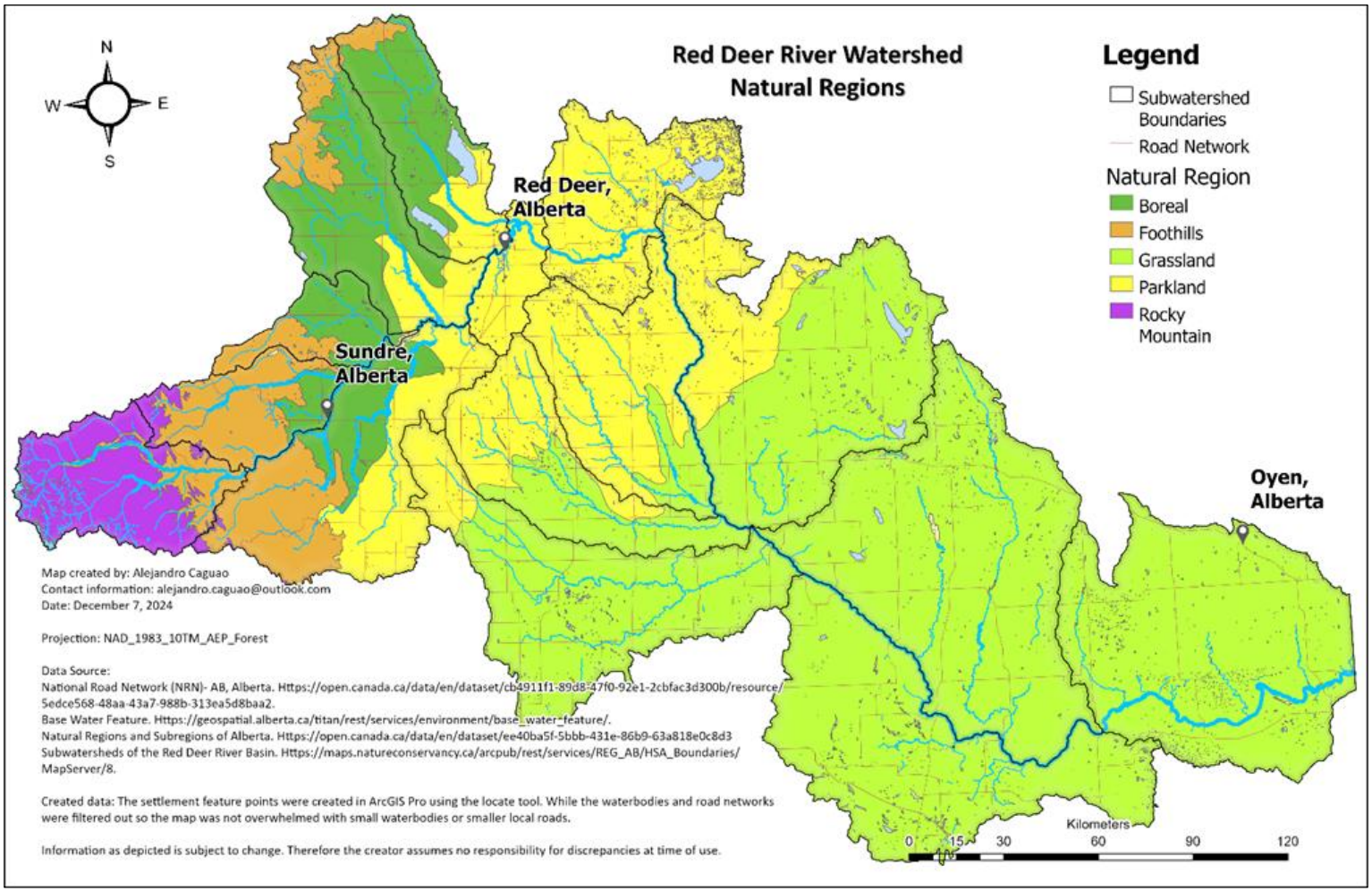


Figure 2 The Red Deer River watershed showing natural regions, sub-watersheds, the town of Sundre, the city of Red Deer, and the town of Oyen

The board of directors of a WPAC reviews and approves a set of WHIs recommended by a hired technical consultant. Public consultations on the development of a set of WHIs by WPACs have not always been a practice. The current set of WHIs of the RDRWA and its selection process needs updating to reflect the perspectives of stakeholders. The influence of natural regions on WHI should be considered, and the 'place' in the place-based approach should be defined.

The purpose of this study was to conduct public consultations for the RDR watershed with the following objectives: a) to determine whether stakeholders' watershed issues have been represented in the set of WHIs used in the RDRWA SOW 2009 report, b) to determine whether watershed issues are the same or not throughout the RDR watershed, c) to develop a place-based approach for the watershed, and d) to determine how the results of public consultations will guide the development of a WMP.

Methods

Using various communication methods and media channels, people in the RDR watershed were invited to the RDRWA public consultation workshops that were held on three successive days January 25, 26, and 27, 2011 in urban centers of natural regions, Sundre (Foothills and Boreal), Red Deer (Parkland), and Oyen (Grassland), respectively (Figure 2). The Rocky Mountain natural region was not included in this study.

During the workshops, the 2009 RDRWA SOW report was presented, after which participants were asked to answer one question, 'What are your watershed issues?' and provide answers in their own words. The participants formed groups of 7-8 people at a table. The issues raised were recorded and shared with all participants at the end of each workshop.

All data in this study were analyzed by the main author based on her professional judgement. Similar environmental issues were grouped together, counted and classified under the relevant group of WHIs found in RDRWA (2009) and AE (2008), or generated. Non-environmental issues turned out to be social and institutional support issues. Similar issues that belonged under a common topic were grouped, counted, and the topic became the indicator group name. For brevity, the words 'group' or ‘groups’ are removed from the remainder of the text.

At each location of the event, the percentage of issues under each environmental indicator and each social and institutional indicator was calculated. The graphs were made using Microsoft Excel.

To determine the influence of natural regions, the percentages of issues were ranked from highest (=1) to lowest, separately, for environmental, and social and institutional indicators, for each location of the event. The difference between maximum and minimum ranks was calculated, and the midpoint of their range was determined. Comparisons were made between the three event locations, using three categories: a) Similar – the difference was less than or equal to the mid-point; b) Different - the difference was greater than the mid-point; and c) Unique - an event location did not have this issue; it was unique to one or two event locations. Although the Unique category could be associated with the influence of natural regions it was not included in the process that compared three locations.

To facilitate the preparation of WMPs in phases, indicators were prioritized by ranking. The number of issues at the three locations of events was combined separately for environmental, and social and institutional indicators. Then the percentage of the number of

issues per indicator was calculated over the corresponding total number of issues, then ranked from highest (=1) to lowest.

Statistical ranking was done using the Microsoft Excel Analysis Toolpak. The area of the watershed and the natural regions in ha were determined by using the calculate-geometry tool in ArcGIS Pro using area geodesic. Population information was obtained from StatCan (2011) and population density was calculated.

Results and Discussion

The distribution of the number of participants and issues among the three event locations is shown in Table 1. Watershed issues belonged to two broad categories: environmental, and social and institutional. Information on human population and population density are included in Table 1.

Table 1 Number of participants and issues and corresponding percentages at the three locations of events, area (ha) of the natural regions, population density per ha and urban center population

Urban Centre Natural Region	Sundre (Foothills and Boreal)	Red Deer (Parkland)	Oyen (Grassland)	Total
Number of participants (%)	36 (28%)	77 (59%)	17 (13%)	130 (100%)
Number of all issues (%)	66 (23%)	153 (53%)	68 (24%)	287 (100%)
Number of environmental issues (%)	43 (33%)	54 (42%)	32 (25%)	129 (100%)
Number of social & institutional issues (%)	23 (14%)	99 (63%)	36 (23%)	158 (100%)
Natural Region population	21,466	195,691	120,531	337,688
Natural Region Area (ha)	877,509	1,191,169	2,760,660	4,829,338
Natural Region population density per ha	0.024	0.164	0.044	
Urban centre population	2,610	90,564	923	

Environmental, and Social and Institutional Indicators

In addition to the six environmental indicators used in the 2009 RDRWA SOW report, three new indicators were identified (Figure 3), (Table 2). The set of eight social and institutional indicators was completely new and deserves consideration in the future RDRWA SOW report and WMP (Figure 4, Table 2). The importance of each indicator, shown as a percentage of issues, varied between locations. The fact that social and institutional issues (158) outnumbered environmental issues (129) (Table 1) attests to their importance in watershed management planning. The studies cited found that addressing social factors is important in gaining the acceptance of a WMP by landowners. The identification of a total of 11 new indicators through this current study shows that the process of developing indicators should include public or stakeholder consultations as these could provide a wide range of local knowledge, expertise, and experiences, as found by the cited studies.

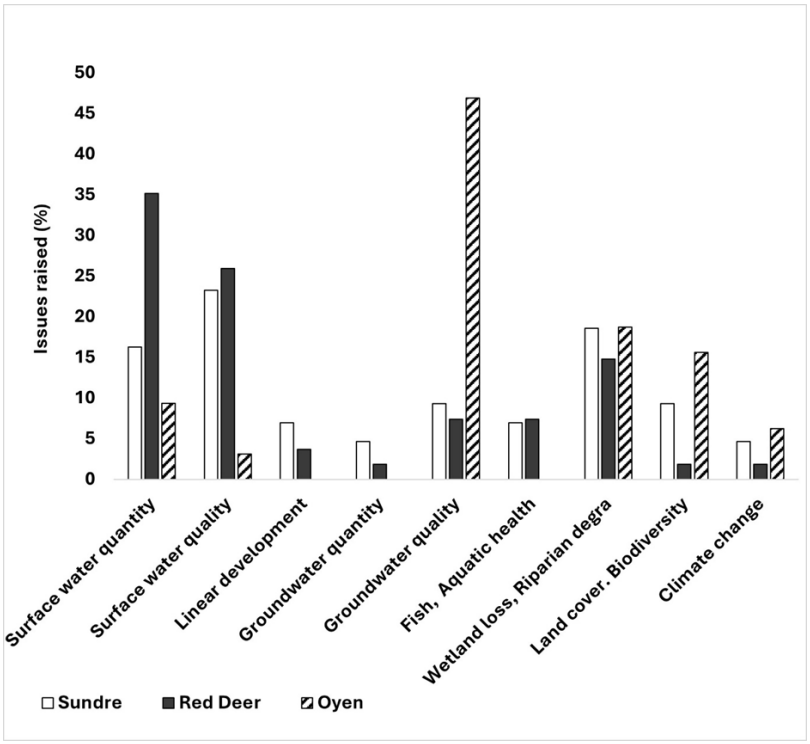
Influence of Natural Regions on Indicators

The range of differences in ranks was 0 to 5. The difference of 2 (the midpoint was 2.5) was chosen to differentiate Similar vs. Different categories (Table 2). The majority (67%) of the nine environmental indicators were in the Different category, indicating the influence of natural regions. However, the majority (50%) of the eight social and institutional indicators were in the Similar category, indicating a weaker influence of natural regions. There were three environmental indicators (Figure 3) and two social and institutional indicators (Figure 4) that were in the 'Unique' category. Unique category indicated that some issues or indicators are specific to a natural region or two and are not applicable throughout the large watershed.

Table 2 Percentages of issues (A, A') and their corresponding indicator ranks (B, B') based on the total of three locations (1 = highest), differences in maximum and minimum ranks (C, C') for each indicator at the three locations (comparison of natural regions) and their corresponding comparison category (D, D')

Columns	A	B	C	D		A'	B'	C'	D'
Environmental indicators (N=129)	%	Rank	Max-Min Ranks	Location comparison category	Social & institutional indicators* (N=158)	%	Rank	Max-Min Ranks	Location comparison category
Surface water quantity	23	1	3	Different	Regulations & enforcement	31	1	1	Similar
Surface water quality	19	2	5	Different	Science & monitoring	25	2	5	Different
Groundwater quality	18	3	3	Different	Development, sustainability, watershed plans	14	3	0	Similar
Wetland loss & Riparian areas degradation	17	4	1	Similar	Education & awareness	13	4	2	Similar
Land cover & Biodiversity*	8	5	4	Different	Stewardship & incentives	9	5	2	Similar
Fish & aquatic health*	5	6	-	Unique	Industry & landowner relationship	5	6	4	Different
Climate change*	4	7	3	Different	Drinking water quality	2	7	-	Unique
Linear development	4	7	-	Unique	Indigenous rights	1	8	-	Unique
Groundwater quantity	2	9	-	Unique					
Total	100				Total	100			

*Indicators developed through public consultations.

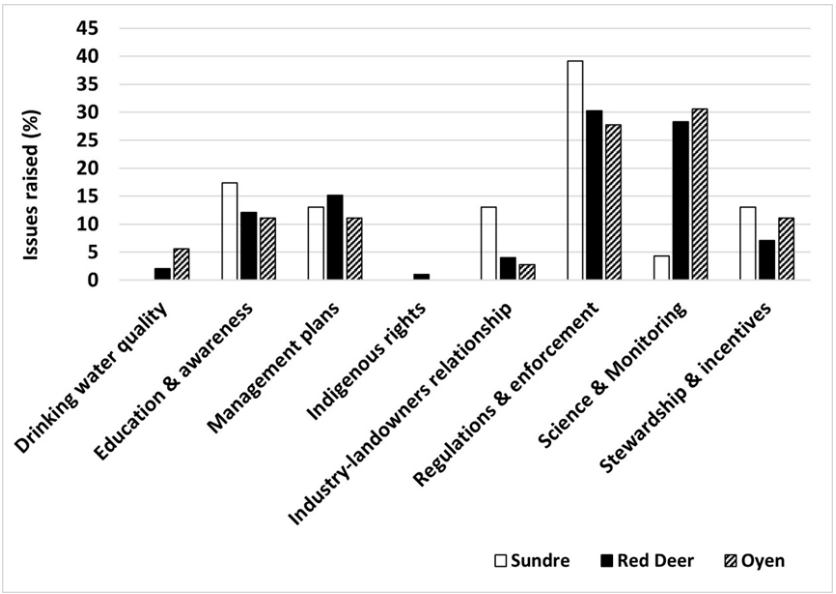


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207 Figure 3 Percentage of environmental issues at each workshop location, $N_{Sundre} = 43$, $N_{Red\ Deer} =$

208 54, $N_{Oyen} = 32$



209

210 Figure 4 Percentage of social and institutional issues in each workshop location, $N_{Sundre} = 23$,

211 $N_{Red\ Deer} = 99$, $N_{Oyen} = 36$

Adaptation of Natural Regions to the Place-Based Approach

Based on the influence of natural regions (ecological land units) on environmental factors, natural regions are the appropriate 'places' for a place-based approach in watershed management planning (Figure 2). People within a natural region constitute a community with a common understanding of their physical environment and associated environmental, social, and institutional issues. The use of natural regions facilitates the integration of plans and programs for biodiversity, parks, fish and wildlife management, and species at risk into a SOW report and a WMP as their data are collected based on these ecological land units. Additionally, this approach is helpful in collating ecological data across areas that fall within a shared ecoregion, for example, in North America (USEPA, 2024).

Prioritization of indicators for the Preparation of Watershed P*lans in* P*hases*

Planning is a lengthy and costly process. It is practical for watershed organizations to prioritize indicators and develop a WMP in phases that cover a few indicators at a time. The ranking of indicators could be used to prepare a WMP in phases (Table 2). For example, phase 1 could be on the quantity and quality of surface water. This phase 1 would then have three chapters, one for each natural region (Foothills and Boreal, Parkland, and Grassland). Social and institutional indicators would be the fourth chapter of the WMP phase, as these would need information on environmental indicators. These do not need to be grouped by natural regions because they do not strongly influence them. They are usually applicable province-wide.

Conclusions

Watershed health indicators should include environmental, and social and institutional indicators. Stakeholders should be involved in the development of watershed health indicators. This would provide legitimacy of health assessments and plans that are essential to gain political support and influence government policy. The use of ecological land units is a place-based approach for

communities with similar environmental issues. The land masses of the Earth have natural delimitations of watersheds and ecoregions that can overlap each other. Integrating ecological land units into watershed management planning would help prepare geographically, ecologically, and socially comprehensive watershed reports and management plans. The findings of this study are useful not only for the Red Deer River watershed, but also for other jurisdictions in Canada and around the world where citizens participate in watershed health assessments or management planning. Suggested future studies would be, a) obtain stakeholders' feedback on the policy highlights (recommendations) of this study, and b) conduct a similar study to find out changes in watershed issues.

Acknowledgment

The authors are grateful for the project funding provided by the Government of Alberta through the Red Deer River Watershed Alliance (RDRWA), and the RDRWA organization itself. We thank Douglas Thrussell, Layne Seely, and Alejandro Caguao (maps), and Alia M. Khan (artwork) for their help and Dale Christian and Ken Vanderwark for their appreciation of this project**.**

Disclosure

The authors report there are no competing interests to declare.

Data Availability Statement

The participants of this study did not give written consent for their data to be shared publicly, so supporting data are not available.

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