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INTEGRATED GIS TECHNIQUES FOR LAND SUITABILITY ASSESSMENT IN SOUTHERN IDAHO FOR SPRING WHEAT

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Abstract—**The accurate evaluation of land suitability for special agriculture production plays an important role to decrease the negative environmental impacts. The current study aimed to apply GIS techniques for analyzing land suitability to wheat production in 5474.27 ha of semi-arid regions of Bingham and Bonneville counties of southern Idaho. This research used the Idaho West State Plane projection for the least distorted projection for its investigation. "Convert feature class to feature class" and "copy raster" procedures were used to ensure that all required data layers are stored in the active database. DEM data was gathered in the form of multiple rasters and then turned into a single mosaic dataset so that all of the data are converted to a single mosaic dataset. The results indicated that Bingham County is more suitable for wheat than Bonneville County. A change in irrigation, cropping pattern, rotation, and land use type of Bonneville County might be helpful to increase its wheat production. It was concluded that integrating GIS techniques could be an accurate and effective method for better land use planning and management for agriculture productions.**

Keywords—**Agronomy, GIS, ArcGIS, Wheat, Idaho, Semi-arid cropping system**

I. INTRODUCTION

Wheat is one of the major crops grown in Idaho, with production occurring throughout the state. According to the United States Department of Agriculture (USDA), Idaho produced approximately 94.2 million bushels of wheat in 2022, with an average yield of 85 bushels per acre (USDA, 2022). Wheat production in Idaho is primarily concentrated in the southern part of the state. The top wheat-producing counties in Idaho are Canyon, Bingham, and Power (Abbate et al., 2004).

Bingham (total area of 5,420 km2 island and 67 km2 (1.2%) is water) (Parliman, 1986) and Bonneville (total area of 4,920 km2 island and 90 km2 (1.8%) is water) (Phillips, et al.,2011) counties both are adjacent and located in southern Idaho and known for diverse geography, including farmlands, mountains, and the Snake River. The Snake River flows southwest through the middle of Counties. The availability of water is crucial for agriculture of these two county, as it is located in a semi-arid region. Center pivot and drip irrigation, are commonly used to provide water to crops and ensure their optimal growth. Both Bonneville and Bingham County have significance important on Idaho economy through farming and ranching. Potatoes, wheat, sugar beets, and barley are main cash crop here (Koirala et al., 2020).

In general, wheat grows best in 15-25°C, and it requires a minimum 120 frost-free days for a good yield. As for soil type, wheat prefers well-drained soils with good water-holding capacity, adequate nutrient levels, and a neutral pH between 6.0 and 7.5. Wheat can be grown in a variety of soil types, including sandy, loamy, and clay soils (Porter et al.,1999). However, with appropriate management practices, wheat could be grown successfully in a wide range of climates and soil types. Recently, GIS techniques (Li et al., 2012) has been applied in land suitability evaluation studies. Hence, the integrated GIS techniques could be a strong method to

enhanced the accuracy of land suitability evaluation for wheat production.
This study addressed the possibility of wheat production in Bingham and Bonneville county of Idaho through integrated GIS techniques. Information on soil type, land class types, irrigation capability of the study area, farmland type, crop productivity index, available water storage, non-irrigated land surface type, and current wheat production of the study area were integrated by GIS As we know, the most suitable soil type, weather, and how much irrigation are needed for wheat production. So based on our map and findings, we could make an assumption about the potentiality of wheat production in southern Idaho. The aims of the current study are 1) to evaluate precisely the land suitability for wheat production; 2) to generate the best method for assessing the land suitability by applying the GIS technique for the southern part of Idaho dominated by the wheat-potato-fallow based cropping rotational systems.

II. MATERIALS AND METHOD

In this research, US state maps, county maps and Living Atlas through ArcGIS were used along with a topographic base map (Map 1) along with digital elevation models (DEMs) were also used. The DEMS for the national map was numerous files, so all ofthose data are combined into a single mosaic raster. The slope of the area is computed and shown by making use of functions inside ArcPro, with the DEMs. These major data sources are used in order to provide a response to the research question. The DEM and the land cover categorization map both have a spatial resolution of 30 meters, which makes it simple to deal with both of them. Because this project is looking at such a large area of land, a map with a spatial resolution of 30 m is enough. Also, the original data for all maps came from the U.S. Geological Survey (USGS). This indicates that there are less opportunities for error between the two datasets since they are both using the same datum.

III. DATA SOURCES

Layer: Local counties
Agency: Esri (ArcGIS online)
Format: Vector
Year: 2022

Layer: USA Soil Map Units
Agency: Esri (USA Soil Map Units)
Format: Raster
Year: 2022

Layer: Irrigation
Agency: Esri (US SSURGO)
Format: Raster
Year: last updated in 2022

Layer: USA Crop Productivity Index
Agency: Esri (USA National Commodity Crop Productivity Index)
Format: Raster
Year: 2022

Layer: USA NLCD Land cover types
Agency: Esri (USA NLCD land cover types)
Format: Raster
Year: 2022
Layer: Land Surface type & non-irrigated class
Agency: Esri
Format: Raster
Year: last Updated in 2021

Layer: Available Water Storage
Agency: Esri (USA SSURGO)
Format: Raster
Year: last Updated in 2022

Layer: Wheat Production of Study area
Agency: Esri
Format: Raster
Year: last Updated in 2022

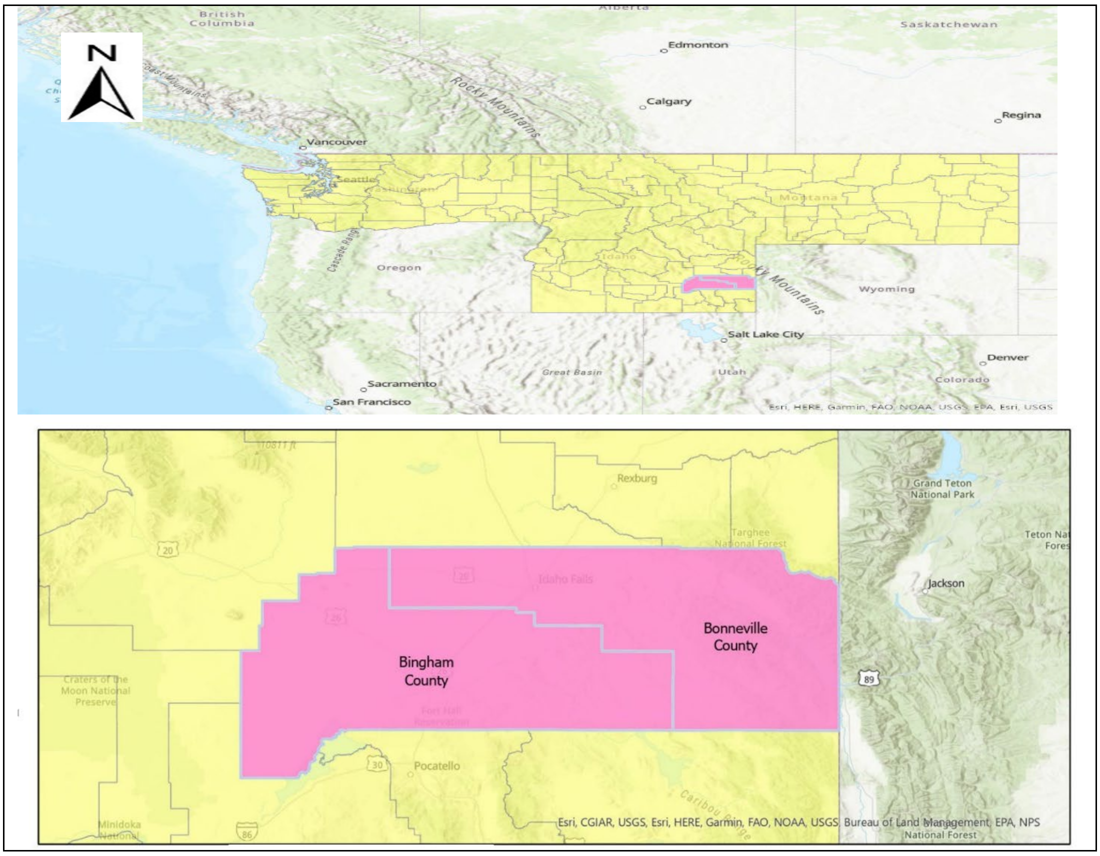

Figure 1: Location of the study area (Bingham and Bonneville County) in Idaho.

IV. RESULTS AND DISCUSSION

In the present study, the following factors were used to assess the land suitability in the Bingham and Bonneville county considering the actual situation in the studied area: (i) Topography data: elevation and slope factors, (ii) Climatic factors: mean, minimum and maximum temperatures in the growth season.

From the map of the land cover type of study area we found that both counties do not have that much open water, and Bingham County has more cultivable land than Bonneville County. On the other hand, the east and east-south parts of Bonneville County are mainly covered with mixed, evergreen, and deciduous forest, which makes it unsuitable for agriculture. Sedge was also observed over both counties.

The best soil type for wheat production is loamy soil with a pH range of 6.0 to 7.5. So based on this information, Mollisols are the best soil class for wheat production (Bhaduri et al., 2012). However, we found that, most of the soil of these two counties are dominated by the Aridisols and Andisols (Figure 3). Aridisols and Andisols both have the same textural class of soil as Mollisols only lack of soil moisture. Both counties could be suitable for wheat production if it is possible to irrigate the soil properly.

Wheat is generally best grown on flat or gently sloping land with good drainage and access to irrigation or rainfall (Valor et al., 1996). Flat land is ideal for planting wheat because it is easier to work with and allows for more uniform crop growth. Gentle slopes are also suitable, as long as erosion is controlled through appropriate soil management practices such as conservation tillage or terracing.

From the map, we found that the east part of Bingham County and most of the part of Bonneville County are dominated by hills, low hills, low mountains, high mountains, and foothills. Those types of land cover type are not suitable for wheat production. On the other hand, the east part of Bonneville County and the majority part of Bringham County (the West and middle part) are made of flat land, which is the perfect land class type for wheat.

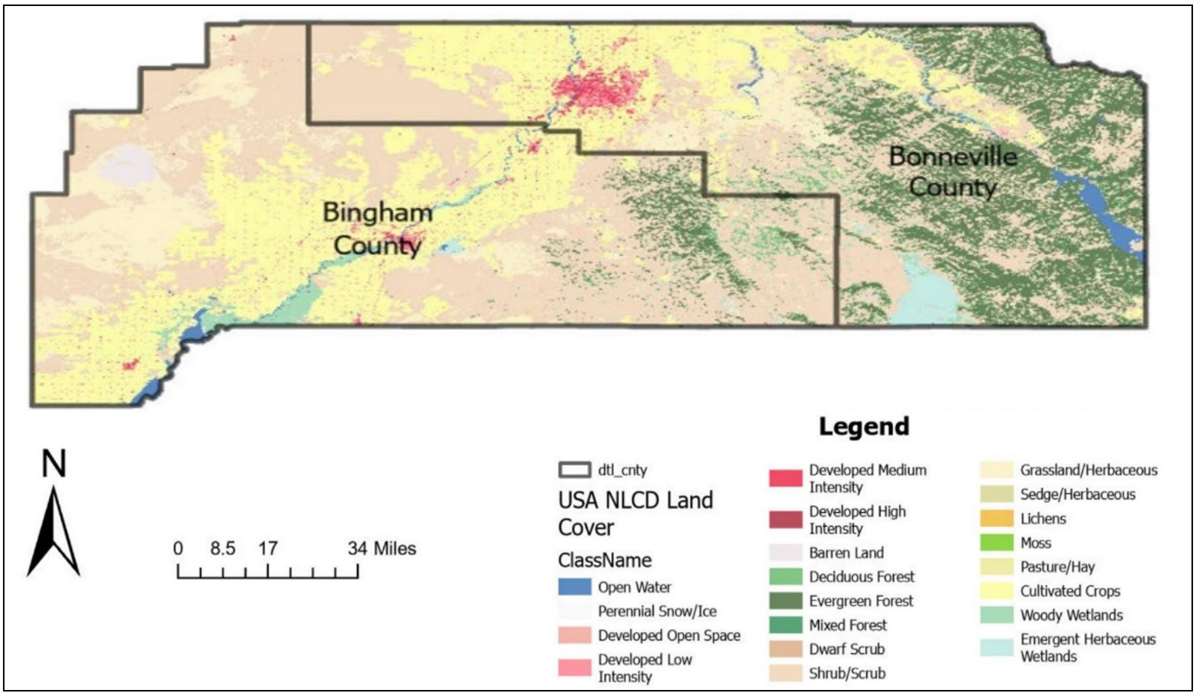

Figure 2: Map of Land cover type of study area

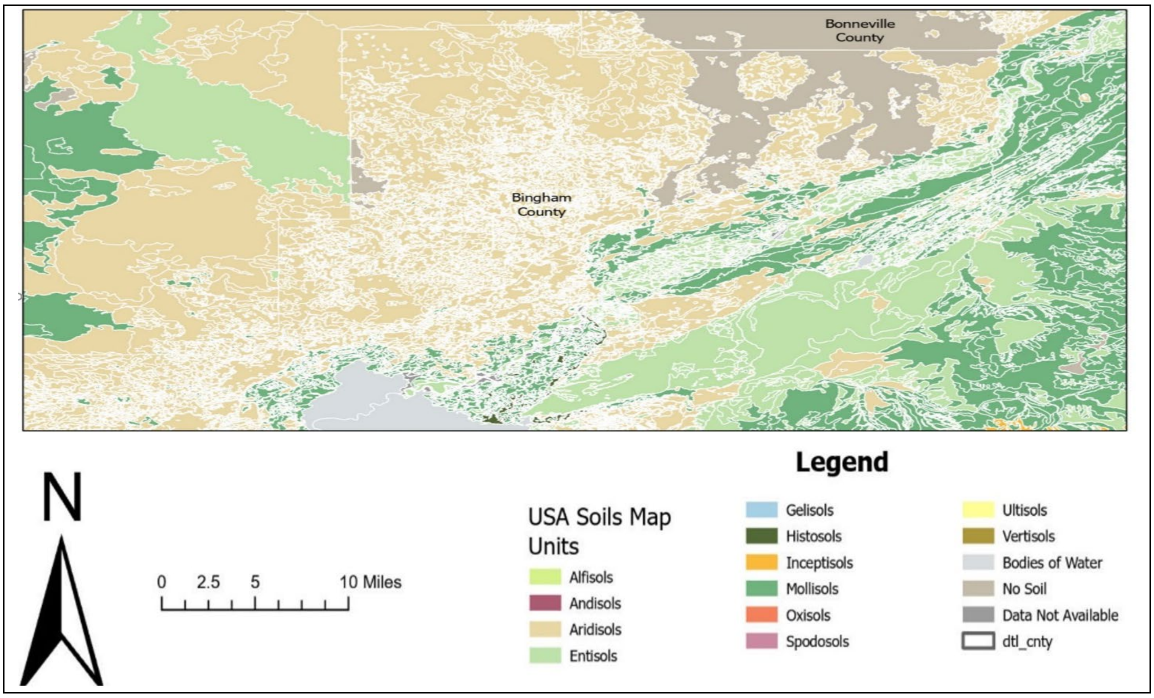

Figure 3: Map of Soil class type of study area

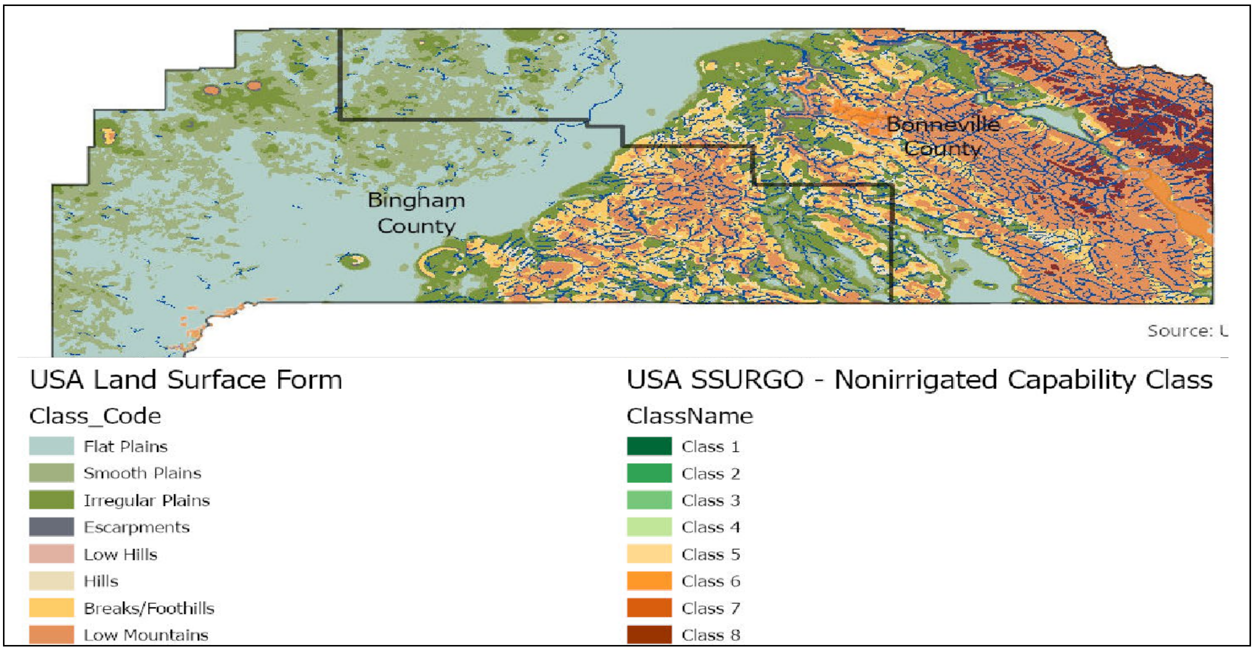

Figure 4: Map of Land surface type and non-irrigation class of study area

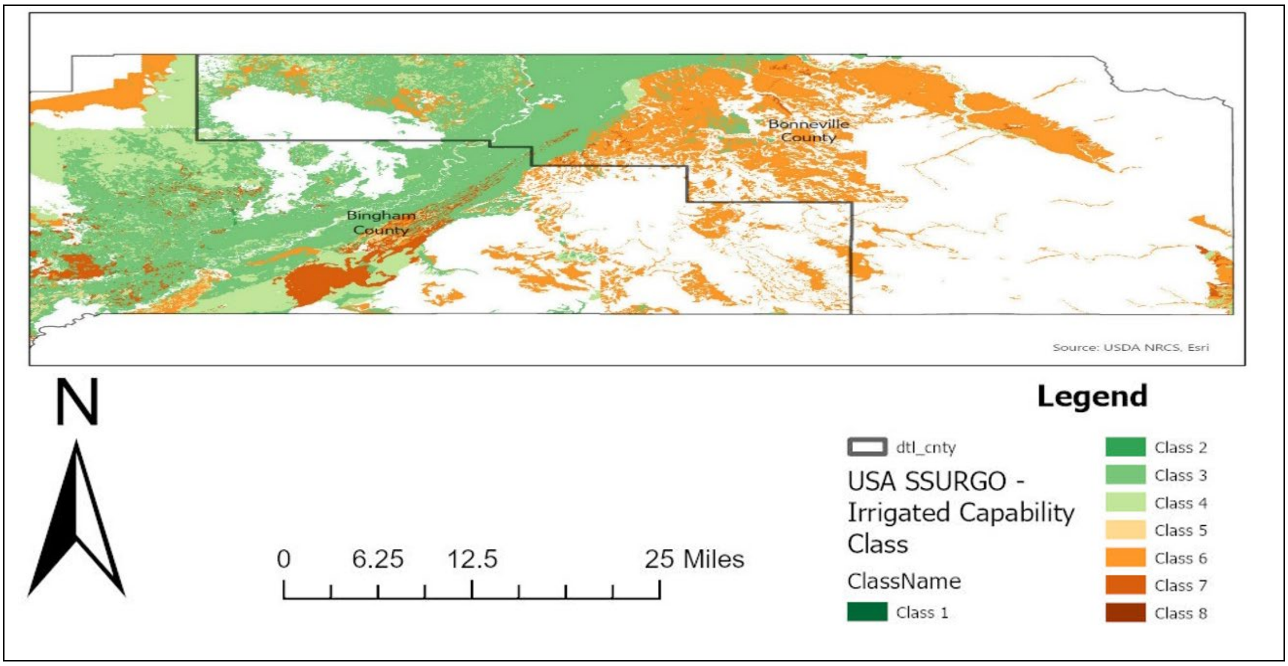

Figure 5: Map of Irrigation capability of the research area

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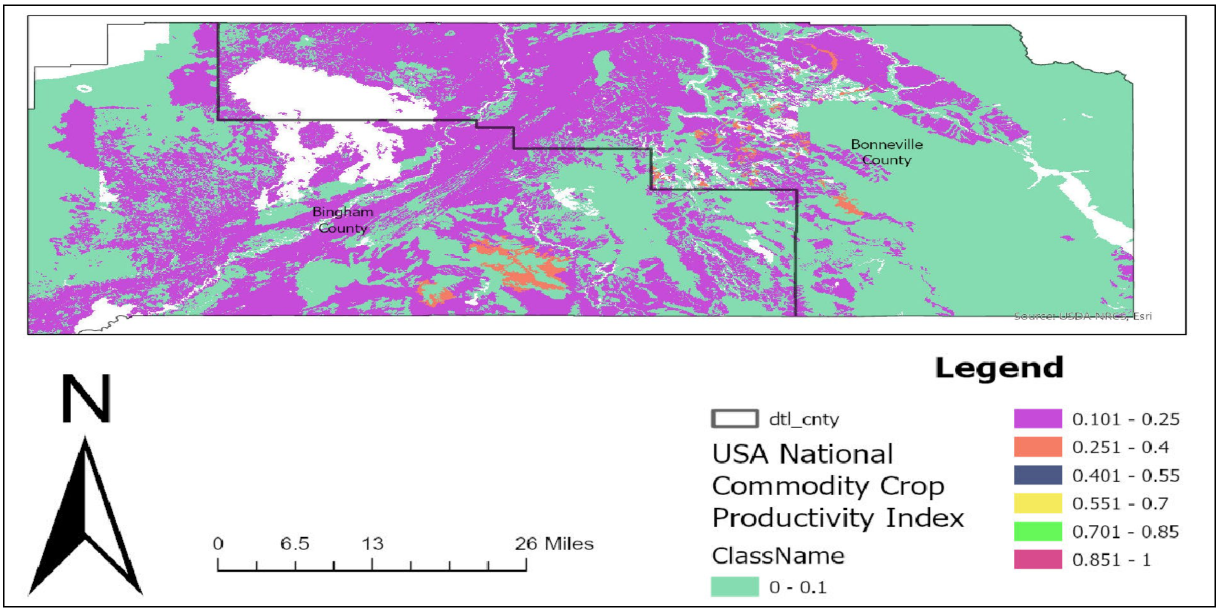

Figure 6: Map of Crop Productivity Index of the study area

Bringham County (the West and middle part) are made of flat land, which is the perfect land class type for wheat.

Non-irrigation capability class refers to a system of land classification that is used to evaluate the soil's natural ability to hold and supply water to plants without the use of irrigation and based on several factors, including the soil's texture, depth, slope, and drainage characteristics. USDA developed a non-irrigation capability classification system that categorizes soils into eight classes based on their ability to support sustained crop growth without the use of irrigation. These classes range from Class I, which has the highest productivity and best natural water-holding capacity, to Class VIII, which has the lowest productivity and poorest water-holding capacity.

Wheat can be grown on soils with non-irrigation capability classes ranging from Class I to Class IV. Class I and II soils are considered highly productive, while Class III and IV soils have moderate to high productivity potential. Maps showed us that, Bringham County is mainly dominated by Class I to Class IV, and majority part of Bonneville County (except the east portion) is covered by Class to V Class VIII (Figure 4). Soil with Class V to VIII capability may not be suitable for wheat production without significant modifications, such as the implementation of irrigation or improved water management practices.

The USA SSURGO (Soil Survey Geographic) provide Irrigated Capability Class (ICC), the soil's suitability for irrigation and ranges from 1 to 8, with Class 1 being the most suitable for irrigation and Class 8 being the least suitable.

The classification is based on several factors, including the soil's texture, depth, structure, drainage, and salinity. Soils with higher ICC values generally have better water-holding capacity, deeper root zones, and more favorable physical and chemical properties for crop growth and irrigation. If we consider the irrigation capability of the study area, we found that almost half of the area belongs to ICC class 5 to class 8, which is not suitable for wheat production and the west part of study is area under class 1 to class 4, which are generally well-suited for irrigated agriculture.

The Crop Productivity Index is calculated on a scale of 0 to 1, with 1 being the most productive and 0 indicating that the area is unsuitable for crop production. Soils with a higher CPI generally have better physical and chemical properties for crop growth and are more suitable for agriculture.

Crop Productivity Index map of Bingham and Bonneville county exhibit that most of the land of Bingham county are more productive than the Bonneville county (Crop Productivity Index is low as 0-0.1). So the land of Bonnevile county may require significant modifications or management practices to support wheat growth.

All these maps gives us an idea of the wheat production based on the data and map of soil type, available irrigation water, water storage, soil type, and land cover type. Based on the above analysis, we could make a conclusion that Bingham County is more suitable for wheat than Bonneville County. A change in irrigation, cropping pattern, rotation, and land use type of Bonneville County might be helpful to increase its crop as well as wheat-pea production.

Acknowledgment:

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