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A Web GIS Platform for Environmental Livelihood Value Assessment in Northeastern British Columbia

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ABSTRACT

Traditional practices of the West Moberly First Nations (WMFN), the Saulteau First Nations (SFN), and the McLeod Lake Indian Band (MLIB) in northeast British Columbia were examined in a collaboration between the province of British Columbia (BC) and the University of Saskatchewan. A study of environmental livelihood of the three First Nations examines a way of life that heavily relies on environmental factors. A database containing the information gathered was developed into an integrated 2D and 3D Web geographic information system (GIS) platform. The user-friendly Web GIS allows data, along with social and ecological changes, to be updated quickly.

1. Introduction

I In 2016, a Regional Strategic Environmental Assessment (RSEA) was initiated by the British Columbia (BC) government. The study area contained a section of Treaty 8 land.[1] This assessment included the following objectives:

1) Establishment of government relationship with First Nations living in Treaty 8 land in BC to support environmental decision-making;
2) Identify and validate current and relevant social, economic, and ecological values affected by industrial development;
3) Identify and establish management thresholds or benchmarks that trigger management actions; and
4) Work toward the desired outcomes through the development of scenarios that best safeguard the environmentally based livelihoods of First Nations communities.

The RSEA aims to gather information about the livelihood of the BC First Nations residing in Treaty 8 land. Environmental livelihood involves activities such as hunting, fishing, gathering, and other land-based activities that comprise a critical part of the First Nations' way of life. We examine the dependence on nature of the bands as well as the industrial developments in the area (Biggs et al., 2015).

To advance First Nations-to-government relations, an RSEA Management Committee was formed with representation from the West Moberly First Nations (WMFN), the Saulteau First Nations (SFN), and the McLeod Lake Indian Band (MLIB). The mandate of the RSEA Management Committee is to generate trusted information regarding cumulative industrial developmental impacts

[1] Treaty 8 was signed in 1899. It comprises a vast territory in northeastern British Columbia and extends into northern Alberta and northwestern Saskatchewan.

on Treaty 8 territory. The information gathered will be used to mitigate potentially adverse impacts on First Nation members' rights and livelihoods.

At the request of the RSEA Management Committee, we undertook to build a Web GIS platform for Environmental Livelihood Value Assessment in northeastern British Columbia (hereafter, the Web GIS BC project). Our research documented the extent to which First Nations communities rely on natural resources and the conditions required for the continuance of their subsistence activities. This research provides baseline livelihood data that can be used to assess how industrial and conservationist land uses might affect the environmental livelihoods of First Nation members. These data can support informed decision making by First Nations and the Government of British Columbia. This research represents an opportunity for First Nations to protect vital aspects of their land-based culture and to work with the Government of British Columbia in a more meaningful and informed manner when making future planning decisions.

We describe the integrated 2D and 3D Web GIS platform developed for the RSEA decision-making process. The Web GIS platform enhances access to environmental and livelihood data and facilitates exploration, visualization, analysis, and dissemination of the output of the environmental livelihood survey (Kienberger, Stefan, et al. 2013). The Web GIS platform functions across browsers, including mobile devices, promoting dynamic and interactive use (Hickok, Joel A. 2014). Public access to the Web GIS platform will be released in the near future.

Table 1: Data features and sources

Data Feature	Data source
Study Area	TSL Laboratory
First Nation Communities	BC First Nations
Animal Harvest	BC First Nations
Harvesting Barriers	BC First Nations
Hunting licence	BC First Nations
Food sharing	TSL Laboratory
Road network	Statistics Canada
Water bodies	ESRI
Base Map	ESRI

2. Methods and Data

2.1 Data

First Nations' research assistants administered surveys to First Nations' households. The surveys identified: (1) The total edible food weight and the number of wildlife species harvested by First Nation members over a 12 month period; (2) The extent to which traditional foods are shared between First Nation households; (3) Harvest areas by food weight, species, family, and community; (4) Areas within traditional areas of each First Nations band that are no longer used, whether due to competing land uses or other constraints; and (5) Changes in the landscape that First Nations' members have experienced throughout their lifetimes.

Responses to survey questions were manually entered on a database. Geospatial data (study boundary, infrastructure, road network, water bodies, and a base map) were collected from an open-source database. Table 1 shows data features and sources.

2.2 Methods

The Web GIS platform was developed with ArcGIS technologies that include data, server, and application tiers.

Data tier. Spatial and non-spatial attribute data for the study area were recorded in a data tier using a relational database management system (RDBMS)—the Microsoft SQL Server supported by ArcGIS 9.3. An enterprise geodatabase comprises storage management, definitions of data attributes, multiuser transaction processing, and complex query processing. On the geodatabase, ArcSDE technology was integrated with ArcGIS Desktop and ArcGIS Server, and used as the gateway between ArcGIS applications and the RDBMS.

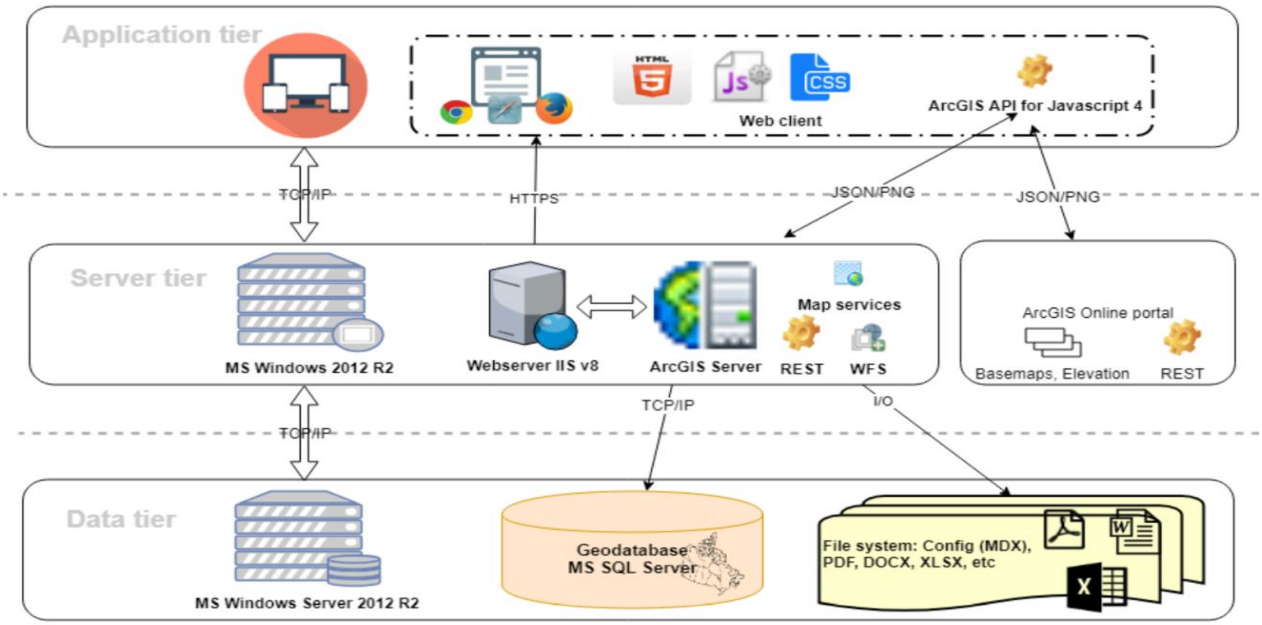

Figure 1. Architecture of the Web GIS application

Server tier. ArcGIS Server 10.6 was used to map services through an IIS Web Server on a Windows Server 2012 R2 system. The ArcGIS server can provide spatial services such as mapping, network analysis, Web feature service (WFS), Web mapping service (WMS), Web map tile service (WMTS), geodatabase queries, geo-processing, and Web processing. These services can be accessed from applications and devices, and from a JavaScript Web-client through Hypertext Transfer Protocol.

Application tier. ArcGIS API for JavaScript was used with front-end technologies such as HTML5, JavaScript, JQuery, Web GIS, and CSS to develop an integrated 2D and 3D user-friendly and responsive Web GIS. ArcGIS API for JavaScript supports similar approaches for CSS to develop an integrated 2D and 3D user-friendly and responsive Web GIS. ArcGIS API for JavaScript supports similar approaches for working layers, renderers, tasks, geometry, pop-ups, and navigation in both 2D and 3D views. Figure 1 shows the architecture of the Web GIS application and the components at each tier.

When users access the Web GIS application for the first time, the IIS Web Server will handle the user's request from the browser and respond with a Web page that includes the ArcGIS API for JavaScript. When ArcGIS API for JavaScript is loaded and running, it sends requests to the ArcGIS Server. It then presents integrated 2D and 3D maps on a browser in JSON, PNG, or JPG format. Figure 2 shows the data flow of an integrated 2D and 3D Web GIS application.

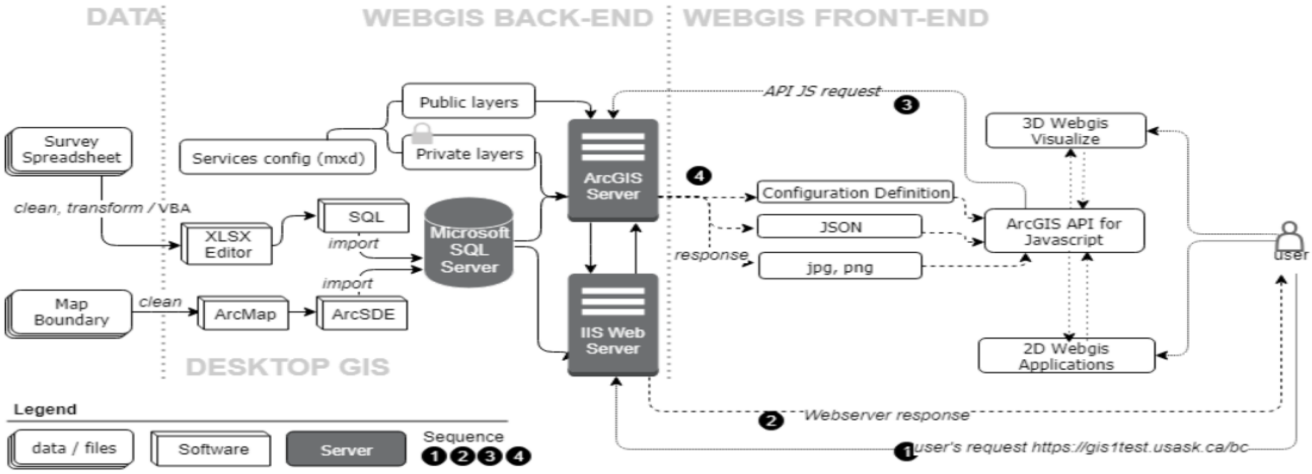

Figure 2. Data flow of the 2D and 3D Web GIS application.

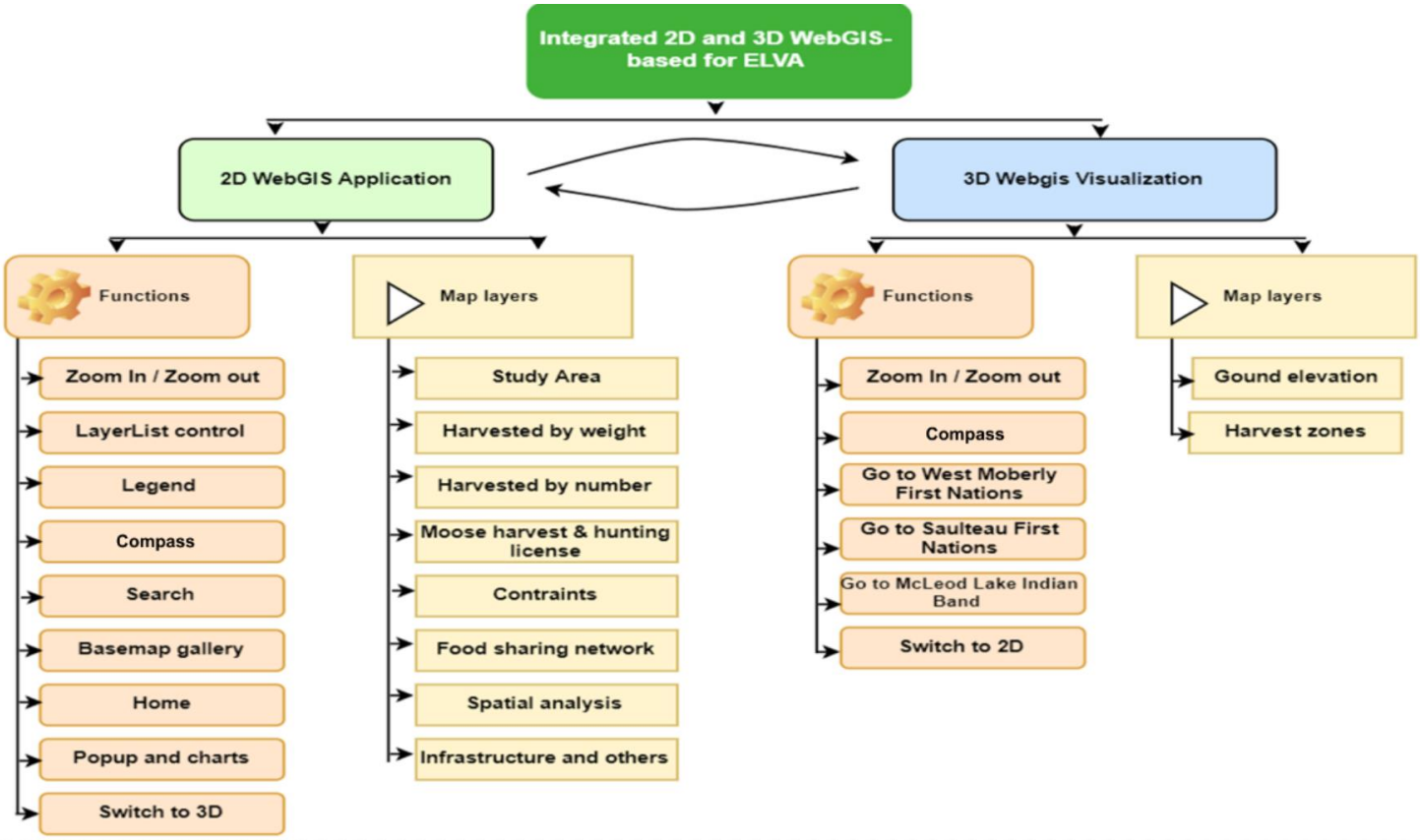

Figure 3. GIS application and 3D Web-GIS visualization for Environmental Livelihood Value Assessment

The Environmental Livelihood Value Assessment Application was built with ArcGIS API for JavaScript 4.9, which can build Web applications that combine 2D and 3D without installing additional plug-ins. 3D Web GIS is able to use map images and feature layers that exist in 2D Web GIS. For example, the "harvest zones" layer in the Web GIS BC project can be viewed in both

2D and 3D. The 2D view is necessary because the 3D view cannot display complicated results (e.g., client-side statistical queries, Identify Task). Figure 3 shows the data and functions of the 2D and 3D Web GIS visualizations.

3. Results

The Web GIS was developed involving integrated 2D and 3D base maps, a Table of Contents, and popup information windows to supplement visualization of the survey component of the Web GIS BC project.

3.1 Integrated 2D and 3D Base Maps

The Web GIS contains 10 base maps, including satellite imagery and topographic maps. It is predicted that the supply and availability of satellite and aerial imagery will double in the near future through Web portals and online GIS services. The base maps can be changed by editing the legends.

Our Web framework allows users to access hunting data in 3D, and to access 3D support devices on the Internet, regardless of the user's hardware, operating system, and pro-GIS software. Figure 4 shows zone O20, a study zone in which the WMFN is directly located at, in different 3D views. Figure 4 answers questions such as (1) Where are people harvesting, especially moose harvesting, and where are the main harvesting hotspots? (2) What is the average distance traveled to harvest? (3) which zones have the highest harvest? Harvest location maps were produced based on 100 households that completed the environmental livelihood survey. Spatial analysis tools were used to investigate harvesting patterns.

Figure 4. 3D view of Zone O20

By applying online mapping technology, 2D map information can be transferred to a 3D model (Alias Abdul-Rahman, Morakot Pilouk, 2008). The 2D view is the default when the map is opened and the 3D view can be entered by clicking the 3D button on the legend. Once the 3D view is entered, the legend replaces the 'expand' and the 'default' map view buttons to 'pan' and 'rotate' buttons, respectively.

A button with four selectable options is located on the legend to locate the three First Nations and to return to the 2D view. Figure 5 shows a 3D view of the study area.

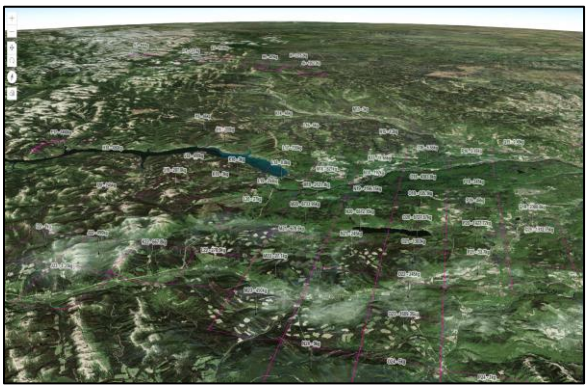

Figure 5. 3D map view of the Web GIS BC Project.

3.2 Table of Contents.

A Table of Contents on the right-hand side of the map has eight categories of datasets: Study area, Harvested by weight, Harvested by number, Moose harvest and hunting license, Constraints, Food sharing network, Spatial analysis, Infrastructure and others. When users click on a desired category, the default layers and legends of the dataset are toggled to facilitate comprehension. Users can select the data they wish to view. Clicking on the triangle on the left side of the text will expand the selection. A click on the eye symbol will toggle the selected data to display on the map. A legend is available for each layer.

The Web GIS platform supports spatial analysis, including hotspot maps that are toggled via 'Spatial analysis.' Other features include the number of moose harvests per hunting region, and a food sharing map showing the movement of food being shared within and among the three First Nations being studied.

3.3 Data viewer popup window

Additional information regarding a zone can be accessed by clicking on 'zone of interest.' The data viewer contains all the information regarding the zone with respect to the area of study toggled in the Table of Contents. The data viewer also contains the information in pie chart form. The data viewer is an alternative way to view the raw map data.

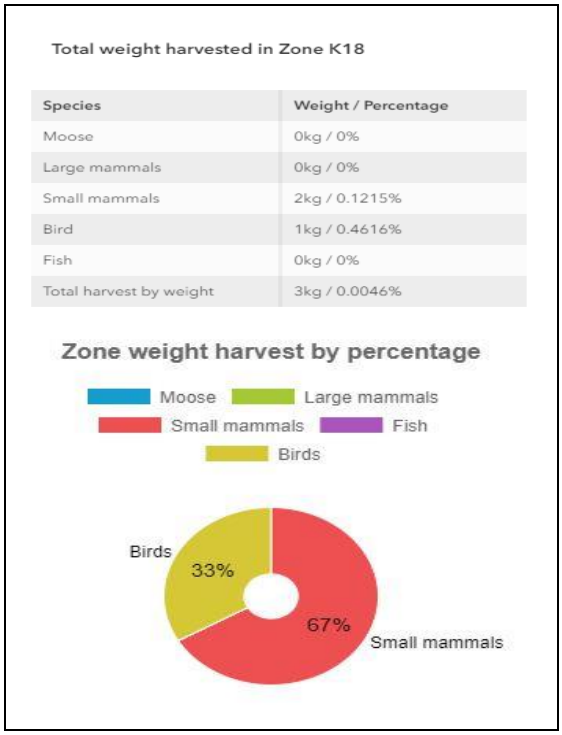

Figure 6. Table and pie-chart in the Web GIS map.

The data viewer changes with the parameters selected in the Table of Contents. For 'moose harvest,' the map and the data viewer are displayed by hunting region (Figure 6). The number of moose kills is categorized by hunting region (per year), and is shown in text and bar graph form (Figure 7).

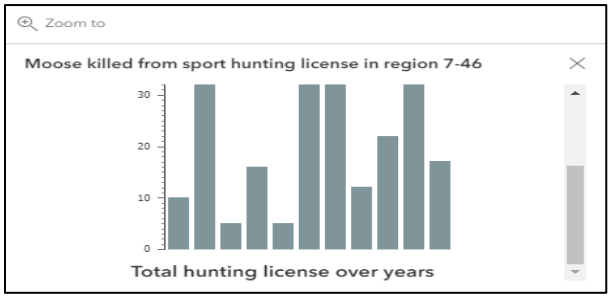

Figure 7. Graph display in data viewer.

4. Conclusion

This study developed an integrated 2D and 3D Web GIS platform to evaluate the environmental livelihood of the West Moberly First Nations, the Saulteau First Nations, and the McLeod Lake Indian Band in northeastern British Columbia. The user-friendly Web GIS visual platform enables First Nations and the Government of British Columbia to better understand the extent to which First Nations derive environmentally based livelihoods and to forecast potential impacts stemming from industrial development. The flexibility of Web GIS allows new inclusions of data to be updated quickly in response to social and ecological changes.

Acknowledgements

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References

Alias Abdul-Rahman, Morakot Pilouk. (2008). *Spatial Data Modelling for 3D GIS*. New York: Springer.

Boulos, M. N. (2005). Web GIS in practice III: creating a simple interactive map of England's Strategic Health Authorities using Google Maps API, Google Earth KML, and MSN Virtual Earth Map Control. *International Journal of Health Geographics*.

Hickok, J. A. (2014). A Web GIS framework for simulating pre-incident planning. *ProQuest*. Retrieved from https://search-proquest-com.cyber.usask.ca/citedreferences/MSTAR_1545690961/CE31A80A5FF14840PQ/1?accountid=14739

Karnatak, H. C. (2007). Multicriteria Spatial Decision Analysis in Web GIS Environment. *GeoInformatica, 11*, 407–429. Retrieved from https://link.springer.com/article/10.1007/s10707-006-0014-8

Kienberger S, H. M. (2013, Nov). *National Center for Biotechnology Information*. Retrieved from NCBI: https://www.ncbi.nlm.nih.gov/pubmed/24258905

Kraak, M.-J. (2004). The role of the map in a Web-GIS environment. *Journal of Geographical Systems*, 6:83–93. doi:10.1007/s10109-004-0127-2

M.Biggs, E. (2015, December). Sustainable development and the water–energy–food nexus: A perspective on livelihoods. *Environmental Science & Policy, 54*, 389-397. Retrieved from https://www.sciencedirect.com/science/article/pii/S1462901115300563

The potential of Web-based GIS. (2004). *Geographical Systems*, 80. doi:10.1007/s10109-004-0133-4