Economic Analysis of Agriculture in the Klamath Basin

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Prepared for:

Oregon State University

Klamath Basin Research and Extension Center (KBREC)

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About Highland Economics:

Highland Economics is a small, woman-owned firm specializing in the economics of natural resources and the environment, business planning and feasibility assessment, and the socioeconomic impact of industries, policies, or management actions. We are a team of five economists, based in Oregon and Montana. We work with non-profits, agricultural interests, tribes, water districts, private companies, and local, state, and federal agencies on a wide range of land, air, water, recreation, agriculture, and habitat issues. This study was led by principal and senior economist Barbara Wyse, who has nearly 20 years of experience analyzing the economics of agricultural production and the socioeconomic impacts of proposed actions or regulatory changes. We aim to provide rigorous, even-handed analysis that uses economic insights to transform complex data into clear and actionable information. We often serve as expert witnesses on economic issues, including numerous cases on agricultural economics and demographic analysis for the U.S. Department of Justice.

This analysis was prepared for:

Klamath Basin Research and Extension Center (KBREC)

The Klamath Basin Research and Extension Center (KBREC) is one of 14 Oregon Agricultural Experiment Station (AES) research locations across the state. These stations research agricultural and natural resource issues related to food and fiber production, processing and marketing, responsible use of natural resources, human nutrition, commercial fishing, and other topics important to the social, economic, and environmental health of the communities they serve and vital to the sustainability of agricultural production. The Oregon AES extends the research arm of Oregon State University's College of Agricultural Sciences, embedded in the communities they serve with focus areas as varied as Oregon's climates and landscapes.

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EXECUTIVE SUMMARY

Water in the Upper Klamath River Basin (Basin) is vital to many interests and supports diverse economic, cultural, social, and environmental values. These include values related to the agricultural economy, endangered species, and tribal treaty rights. All of these values have been affected in recent years when the Basin has faced recurring and severe water shortages. Due to this water shortage context, Oregon State University, with support from the Klamath County Board of Commissioners, commissioned this study. The purpose of the study is to estimate the economic contribution of irrigated agriculture to the regional economy and the economic effects of changes in irrigation water supplies. While the study recognizes that all values supported by water in the Basin are significant and important, the scope of this report focuses on the economic value to the local economy (in terms of local jobs, income, and taxes) of the diversion of water for use by irrigators.

Photo credit: US Bureau of Reclamation

Irrigation is the primary human use of water in the Basin, and the Klamath Project (Project), which is managed by the U.S. Bureau of Reclamation, delivers irrigation water to a service area of over 200,000 acres in Oregon (Klamath County) and California (Modoc County and Siskiyou County). To support fish and wildife and associated recreation, the Klamath Project also delivers water to two National Wildlife Refuges, which are managed by the U.S. Fish and Wildlife Service.

The study area for the analysis is the three-county area including: Klamath County, Oregon; Siskiyou County, California; and Modoc County, California. This three-county area encompasses the agricultural lands affected by water management in the Upper Klamath Basin including both Project-irrigated lands in the three counties and Off-Project irrigated lands in Klamath County. Data sources include agricultural crop reports from the Bureau of Reclamation, price and yield data from California Agricultural Commissioner Reports and the National Agricultural Statistics Service of the U.S. Department of Agriculture; additional economic information was drawn from federal agencies such as the Bureau of Economic Analysis and Bureau of Labor Statistics. Economic impact modeling to estimate how agricultural output affects total economic activity was conducted using an IMPLAN multi-regional economic impact model.

Findings of the analysis are presented in the subsections below. Following an overview of Klamath Project water supplies, the subsections summarize Upper Klamath Basin water management and the role of water in supporting agriculture (Section 2), agricultural acreage and production value supported by Project and Off-Project irrigation (Section 3), the economic contribution, in terms of jobs and income, of Project and Off-Project agricultural production (Section 4), and the effects of changes in water supply on agricultural production value and regional employment and income (Section 5). Section 6 presents information on the tax revenues, or fiscal contribution, of the Project to local governments based on the economic activity estimates.

KLAMATH PROJECT WATER SUPPLIES & IMPORTANCE OF WATER FOR AGRICULTURE

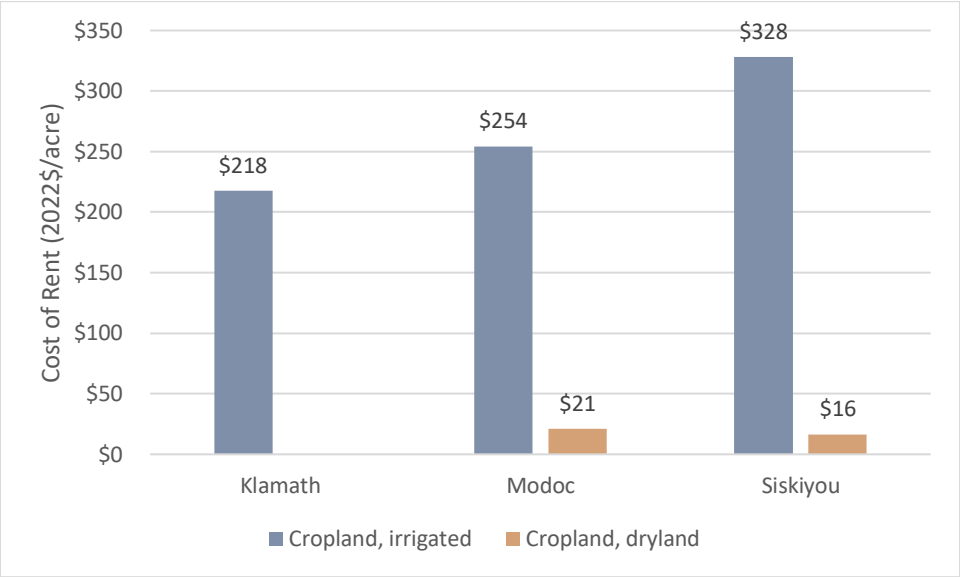
The Klamath Project, as developed and administered by the U.S. Bureau of Reclamation (Reclamation), provides water to a service area of approximately 230,000 acres in Klamath County, Oregon; Siskiyou County, California; and Modoc County, California (Bureau of Reclamation, 2020). Further, in addition to Project irrigation in the Upper Klamath Basin, there is also irrigation of private lands in the Williamson, Wood, and Sprague watersheds above Upper Klamath Lake in Klamath County. These lands, henceforth referred to as "Off-Project" irrigated acreage is almost entirely pasture (US Geological Survey, 2016), and has also been significantly curtailed in recent years.

Average annual precipitation in the area ranges from about 10 to 13 inches per year. This precipitation falls mainly in the winter months as snow (i.e., outside the primary crop growing season). Klamath Project reservoirs store the snow-fed winter and spring runoff, which is released during the spring/summer and fall/winter operating periods (Bureau of Reclamation, 2020). In general, crops grown in the region require at least 20 inches of water to meet their evapotranspiration (ET) needs in an average year. Given the low level of rainfall during the growing season, irrigation plays a critical role in crop production in the study area.

In response to the recent history of surface water supply curtailments, both Project and Off-Project irrigators have invested in developing groundwater wells and have increased their pumping capacity to try to partially offset the reduced surface water supplies. The amount of groundwater extraction is different every year. Based on publicly available information and input from local water managers, the maximum in-season groundwater production to meet irrigation demand within the Klamath Project is also estimated to not exceed 144,000 acre-feet per year. However, the U.S. Geological Survey estimates that the average sustainable yield (i.e., the level of withdrawal that can be maintained without over-drafting the aquifer and adversely affecting groundwater levels) is 54,000 acre-feet per year (US Geological Survey, 2016). These two numbers provide context for evaluating the long-term economic effects of reduced surface water deliveries to the Klamath Project.

The availability of irrigation water allows farms to increase the value of agricultural production from their land. Irrigation makes it possible to grow high-value crops, such as fruits and vegetables, which would otherwise be impossible in the Klamath Basin due to very little rainfall. Vegetables and mint/strawberry root (classified as 'other') have significantly higher gross revenues per acre compared to other crop types in the Klamath Basin. While vegetables and fruits only comprise around 12 percent of the total acres in the Basin, they generate approximately 45 percent of total revenues in a full water year. Figure ES-1 compares the average rental rates for irrigated cropland, pastureland, and dryland acreage; the high value of irrigated cropland relative to dry cropland reflects the increased economic value made possible with the availability of irrigation water (recognizing that other factors such as soil quality, and not just the value of irrigation water, may be reflected in the difference in land rental rates).

Figure ES-1: Average Rental Rates for Irrigated and Non-Irrigated Land

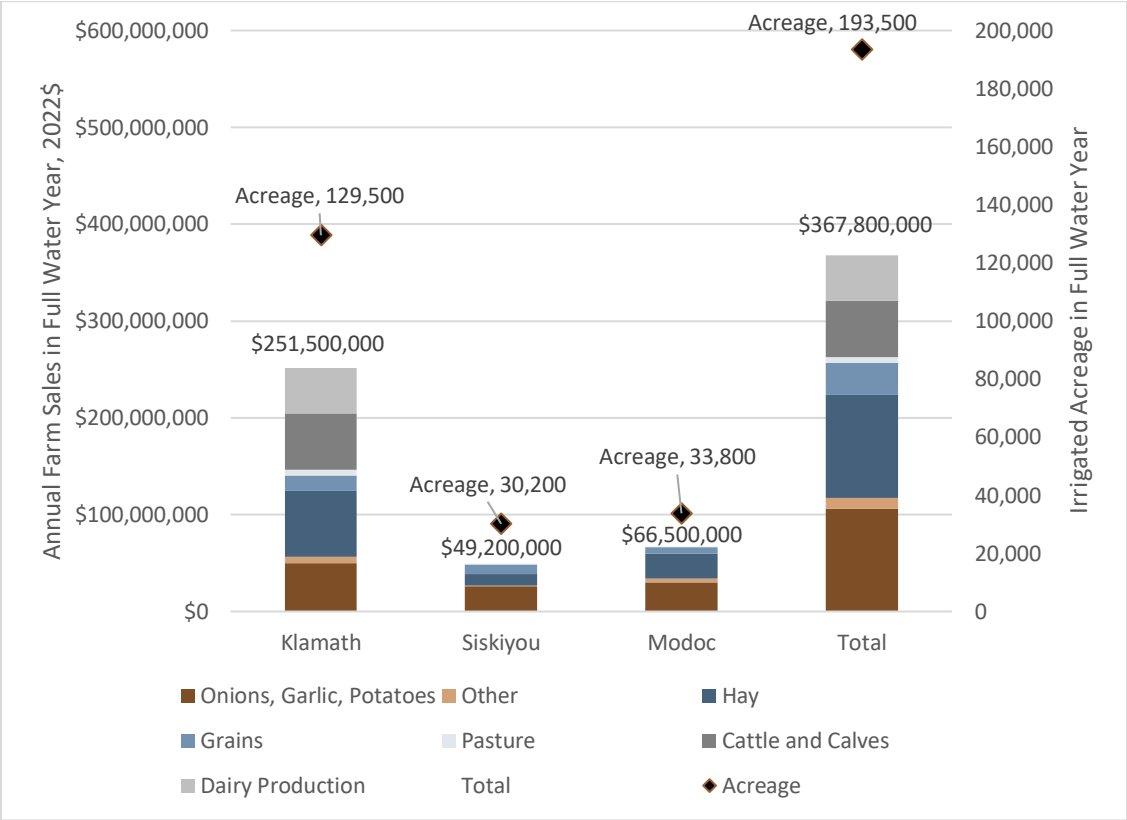


Note: Values represent the average rental rate from 2012-2020, where data was available. We adjusted annual values to 2022 dollars using the Gross Domestic Product Implicit Price Deflator prior to averaging. Source: Highland Economics analysis of (National Agricultural Statistics Service, US Department of Agriculture, 2023).

Value of Klamath Basin Agricultural Production: Full Water Year

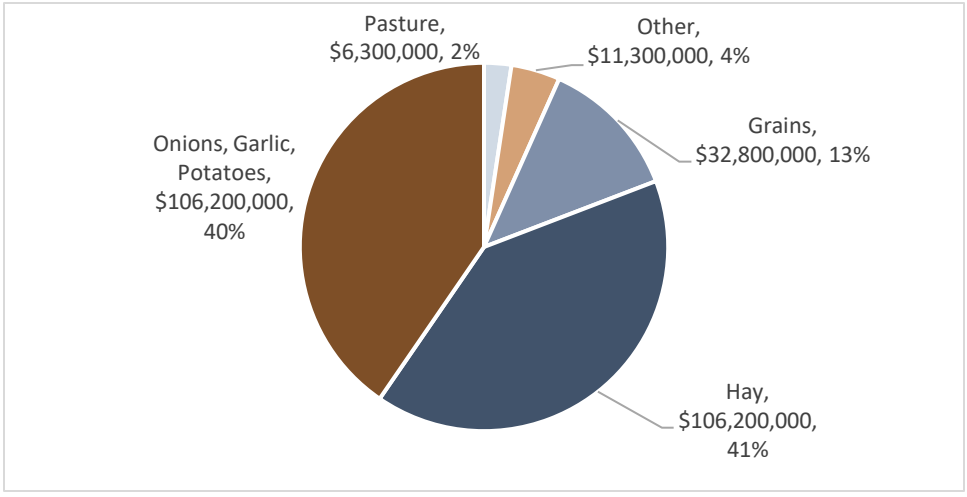
Figure ES-2 presents the farmgate sales value of irrigated crops on lands served by the Klamath irrigated agricultural production on lands served by the Klamath Project in a full water year. Crop production values by crop type for each of the three counties are summarized in the blue and brown bar segments in the figure, while total irrigated acreage by county is shown by the diamond. We also present the value of livestock production supported by Off-Project hay and pasture irrigation in the Upper Klamath Basin in Klamath County, Oregon (summarized in the grey bar segments representing livestock value). While irrigation also supports livestock production in California, the irrigated pasture acreage in the Klamath Project area is small, so this analysis does not quantify livestock supported by Project irrigation in California. **Across all three counties Project and Off-Project irrigation supports an estimated agricultural production value of $367.8 million (including livestock and crops), of which 68 percent is in Klamath County, Oregon.** Figure ES-3 provides more detail on the proportion of irrigated crop value by crop. Onions, garlic, and potatoes account for approximately 40 percent of the crop value; hay comprises approximately 41 percent of value; and grains, pasture, and other crops constitute the remaining 19 percent of value.

Figure ES-2: Value by Crop Type and Total Irrigated Acreage by County



Source: Highland Economics analysis of US Bureau of Reclamation Klamath Project crop reports, Modoc County and Siskiyou County commissioner crop reports and National Agricultural Statistics data.

Figure ES-3: Value by Crop Type



Source: Highland Economics analysis of US Bureau of Reclamation crop reports, five years of yield and crop price data from National Agricultural Statistics Service, Modoc County crop reports, and Siskiyou County crop reports.

Agricultural Economic Contribution: Full Water Year

Upper Klamath Basin agricultural production supports economic activity throughout the local region, as well as outside the region. We present economic contribution in terms of employment (full and part-time jobs) and labor income (employee compensation and proprietor income) directly or indirectly supported by Klamath Project crop production.

The total economic contribution of Project and Off-Project agriculture in the region includes: 1) the direct effects on farms of agricultural jobs and income supported by irrigated crop production, 2) the indirect effects in other sectors of jobs and income supported by farms purchasing inputs such as seed, fertilizer, and farm equipment necessary for crop production, and 3) the induced effects in other sectors such as real estate and health care resulting from the spending of employee wages.

TYPES OF ECONOMIC EFFECTS

Direct: Farm jobs and income related to irrigated crop production and livestock production.

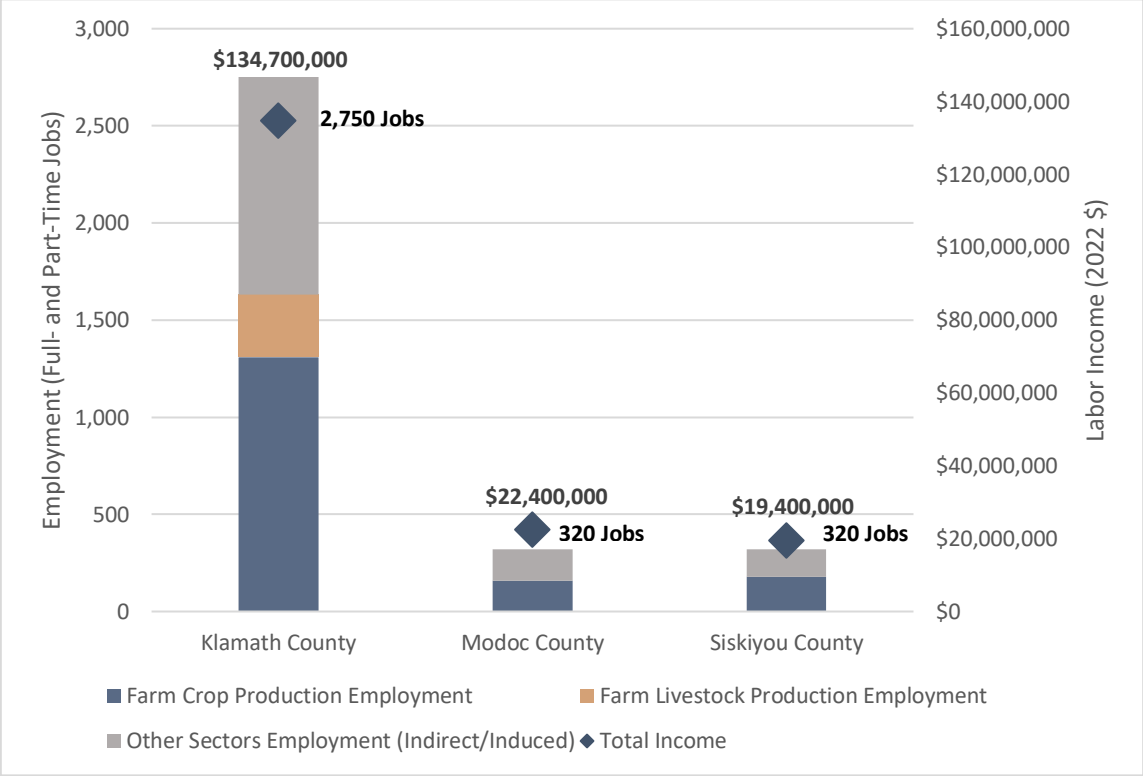
Indirect: Jobs and income at businesses supplying inputs, such as fertilizer, machinery, seeds to the CBP-irrigated farms.

Induced: Jobs and income at businesses such as retail stores and service providers supported by the spending of farm-related income.

There are also additional economic effects of the Klamath Project and Off-Project irrigated agriculture: crop production is a vital input and makes possible substantial local animal production, and Project irrigation infrastructure also provides water for habitat at the refuges that support a thriving local recreation economy.

Figure ES-4 summarizes the estimated total economic contribution (direct, indirect, and induced) from agricultural production. **In the local three-county region, Klamath Project and Off-Project irrigated agricultural production supports an estimated 3,180 jobs (full and part-time jobs) and $176.5 million in income (including total employee compensation and proprietor income) annually.** Note that in the absence of the Klamath Project and Off-Project irrigation, economic activity would fall by less than this amount to the extent that people currently directly or indirectly employed in irrigation-related activities could find alternative employment and economic opportunities.

Figure ES-4: Total (Direct, Indirect, Induced) Employment and Income Supported by Klamath Project and Off-Project Irrigation



Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Economic Impacts of Reduced Project Water Supply to Agriculture

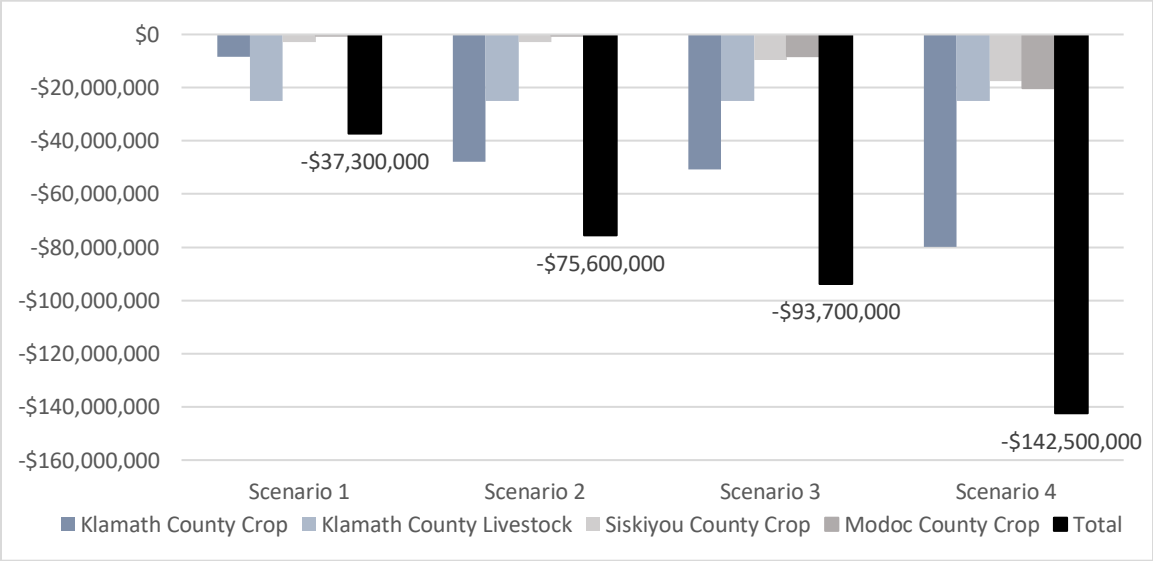
Reductions in water supply reduce farm production value, which in turn reduces farm income and farm spending, which then ripples through the local economy and reduces income and employment in other sectors. Consistent with standard economic impact modeling practices, this analysis estimates the change in total farm employment and income in the local economy based on the current relationship between agricultural production levels and farm employment and income. In other words, the analysis models impact by assuming farm employment and income respond proportionately to a change in farm output. For example, if farm output falls by 10 percent, the level of farm employment/income and spending in other sectors also falls by 10 percent. As such, the impacts presented in this section represent the estimated reduction in regional income and employment supported by agricultural production as water supplies decline.[1] The scenarios modeled range from a 12 percent reduction (Scenario 1) to a 66 percent

[1] Actual changes in regional employment and income may be different. In the short term, employment effects can be 'sticky', in that reduced economic activity does not necessarily translate into reductions in the number of jobs immediately as employers may choose to retain employees in the short-term even with declines in economic activity (although the number of hours of employment or the productivity would decline in this case). Further, in the long-term total income and employment in the

reduction (Scenario 4) in Klamath Project crop water supply, considering both surface and groundwater resources.

As shown in Figure 5-1, we project annual agricultural sales (livestock and crop farm sales) to decline by $37.3 million in Scenario 1 (12 percent crop water supply reduction) to up to $142.5 million in Scenario 4 (66 percent crop water supply reduction). These values include the estimated annual reduction in Klamath Project crop production values in each county due to the modeled decrease in water supply, plus an estimated $25 million long-term annual change in Klamath County livestock production values (primarily Off-Project value) that we include in every water supply reduction scenario. As discussed in Section 5 of the report, the data indicate that there has been a shift in beef cattle ranching activity in Klamath County in response to long-term (i.e., all water years) reduced availability of water to irrigate forage, particularly in Off-Project areas. While we hold constant the reduction in livestock value in all scenarios, crop production values increasingly decline as water supplies decrease, and higher value crops are increasingly impacted with more severe cuts in Klamath Project crop water supply.

Figure ES-5: Estimated Annual Effects on Crop and Livestock Farm Sales by Water Reduction Scenario (2022$)



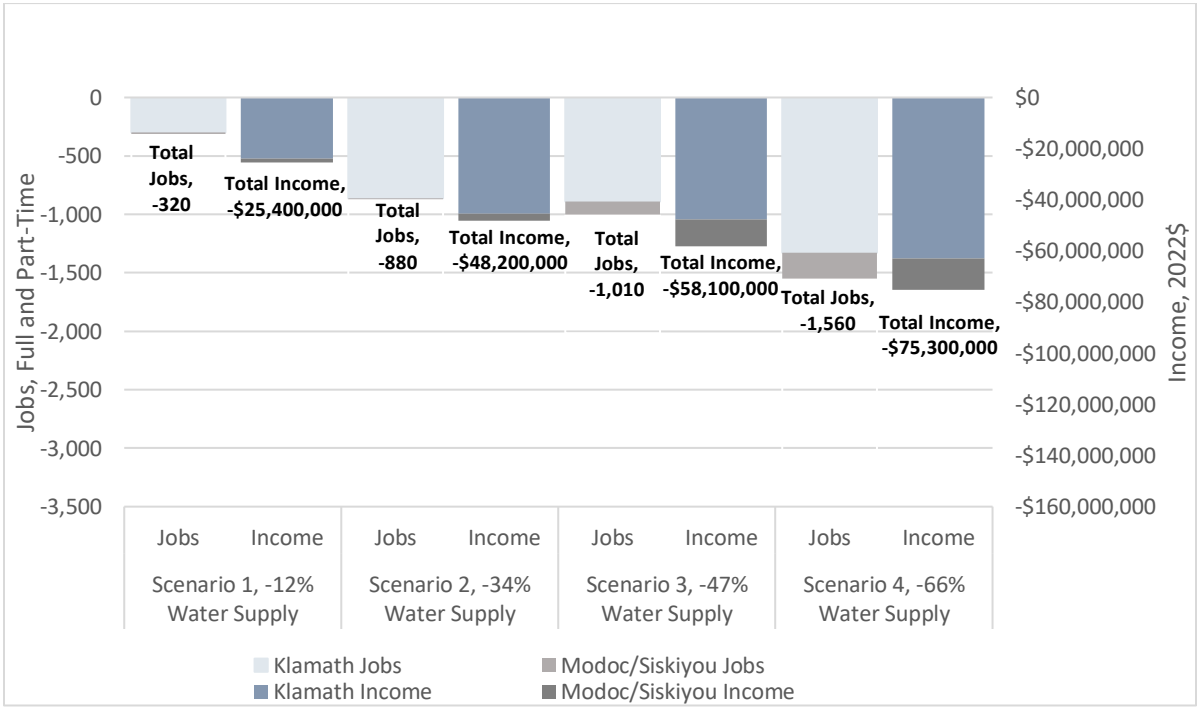
Source: Highland Economics analysis

As shown in Figure 5-2 and Figure 5-3, **as water supply available to Klamath Project crops falls by 12 percent, regional economic impacts are estimated at approximately 330 reduced jobs and $25.7 million in reduced income effects**. These impacts rise to a reduction of 880 jobs and $48.2 million in reduced regional income supported when crop water supply falls by 34 percent. When Klamath Project crop water supply drops by nearly one-half (47 percent), impacts rise to 1,010 jobs and $58.1 million in reduced employment and income supported. Finally, **when crop**

region may fall by less than this amount as people directly or indirectly employed in farm-related activities may find alternative income-generating economic activities in the region.

water supply drops by two-thirds (66 percent), then employment supported falls by 1,560 jobs and $75.3 million in income. In every scenario, effects in Klamath County account for over 80 percent of impacts (including crop and livestock-related impacts).

Figure ES-6: Summary of Economic Impacts by Scenario



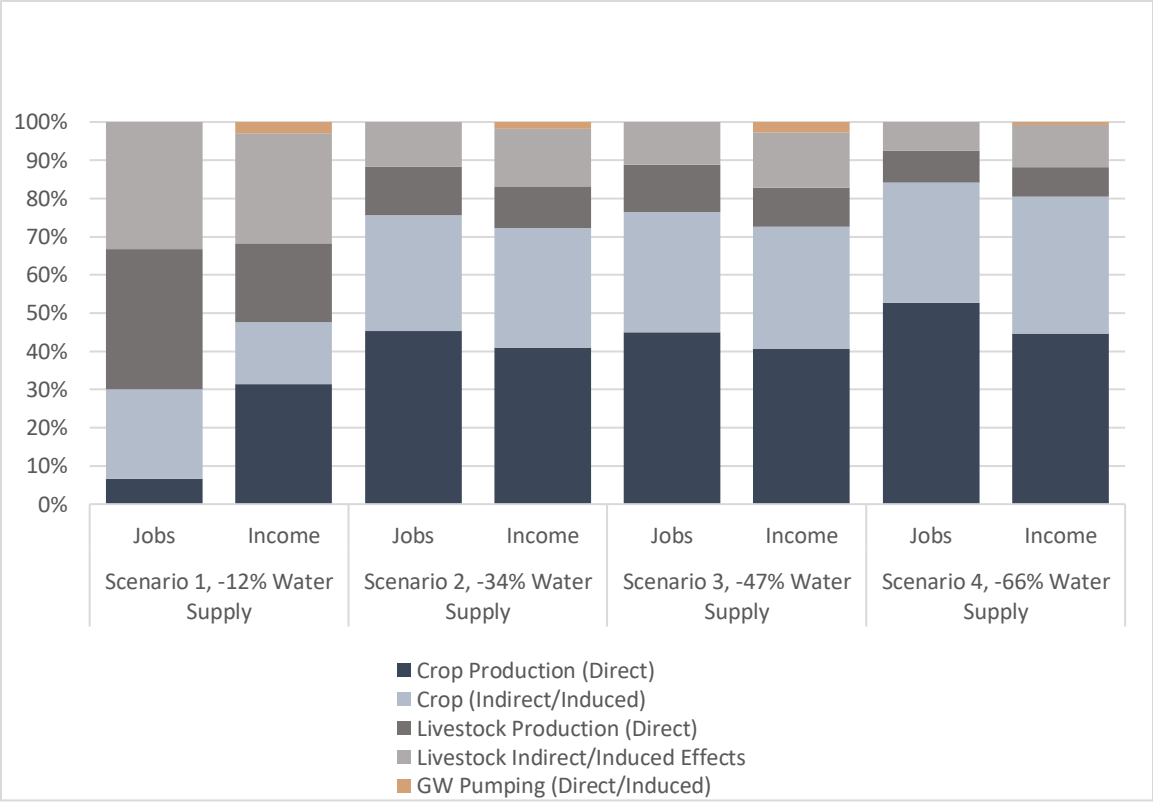
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Klamath County is where most of the impacts are expected to be experienced since California districts have contracts with higher priority for Project water. Figure 5-3 summarizes the distribution of impacts by source in Klamath County. This analysis quantifies five sources or types of economic impacts:

1. **On-farm direct job and employment impacts of reduced crop production** (fallowing or deficit irrigation), resulting from reduced irrigation water supplies. Crop production values increasingly decline as water supplies decrease, and higher value crops are increasingly impacted.
2. **Indirect and induced job and employment impacts of reduced crop production,** resulting from reduced farm spending on inputs from local businesses and from reduced household spending by affected employees and proprietors.
3. **Direct job and employment impacts of reduced livestock production** due to reduced irrigated forage production, particularly in Off-Project areas of Klamath County**.** We hold this constant in all water reduction scenarios as it reflects a long-term change in availability of water for irrigation of forage, particularly in Off-Project areas.

4. **Indirect and induced job and employment impacts of reduced livestock production,** resulting from reduced farm spending on inputs from local businesses and from reduced household spending by affected employees and proprietors.
5. **Direct and induced job and employment impacts of increased groundwater pumping costs.** Klamath Project irrigators are expected to increase groundwater pumping to reduce the economic effects of reduced surface water supplies; this increased groundwater pumping reduces farm net income (direct effect) and reduces the amount of disposable income that farmers can spend in the local economy, thereby affecting income and employment in other sectors as well (induced effect).

Figure ES-7: Klamath County Economic Impacts by Source by Scenario



Source: Highland Economics analysis using a multi-regional input output model of Klamath, Siskiyou, and Modoc counties with 2021 IMPLAN software and data.

Tax Revenues & Water Availability

Agricultural activity supports the tax base of the region through increasing property values (which supports property taxes), stimulating the sale of goods (which results in sales taxes in California), and generating income (which results in income taxes). In the study area, governments levy property taxes and sales taxes at the local (city and county) and state level, while states and the federal government collect income taxes. This analysis focuses exclusively on local taxes.

Sales and use taxes are based on the sale and use of property and goods. The State of Oregon does not have a sales tax and neither does Klamath County. However, counties in California have a minimum sales tax rate of 7.25 percent, of which 6 percent is under the state jurisdiction and 1.25 percent is under local jurisdictions (California Department of Tax and Fee Administration, 2023). Modoc and Siskiyou Counties do not impose an additional sales tax, so the effective sales tax rate is 7.25 percent for both counties. Based on the proportion of county economic activity supported by Project-related crop production, we estimate that the Project supports approximately $785,000 annually in sales and use taxes in both California counties. In Scenario 4, the total output supported by Klamath Project in Modoc and Siskiyou counties drops by approximately one-third. **As such, for the scenarios modeled, the sales and use taxes could drop by approximately $265,000 annually.**

Property taxes are based on the assessed value of a property and the rate at which that value is taxed by various districts in the county. All else equal, irrigated land is more valuable (as discussed in Section 2) than dryland, and thus results in higher property taxes. As such, Project and Off-Project irrigation water supplies increase agricultural land assessed value. Agricultural land that typically is irrigated but does not receive water in a given year could, in theory, be assessed at a lower rate for that year. In practice in the Upper Klamath Basin, however, county assessors are not able to adjust the assessed values from year-to-year depending on the amount of water received by a given parcel of land (DePaul, 2023; Kenneally, 2023). However, the county assessors have taken some measures to alleviate the tax burden on farmers who face reduced revenues due to water supply shortages. For example, in the last six years, Klamath County has cut the assessed value of agricultural land by 50 percent to mitigate the burden on farmers in the Upper Klamath Basin who did not receive surface water (Kenneally, 2023).

Based on property tax rates in Klamath County and the change in assessed value of agricultural land in recent years in Klamath County, we estimate that the **reduced water supplies to irrigators in Klamath County have resulted in a reduction in county property taxes of approximately $1 million annually (a reduction of 1.3 percent of total county property taxes) in the last six years due to reduced water supplies.**

Effects of Klamath Project water supplies on total property taxes in Modoc and Siskiyou Counties would have been proportionately less as the proportion of acres in these counties irrigated with Klamath Project water is much lower (24 percent and 26 percent) compared to nearly all lands in Klamath County being irrigated by Klamath Project or Off-Project water. In Modoc County, the Assessor's Office did not increase the assessed value of agricultural land that constructed groundwater wells (which would typically result in a higher assessment) because the losses from surface water shortages were considered roughly equal to the value of improvements (DePaul, 2023). As such, reduced water supplies resulted in increased costs to the farms in the form of groundwater well investments but did not change the overall property tax payments.

1 INTRODUCTION

Water in the Upper Klamath River Basin (Basin) is vital to many interests and supports diverse economic, cultural, social, and environmental values. These include values related to the agricultural economy, endangered species, and tribal treaty rights. While all these values are significant and important, the scope of this report focuses on the economic value to the local economy of the diversion of water for use by irrigators.

Irrigation is the primary human use of water in the Basin, and the Klamath Project (Project), which is managed by the U.S. Bureau of Reclamation, delivers irrigation water to a service area of over 230,000 acres in Oregon (Klamath County) and California (Modoc County and Siskiyou County). To support fish and wildife and associated recreation, the Klamath Project also delivers water to two National Wildlife Refuges, which are managed by the U.S. Fish and Wildlife Service.

Management of water in the Basin is complex, and the Basin faces water shortages in some years that affect irrigators, fish and wildlife, tribes, and commercial fishing. In 2022, the Basin experienced severe drought conditions, with zero water allocation to farmers from the Klamath Project, the first time this has happened in the history of the Project. In the context of these recurring and severe water shortages, Oregon State University, with support from the Klamath County Board of Commissioners and Ducks Unlimited, commissioned this study. The purpose of the study is to estimate the economic contribution of irrigated agriculture to the regional economy and the economic effects of changes in irrigation water supplies.

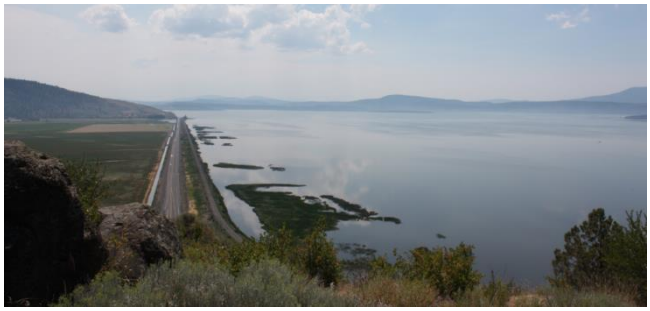


Photo credit: US Bureau of Reclamation

1.1 STUDY AREA

The study area is a three-county area including: Klamath County, Oregon; Siskiyou County, California; and Modoc County, California. The specific focus includes agricultural lands affected by water management in the Upper Klamath Basin, including:

1. Project-irrigated lands in the three counties.
2. Off-Project irrigated lands in Klamath County.

Estimating the economic contribution (in terms of local jobs, income, and taxes) of these agricultural lands to the three-county economy is the purpose of the analysis.

1.2 DATA SOURCES & METHODS

Irrigation districts supported by the Klamath Project are required to report the acreage and yield by crop each year to the U.S. Bureau of Reclamation. We used the data from these crop reports to model the yield and acreage by crop occurring in the project area. Yield data from Bureau of Reclamation were available from 2011 to 2019 and acreage data were available from 2015 to 2019. For data on the price

received per unit of crop, we used the Agricultural Commissioners' reports from Siskiyou and Modoc Counties, which were available from 2012 to 2021. We used data from the National Agricultural Statistics Service of the U.S. Department of Agriculture to supplement the acreage, price, and yield data.

Combining these three data sources (acreage, yield, and price), we estimated the total revenue produced in the Project area under varying water conditions. We provide further descriptions of the data used in our analysis in the Appendix.

To evaluate the direct farm employment and income contribution of the Project, we relied on data from the U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics. These sources provide estimates of jobs and income associated with farm-related activities. For fiscal impacts, we used financial reports from the three counties in the Upper Klamath Basin: Klamath, Siskiyou, and Modoc.

Estimating total economic impacts requires modeling how changes in crop production translate to changes in the regional economy (indirect and induced jobs and income). We used 2021 IMPLAN software and data; IMPLAN models estimate how changes in agricultural output affect total economic activity and the associated effects on employment and income in other sectors of the local economy.

1.3 Report Organization

The remainder of this report is divided into five sections. Section 2 presents an overview of the Upper Klamath Basin water management and the role of water in supporting agriculture and the National Wildlife Refuges. Section 3 presents data on the acreage and agricultural production value supported by Project and Off-Project irrigation. Section 4 presents the economic contribution, in terms of jobs and income, of Project and Off-Project agricultural production. Section 5 estimates the effects of changes in water supply on agricultural production value and regional employment and income. Section 6 presents information on the tax revenues, or fiscal contribution, of the Project to local governments based on the economic activity estimates.

2 KLAMATH BASIN AGRICULTURAL ECONOMY & WATER AVAILABILITY

This section introduces the issues affecting water management and availability in the Upper Klamath Basin and the importance of water for the local agricultural economy. As noted in the introduction to this report, water supplies in the Klamath River Basin (Basin) support diverse economic, cultural, social, and environmental values related to the agricultural economy, the recreation economy, endangered species, and tribal treaty rights. While all these values are significant and important, the scope of this report focuses on the economic value to the local economy of the diversion of water for use by irrigators. As such, the sections below describe the availability and general importance of Upper Klamath Basin water to agricultural users.

Photo credit: US Bureau of Reclamation

2.1 KLAMATH PROJECT WATER SUPPLIES

The Klamath Project, as developed and administered by the U.S. Bureau of Reclamation (Reclamation), provides water to a service area of approximately 230,000 acres in in Klamath County, Oregon; Siskiyou County, California; and Modoc County, California (Bureau of Reclamation, 2020). There are 18 irrigation, drainage, and improvement districts within the Klamath Project, in addition to companies and individual landowners who hold contracts with the United States for irrigation water. Three reservoirs (Upper Klamath Lake, Clear Lake, and Gerber reservoirs) store and release water for the Project, and the Project diverts additional water from the natural flow of the Klamath and Lost Rivers (Bureau of Reclamation, 2020).

Historical runoff in the Klamath River Basin is highly variable (US Bureau of Reclamation, KLamath River Basin Study Technical Working Group, 2016). In addition to this natural variability in hydrology, federal management affects water supplies to the Klamath Project area. Reclamation's foremost operational priority has been to provide, produce, or maintain certain lake levels and river flows to meet requirements under the Endangered Species Act and consistent with tribal trust obligations. Only after ESA and requirements have been met has Reclamation made water available for irrigation to districts and other contractors of the Klamath Project or for wildlife purposes to the National Wildlife Refuges (US Bureau of Reclamation, 2016). This natural variability, coupled with federal management of water supplies to protect endangered species in the basin and meet tribal trust obligations, has caused Project water

Photo credit: US Bureau of Reclamation

supplies to be dramatically curtailed numerous times in recent years, including most recently a 100 percent curtailment (i.e., no authorized water deliveries from the project) in 2021. Further, in addition to Project irrigation in the Upper Klamath Basin, there is also irrigation of private lands in the Williamson, Wood, and Sprague watersheds above Upper Klamath Lake in Klamath County. These lands, henceforth referred to as "Off-Project" irrigated acreage are almost entirely pasture (US Geological Survey, 2016), and irrigation to these lands has also been significantly curtailed in recent years due to state agency management actions.

In response to this recent history of curtailments, both Project and Off-Project irrigators have invested in developing groundwater wells and have increased their pumping capacity to try to partially offset the reduced surface water supplies. Individuals and districts have developed groundwater supplies on a case-by-case basis, as their physical circumstances allow and as permitted by state law (which has changed over time).

Information on groundwater development across the Basin is available from several sources, including the Oregon Water Resources Department (OWRD) and the California Department of Water Resources; however, no comprehensive data source on annual volume of groundwater pumping was available for this analysis. Individual decisions on whether to turn on a well and associated pumping levels are based on several factors, including the surface water supply available from the Klamath Project.

We do know that the amount of groundwater extraction is different every year. Based on publicly available information and input from local water managers, the maximum in-season groundwater production to meet irrigation demand within the Klamath Project is estimated to not exceed 144,000 acre-feet per year. However, the U.S. Geological Survey estimates that the average sustainable yield (i.e., the level of withdrawal that can be maintained without over-drafting the aquifer and adversely affecting groundwater levels) is 54,000 acre-feet per year (US Geological Survey, 2016). These two numbers provide context for evaluating the economic effects of reduced surface water deliveries to the Klamath Project.

In addition to agricultural lands, there are two wildlife refuges, Lower Klamath National Wildlife Refuge (LKNWR, located in Siskiyou and Klamath counties) and Tule Lake National Wildlife Refuge (TLNWR, located in Siskiyou and Modoc counties), that receive water from the Project for irrigation and habitat purposes. These two national wildlife refuges are part of the larger Klamath Basin National Wildlife Refuge Complex that also includes Clear Lake, Upper Klamath, Klamath Marsh, and Bear Valley National Wildlife Refuges. LKNWR and TLNWR provide habitat for a variety of fish and wildlife species and are a key resource that supports migratory birds of the Pacific Flyway (Bureau of Reclamation, 2020). Water released from one of the project's storage reservoirs may be reused several times before it is returned to the Klamath River. Return flows from irrigation within the Klamath Project has historically served as the primary water supply for LKNWR and TLNWR.

Excess water from TLNWR and LKNWR is discharged to the Klamath River via the Klamath Straits Drain (US Bureau of Reclamation, 2016). Water availability for LKNWR and TLNWR has been severely limited in several recent years due to the lack of an established allocation from the

Klamath Project for irrigation and the refuges. This has consequently limited the ability of the refuges to provide habitat for fish, wildlife, and migratory bird species.

2.2 Agricultural Production Value & Irrigation Water

Table 2-1 outlines the irrigated land in each county, the amount of Project-irrigated land by county, and the share of Project irrigated acreage relative to total irrigated land in each county. Project lands comprise the majority of irrigated acres in Klamath County but only a small portion of Siskiyou and Modoc Counties' irrigated acres.

Table 2-1: Full Water Year Irrigated Land in Upper Klamath Basin

Metric	Klamath County	Siskiyou County	Modoc County	Three-County Total
Land in farms (acres) [A]	428,999	687,313	571,191	1,687,503
Harvested cropland (acres) [A]	117,259	87,997	115,640	320,896
Total irrigated area (acres) [A]	165,541	115,572	142,138	423,251
Percent cropland irrigated in county	97%	95%	98%	97%
Total Klamath Project irrigated acres in county[B]	129,461	30,212	33,777	193,450
Project % of irrigated acres in county	78%	26%	24%	46%

A/ Source: (National Agricultural Statistics Service, 2017)
B/ Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019) *and* (Tulelake Irrigation District, 2021)

The availability of irrigation water allows farms to increase the value of agricultural production from their land. Irrigation makes it possible to grow high-value crops, such as fruits and vegetables, which would otherwise be impossible in the Klamath Basin due to very little rainfall. Vegetables and mint/strawberry root (classified as 'other') have significantly higher gross revenues per acre compared to other crop types in the Klamath Basin (see Figure 3-4 in the next section). While vegetables and fruits only comprise around 12 percent of the total acres in the Basin, they generate approximately 45 percent of total revenues in a full water year.

As Table 2-2 below indicates, average annual precipitation in the area ranges from about 10 to 13 inches per year. This precipitation falls mainly in the winter months as snow (i.e., outside the primary crop growing season). Klamath Project reservoirs store the snow-fed winter and spring runoff, which is released during the spring/summer and fall/winter operating periods (Bureau of Reclamation, 2020).

Crop water requirements are shown in Table 2-3 below. In general, crops grown in the region require at least 20 inches of water to meet their evapotranspiration (ET) needs in an average year. Given the low level of rainfall during the growing season, irrigation plays a critical role in crop production in the study area.

Table 2-2: Average Annual Precipitation by County (Inches)

County	Weather Station	Average Annual Precipitation (in inches)
Klamath	Klamath Falls Intl AP	11.14
Siskiyou	Dorris 0.2 SW	13.31
Modoc	Tulelake	10.70

Source: (National Oceanic and Atmospheric Administration, 2020)
Note: Average precipitation from 1991-2020.

Table 2-3: Average Annual Water Requirement by Crop and Location (Inches)

Crop	AgriMet* Station Location		
	Klamath Falls, Klamath County	Lorella, Klamath County	Worden, Klamath County
Alfalfa	33.6	33.5	32.4
Pasture	26.8	26.8	26.0
Winter Grain	24.1	23.9	23.4
Spring Grain	22.0	21.2	20.6
Onions	23.1	22.9	21.8
Potatoes	21.6	22.4	21.1
Peppermint	24.5	24.2	23.3
Strawberries	25.5	27.1	N/A

Source: (AgriMet, 2015)
**AgriMet is a cooperative agricultural weather network of weather stations operated by the US Bureau of Reclamation.*

Data from the 2017 Census of Agriculture suggests that farmers grow very few crops in the study area without irrigation. These primarily-dryland crops include:

- Haylage (in Klamath County)
- Spring wheat (in Modoc County)
- Winter wheat (in Klamath, Modoc, and Siskiyou Counties) (National Agricultural Statistics Service, US Department of Agriculture, 2023).

A majority of the acreage in all other crops (for which there are data available) is irrigated. Table 2-4 summarizes estimated total crop ET water needs for Klamath Project lands for the cropping pattern irrigated in a full water year.

Table 2-4: Full Water Year Acreage and Crop Water Demand by District

District/Entity	Full Water Year Acreage	Crop ET Demand	% Crop ET Demand from Pasture, Grain, Hay
Tulelake Irrigation District (TID)	58,574	134,014	82%
Klamath Irrigation District (KID)	43,459	2,869	87%
Klamath Drainage District (KDD)	17,738	10,905	97%

Klamath Basin Improvement District (KBID)	8,916	0	95%
USFWS Refuge	5,554	859	100%
Van Brimmer District Company	4,665	128,634	96%
Other Oregon Lands	54,544	9,109	97%
Total Klamath Project	193,450	450,000	90%

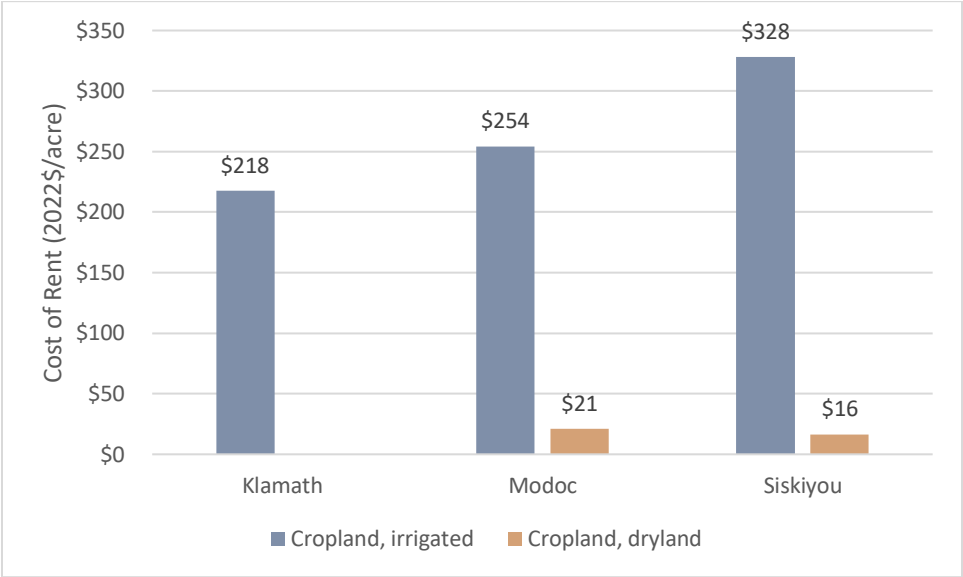
Source: Highland Economics analysis of Bureau of Reclamation crop data and Bureau of Reclamation AgriMet evapotranspiration data.

While only a portion of farmland acreage in each county is rented (versus owned), comparing the rental rates for irrigated land to the rental rates for dryland provides an indication of the per-acre value of irrigation water. Even though rented land accounts for only a portion of total agricultural land, county level data on land value/rent that differentiates between dryland and irrigated lands is only available for rented agricultural land. The comparison below of the cash rent value of irrigated land versus dryland does not account for other factors, such as soil quality, that may also affect land value. To the extent that irrigated land is better agricultural land, then the values below for irrigation water derived from a comparison of dryland and irrigated land rental values would tend to overestimate the additional value provided by irrigation water.

Figure 2-1 below compares rental rates of irrigated cropland and dryland cropland. Across the Klamath Project counties, the average rental rate for irrigated cropland is $267 per acre (2022 dollars), this is slightly higher the Oregon average ($245 per acre) but about half of the California average ($524 per acre).[2] Rent for dryland cropland averages $19 per acre, suggesting that access to irrigation may generate an additional value of $248 per acre per year on average (assuming similar soils and other land characteristics). Within the Klamath Project counties, this potential additional value of irrigation ranges from $233 in Modoc County to $312 in Siskiyou County (there were not available data for dryland rental rates in Klamath County). The value of water in the Klamath Project as suggested by land rental rates is roughly 75 percent higher than the Oregon average ($143 per acre, estimated based on $245 for irrigated cropland versus $102 for dryland cropland) but about 50 percent lower than the California average ($491 per acre, estimated based on $524 for irrigated cropland versus $33 for dryland cropland). This suggests that the Project irrigation may bring higher-than-average value to agriculture production relative to the Oregon average but lower-than-average value relative to the California average.

[2] Values represent the average rental rate from 2012-2020, where data was available (National Agricultural Statistics Service, US Department of Agriculture, 2021). We adjusted annual values to 2022 dollars using the Gross Domestic Product Implicit Price Deflator prior to averaging.

Figure 2-1: Average Rental Rates for Irrigated and Non-Irrigated Land

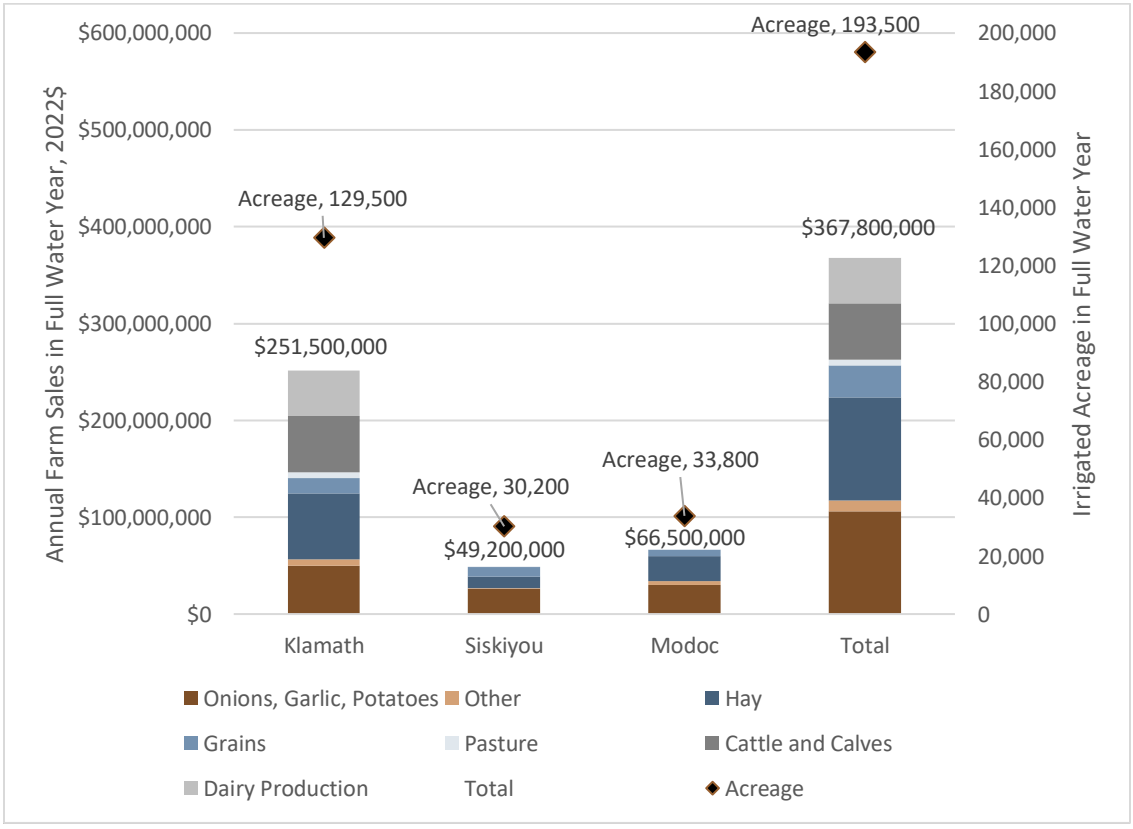


Note: Values represent the average rental rate from 2012-2020, where data was available. We adjusted annual values to 2022 dollars using the Gross Domestic Product Implicit Price Deflator prior to averaging.
Source: Highland Economics analysis of (National Agricultural Statistics Service, US Department of Agriculture, 2023).

3 KLAMATH BASIN AGRICULTURAL PRODUCTION: FULL WATER YEAR

This section presents the farmgate sales value of irrigated agricultural production on lands served by the Klamath Project in a full water year (Section 5 discusses the acreage and value in reduced water supply years). Crop production values by crop type for each of the three counties are summarized in the blue and brown bar segments in Figure 3-1 below, while total irrigated acreage by county is shown by the diamond. We also present the value of livestock production supported by Off-Project hay and pasture irrigation in the Upper Klamath Basin in Klamath County, Oregon (summarized in the grey bar segments). While irrigation also supports livestock production in California, the irrigated pasture acreage in the Klamath Project area is small, so this analysis does not quantify livestock supported by Project irrigation in California. Figure 3-1 summarizes total irrigated acreage (estimated at 193,500 acres across all three counties) and total estimated agricultural production value of $367.8 million (including livestock and crops) supported by Project and Off-Project irrigation, of which 68 percent of value is in Klamath County, Oregon.

Figure 3-1: Value by Crop Type and Total Irrigated Acreage by County



For a full description of data sources and additional data tables used in the agricultural analysis, please see Appendix A.

3.1 Agricultural Acreage

This section describes the acreage of agricultural lands, the crops grown, and the estimated value of the agricultural goods produced in a full irrigation water year.

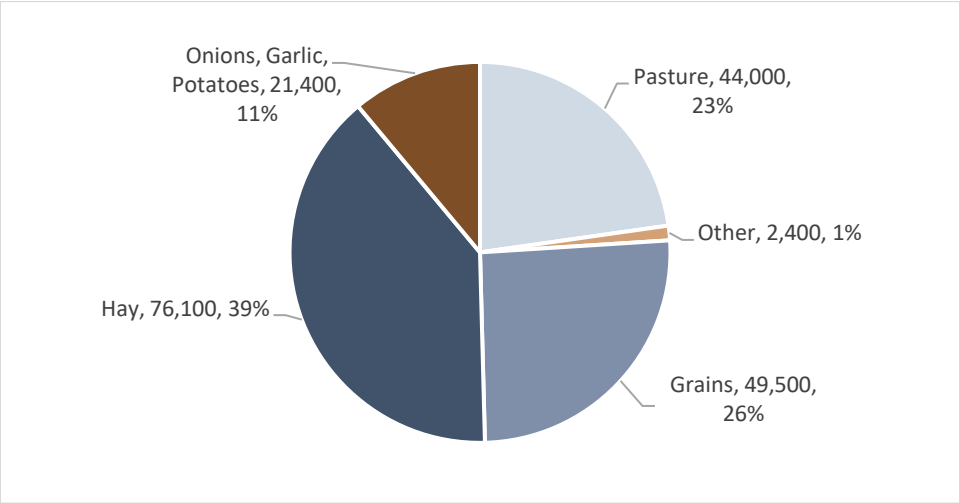
Of the approximately 193,450 acres irrigated in the Klamath Project from Upper Klamath Lake in the Klamath River in a full water year (not including areas dependent on Clear Lake, Gerber, and the Lost River for their water supply), about 67 percent of acres are located in Klamath County, Oregon; 16 percent are located in Siskiyou County, California; and 17 percent are located in Modoc County, California. Table 3-1 below shows the estimated full water year annual acreage of approximately 193,450 acres by county and crop type. The maximum acreage grown (i.e., even in the most water abundant year) from 2011 to 2019 was 193,562 acres (based on District crop reports provided to the Bureau of Reclamation), while the average acreage grown from 1993 to 2000 (before the Project was routinely experiencing water shortages) was almost 197,000 acres. The current estimated full water year acreage is based largely on acreage from 2017 (the last full water year with full Project acreage data available), with the following adjustments: the acreage for potatoes, onions, lettuce, garlic, and seed vegetables were taken from the 2019 crop year. Figure 3-2 presents graphically the proportion of acreage by primary crop type.

Table 3-1: Annual Klamath Project Acres by Crop Type and County

Crop Type	Klamath	Siskiyou	Modoc	Total	% of Total
Alfalfa Hay	42,330	7,810	14,500	64,640	33%
Barley	12,600	10,980	4,370	27,950	14%
Dry Onions	1,210	550	2,240	3,990	2%
Garlic	210	0	130	340	0%
Pasture	41,600	1,780	660	44,030	23%
Mint	60	210	2,000	2,270	1%
Oats	1,600	150	0	1,740	1%
Other Hay	8,820	130	2,500	11,450	6%
Potatoes, Chip	7,050	2,180	1,650	10,890	6%
Potatoes, Fresh	2,530	2,060	1,630	6,230	3%
Strawberry Rootstalks	130	0	0	130	0%
Wheat	11,330	4,360	4,110	19,800	10%
Total	129,460	30,210	33,780	193,450	100%

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019). *Data is based on acreage from 2017 (the last full water year with full Project acreage data available), with the following exceptions: We adopted the acreage for potatoes, onions, lettuce, garlic, and seed vegetables from the 2019 crop year. We estimated acreage in Modoc County from Tulelake Irrigation District's 2021 and 2022 crop reports since 2017 data was not delineated by county.*

Figure 3-2: Acreage by Crop Type



Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019)

3.2 Agricultural Production Value

In a full irrigation water year, these approximately 193,450 acres of irrigated lands produce an estimated $261.7 million in gross crop production value (farmgate sales). This estimate is based on recent cropping patterns and five-year average prices and yields per acre for each crop type.[3] As shown in Figure 3-3 and Figure 3-5 below, approximately 80 percent of total crop production value is from vegetables and hay, each with $106.2 million annual value. Vegetables provide approximately 40 percent of value on 11 percent of irrigated crop acreage due to their high value per acre (approximately $4,960 per acre, as shown in Figure 3-4), while growers produce alfalfa and other hay on 39 percent of irrigated crop acreage (with average production value of approximately $1,400 per acre). Other key crops are grains and pasture, as well as mint and strawberry rootstalk (we combine mint and strawberry rootstalk in the 'other' category in the charts). Grains and pasture combine for 15 percent of irrigated value on 49 percent of irrigated acres.

In sum, high-value crops (potatoes, onions, garlic, other vegetables, strawberry root, and mint) make up 12 percent of all district acres and 45 percent of all value. These crops, however, require rotation with grain and hay crops to maintain soil fertility and control disease and pests.

[3] Note that we normalized all prices to 2022 dollars (using the GDP implicit price deflator) before averaging over the last five years.

Figure 3-3: Total Production Value by Crop by County

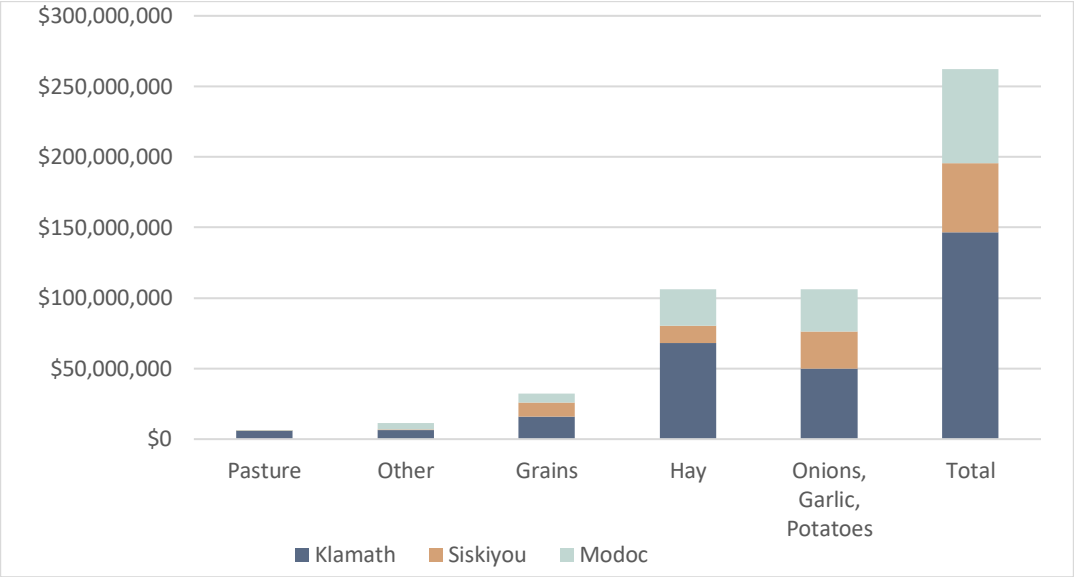
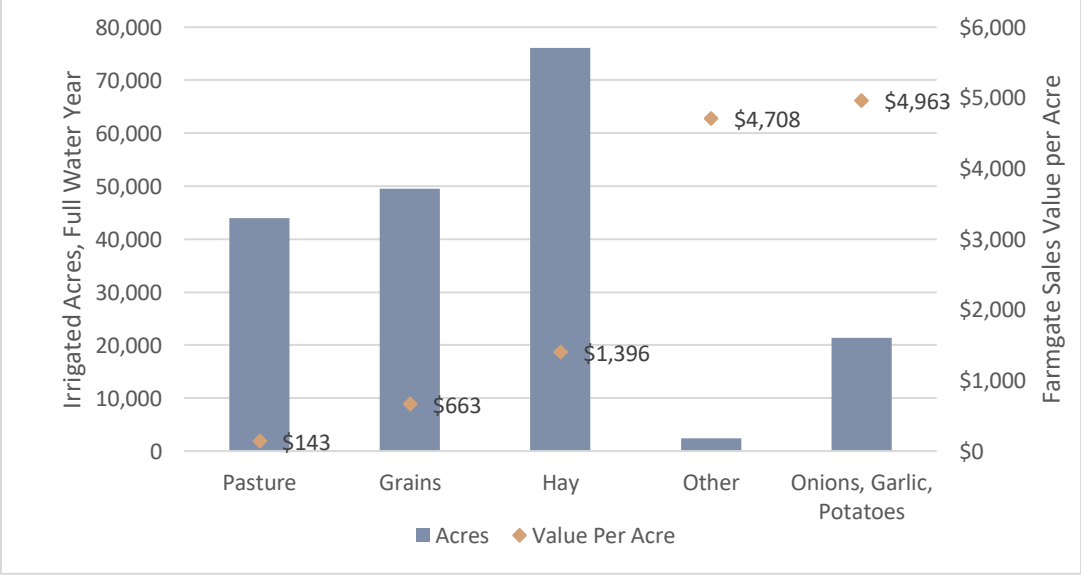
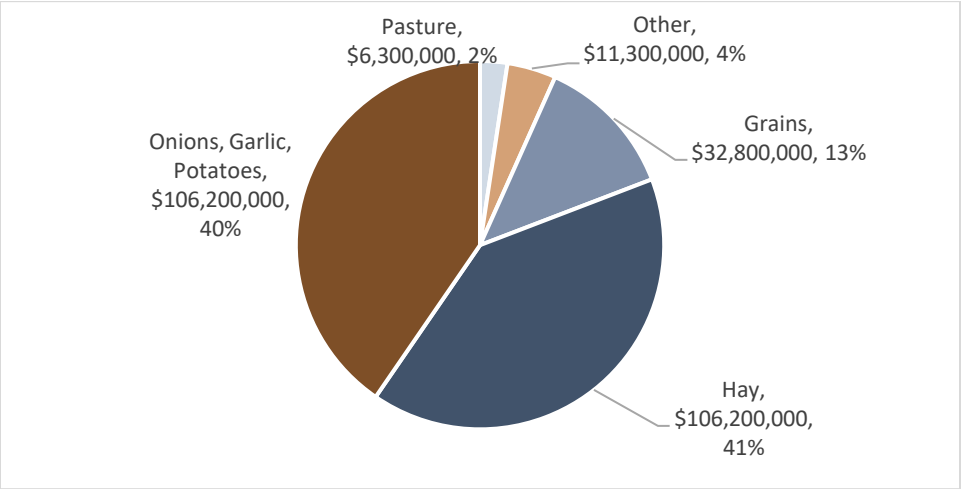


Figure 3-4: Irrigated Acreage and Average Crop Revenue/Acre



"Other" category includes strawberry root and mint.
Source: Highland Economics analysis based on Klamath Project acreage, Modoc County and Siskiyou County commissioner crop reports and USDA National Agricultural Statistics Service data.

Figure 3-5: Value by Crop Type



Source: Highland Economics analysis of US Bureau of reclamation crop reports and five years of yield and crop price data from National Agricultural Statistics Service and Modoc County crop reports and Siskiyou County crop reports.

In Klamath County, in addition to Project irrigation in the Upper Klamath Basin, there is also irrigation in the Williamson, Wood, and Sprague watersheds above Upper Klamath Lake. This Off-Project irrigated acreage is almost entirely pasture (US Geological Survey, 2016). The amount of Off-Project irrigated pasture is estimated to be approximately equal to all non-Project irrigated pasturelands in Klamath County based on the difference between Klamath County total irrigated pastureland from the 2012 and 2017 Census of Agriculture data and the Klamath Project irrigated acreage in those years (see Table 3-2).

Table 3-2: Upper Basin Pastureland Irrigation (Klamath County)

Metric	2012	2017
Total Pastureland	444,643	320,981
Total Irrigated Pastureland	65,198	66,817
Total Klamath Project Irrigated Pastureland	*40,761*	*41,600*
Estimated Off-Project Irrigated Pastureland	*24,437*	*25,217*

Sources: (National Agricultural Statistics Service, US Department of Agriculture, 2023) and (U.S. Bureau of Reclamation, 2020)

The primary economic value of the Off-Project irrigation is in supporting livestock production. In other words, Upper Basin irrigated pasture and hay lands (both Project and Off-Project) support the dairy and cattle ranching industries in Klamath County. As such, Table 3-3 presents the annual sales values from dairy farming and cattle ranching in the County in the Census of Agriculture years. Cattle sales (of both dairy and beef cattle) and dairy milk production data at the local level are only available at the county level every five years from the Census of Agriculture. While annual sales data for livestock and livestock products are not available at the county level, these sales data are available at the state level. To estimate the current value of cattle sales and milk production in Klamath County, we start with the 2017 Census of Agriculture county sales data, then index this value to 2022 prices based on the change in statewide price

levels (an increase of approximately 18 percent for both the price of milk and the price of cattle from 2017 to 2022), and then further adjust the values to account for changes in the countywide herd size (a decrease of 7 percent in countywide cattle inventory and an increase of 10 percent of dairy cows) since 2017[4]. The results of this analysis are shown in Table 3-3. While irrigation in the Lower Basin in Modoc and Siskiyou Counties also supported livestock production, this analysis focuses solely on the livestock values supported in the Upper Basin as there is limited irrigated pasture on Project lands in the lower basin.

Table 3-3: Livestock Inventory and Sales in Klamath County

Year	Sales Value of Cattle, Including Calves, $	Milk Sales, $	Cattle, Including Calves	Beef Cow Inventory	Dairy Cow Inventory	Beef and Milk Cow inventory
Estimated Current Value in 2022 Dollars[1]	**$58,200,000**	**$46,800,000**	**71,000**	**27,000**	**6,800**	**33,800**
2017	$52,663,000	$36,207,000	76,000	30,000	6,200	36,200
2012	$50,129,000	$25,036,000	81,000	40,000	4,100	44,100
2007	$53,914,000	$18,927,000	86,000	39,500	5,000	44,500

Source: Highland Economics analysis of Census of Agriculture data for Klamath County, 2017, 2012, 2007.

Of the total value of cattle and calf sales, we apportion approximately 80 percent to the beef cattle ranching sector, and approximately 20 percent to the dairy cattle sector (as approximately 80 percent of total cows are beef cows). As such, we estimate that the value of cattle sales from beef cattle ranching is approximately $46.9 million.

[4] The statewide milk production per cow was nearly the same in 2022 as it was in 2017, so no adjustment was made for that factor.

4 AGRICULTURAL ECONOMIC CONTRIBUTION: FULL WATER YEAR

Upper Klamath Basin agricultural production supports economic activity throughout the local region, as well as outside the region. **We present economic contribution in terms of employment (full and part-time jobs) and labor income (employee compensation and proprietor income) directly or indirectly supported by Klamath Project crop production.**

The total economic contribution of Project and Off-Project agriculture in the region includes: 1) the direct effects on farms of agricultural jobs and income supported by irrigated crop production, 2) the indirect effects in other sectors of jobs and income supported by farms purchasing inputs such as seed, fertilizer, and farm equipment necessary for crop production, and 3) the induced effects in other sectors such as real estate and health care resulting from the spending of employee wages.

There are also additional economic effects of the Klamath Project and Off-Project irrigated agriculture: crop production is a vital input and makes possible substantial local animal production, and Project irrigation infrastructure also provides water for habitat at the refuges that support a thriving local recreation economy.

TYPES OF ECONOMIC EFFECTS

Direct: Farm jobs and income related to irrigated crop production and livestock production, including farm proprietors and farm employees.

Indirect: Jobs and income at businesses supplying inputs, such as fertilizer, machinery, seeds to the CBP-irrigated farms.

Induced: Jobs and income at businesses such as retail stores and service providers supported by the spending of farm-

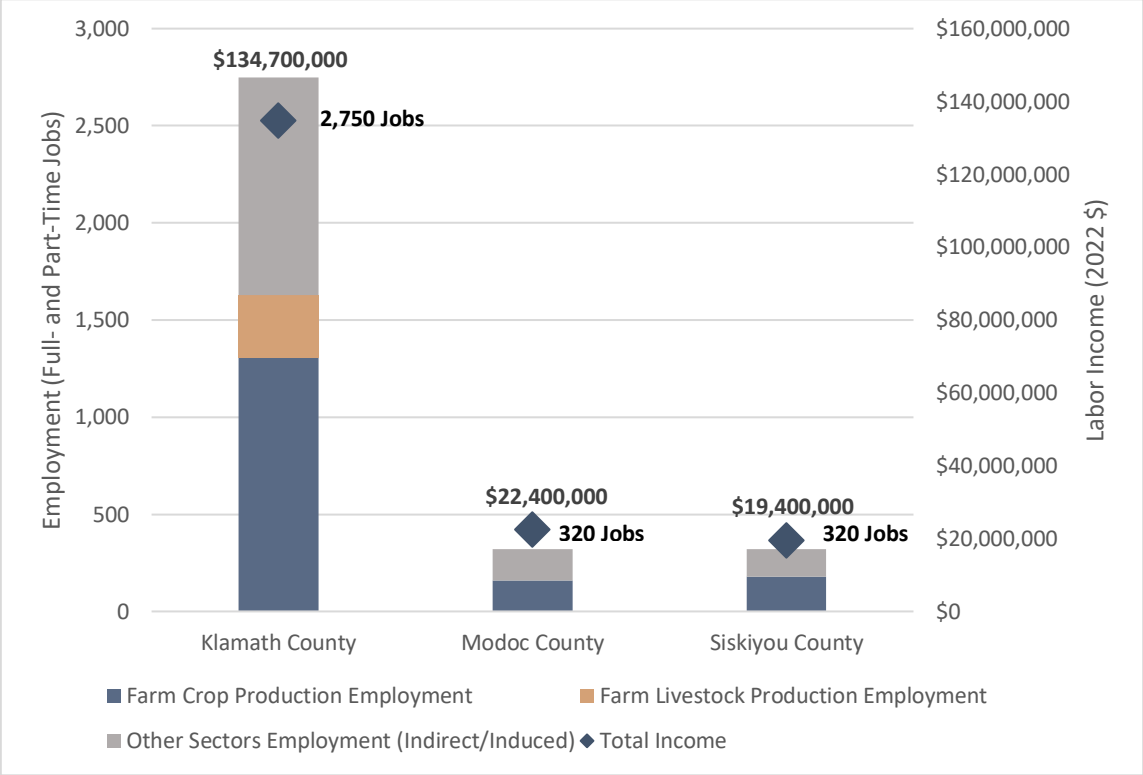
To estimate the indirect and induced "ripple" effects of economic activity, this analysis used IMPLAN, a regional economic model that simulates the economic relationships between industries in terms of input and output, jobs, and taxes (IMPLAN, 2021). We developed the values presented in this section using 2021 data in an IMPLAN model of the Klamath County, Siskiyou County, and Modoc County economies. We conducted the analysis using a Multi-Regional Input Output (MRIO) model framework that provides the total economic impact of production in the three-county region on each county economy.[5]

Figure 4-1 summarizes total economic contribution (direct, indirect, and induced) from agricultural production. **In the local three-county region, Klamath Project and Off-Project irrigated agricultural production supports an estimated 3,180 jobs (full and part-time jobs, including employees and proprietors) and $176.5 million in income (including total employee compensation and proprietor income) annually**. Note that in the absence of the Klamath

[5] In an MRIO model, economic impacts in each county include those related to agricultural production in the county as well as economic effects in each county that are related to agricultural production in the other two counties (i.e., if producers in Siskiyou County purchase services from Klamath County, the effects on Klamath County service providers are included as an impact in Klamath County).

Project and Off-Project irrigation, economic activity would fall by less than this amount to the extent that people currently directly or indirectly employed in irrigation-related activities could find alternative employment and economic opportunities.

Figure 4-1: Total (Direct, Indirect, Induced) Employment and Income Supported by Klamath Project and Off-Project Irrigation



Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

4.1 Direct Farm Production and Employment

To accurately estimate the employment and income impacts of Klamath Project agricultural production, we adjusted the data in the IMPLAN model to accurately reflect total local farm production value and local farm employment and farm income data (i.e., we adjusted the default data in IMPLAN for agricultural production). The data presented below on agricultural employment (including farm employees and farm proprietors) and income data, combined with county-level total agricultural production values, thus form the basis of our estimate of the direct farm jobs and income supported by the Klamath Project.

In 2020, the three-county study area employed over 55,000 full- and part-time workers (U.S. Bureau of Economic Analysis, 2021). The Klamath employment represents 1 percent of Oregon's total employment, while Siskiyou and Modoc Counties represent 0.1 percent of California's total employment. Of the total employment in the three counties, about 3,500 jobs were farm-related, representing 6 percent of the study area total employment. Trends in farm employment

from 2010 to 2021 varied across the study area: employment in Klamath and Modoc counties was fairly steady, while Siskiyou County employment grew by about 5 percent. Employment statistics for the study area, the state, and the nation are shown in Table 4-1 below, while income is shown in Table 4-2.

Crop and animal production comprises at least 5 percent of all private employment in the three-county area (U.S. Bureau of Labor Statistics, 2022).[6] In Modoc County, where farm employment is especially high, 11 percent of all private employment is related to crop production alone.[7] Table A-1 breaks down the average annual employment by farming industry, with detail provided for each farming sectors as defined by the North American Industry Classification System (NAICS).

Table 4-1: Full and Part-Time Farm and Total Employment in 2021

Geography	Total Employment	Farm Employment		Non-Farm Employment	
	Jobs	Jobs	Percent	Jobs	Percent
Klamath Basin Counties					
Klamath County, OR	31,538	1,739	6%	29,799	94%
Modoc County, CA	4,144	531	13%	3,613	87%
Siskiyou County, CA	20,789	1,243	6%	19,546	94%
Study Area Total	*56,471*	*3,513*	6%	*52,958*	94%
Oregon	2,559,454	69,840	3%	2,489,614	97%
California	23,906,353	229,419	1%	23,676,934	99%
United States	150,740,000	811,000	1%	149,929,000	99%

Sources: (U.S. Bureau of Economic Analysis, 2021; U.S. Bureau of Economic Analysis, 2021)

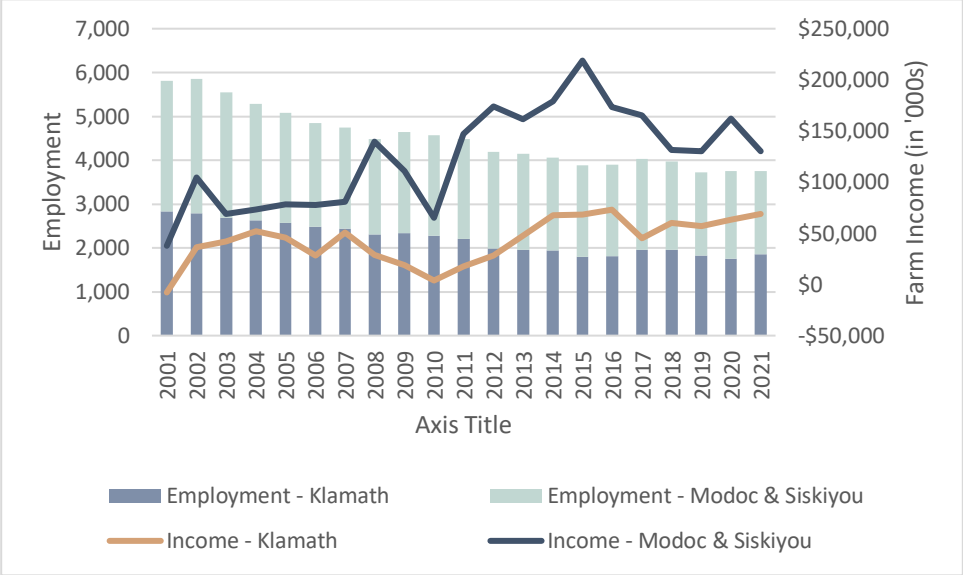
Table 4-2: Farm and Total Labor Income, 2021

Geography	Median Household Income	Total Compensation	Farm Compensation		Non-Farm Compensation	
		$000's	$000's	Percent	$000's	Percent
Klamath Basin Counties						
Klamath	$49,869	$1,856,602	$68,733	4%	$1,787,868	96%
Modoc	$54,533	$253,032	$49,144	19%	$203,888	81%
Siskiyou	$53,217	$1,215,568	$81,347	7%	$1,134,222	93%
Study Area Total	*N/A*	$3,325,201	*$199,224*	6%	*$3,125,978*	94%
Oregon	$76,384	$191,420,003	$1,802,405	1%	$189,617,598	99%
California	$90,629	$2,208,753,535	$17,990,574	1%	$2,190,762,961	99%
United States	$74,415	$13,383,414,006	$33,634,438	0.3%	$13,349,779,568	99.7%

Sources: (U.S. Bureau of Economic Analysis, 2021; U.S. Census Bureau, 2021)
Note: Values adjusted for inflation to 2022 dollars using GDP Price Deflator.

[6] The Bureau of Labor Statistics suppressed data on animal production in Modoc County.
[7] The Bureau of Labor Statistics suppressed data on animal production in Modoc County.

Figure 4-2: Three-County Farm Employment and Farm Income (2001 to 2021)



Sources: (U.S. Bureau of Economic Analysis, 2021)
Note: Income values adjusted for inflation to 2022 dollars using GDP Price Deflator.

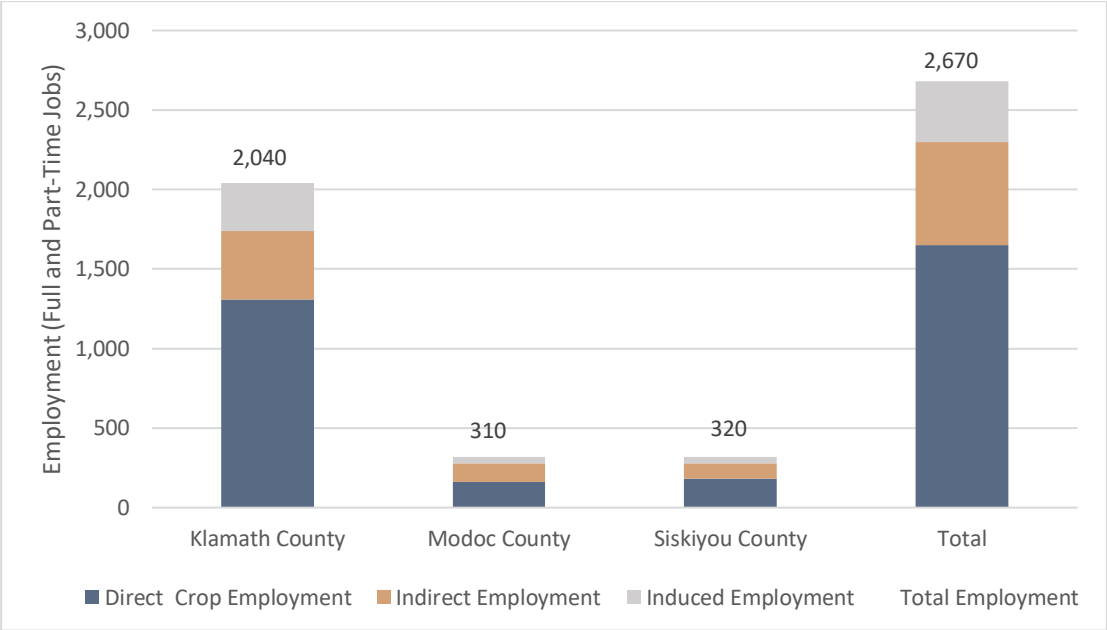
4.2 Economic Contribution of Farm Production and Employment

The figures below highlight the total employment and local income supported by crop production (Figure 4-3 and Source: *Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.*

Figure 4-4) and livestock production (Figure 4-5 and Figure 4-6). For each of these two components or pathways of economic impact, the direct impacts are presented (represented by the blue bars) separately from the indirect (orange bars) and induced impacts (grey bars) in order to show the level of employment and income in the directly affected farm sector versus the level of employment and income estimated in linked, supporting sectors.

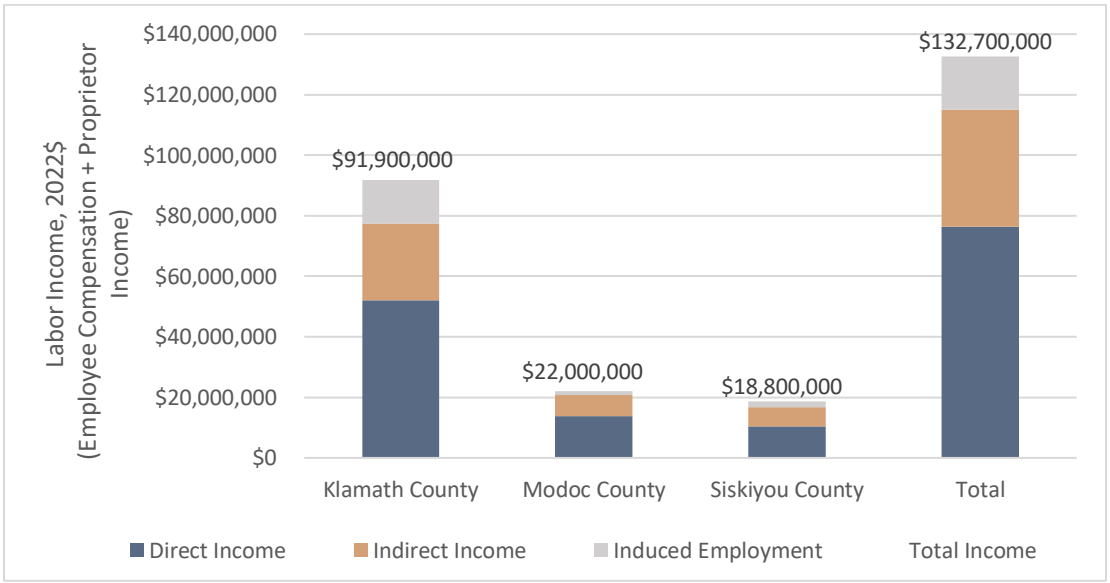
We present results for each of the three counties. As shown in Figure 4-3 and Figure 4-4, total Project crop production is estimated to support approximately 2,670 jobs and $132.7 million in income in the three counties. As highlighted in these figures, approximately 60 percent of these local impacts are the direct, indirect, and induced effects of crop production. As shown in Figure 4-5 and Figure 4-6, we estimate livestock production in Klamath County (which we expect Project and Off-Project irrigation to support completely) to support 720 jobs and $42.8 million in income in Klamath County. Additionally, approximately 10 jobs and $1.0 million in income is supported in Modoc and Siskiyou Counties related to Klamath County livestock production.

Figure 4-3: Employment Supported by Klamath Project Crop Production



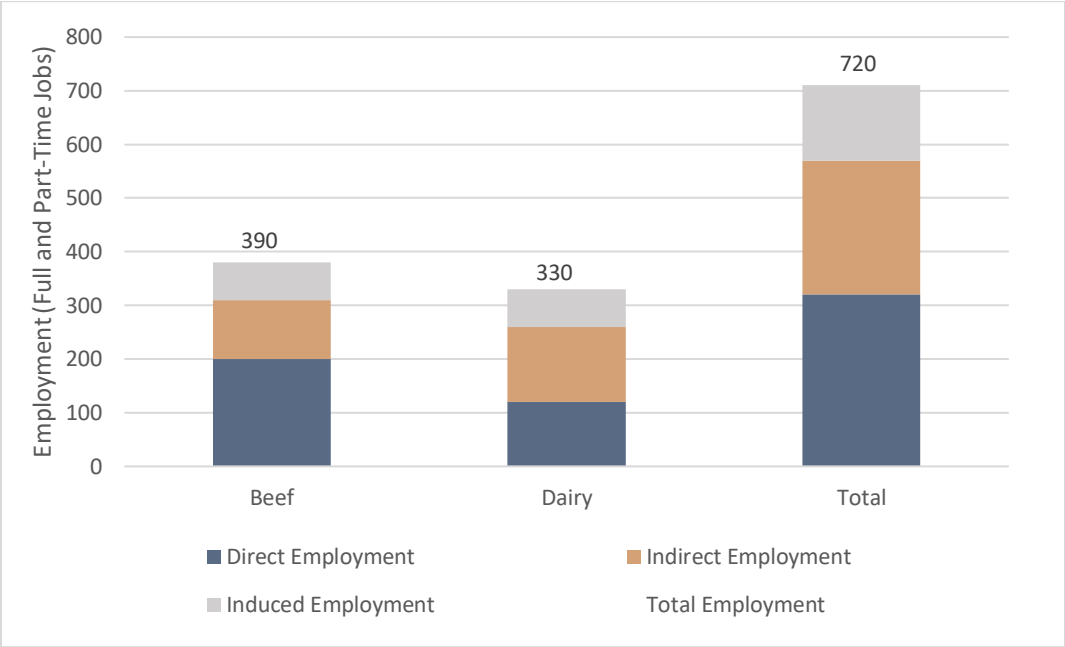
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Figure 4-4: Labor Income Supported by Klamath Project Crop Production



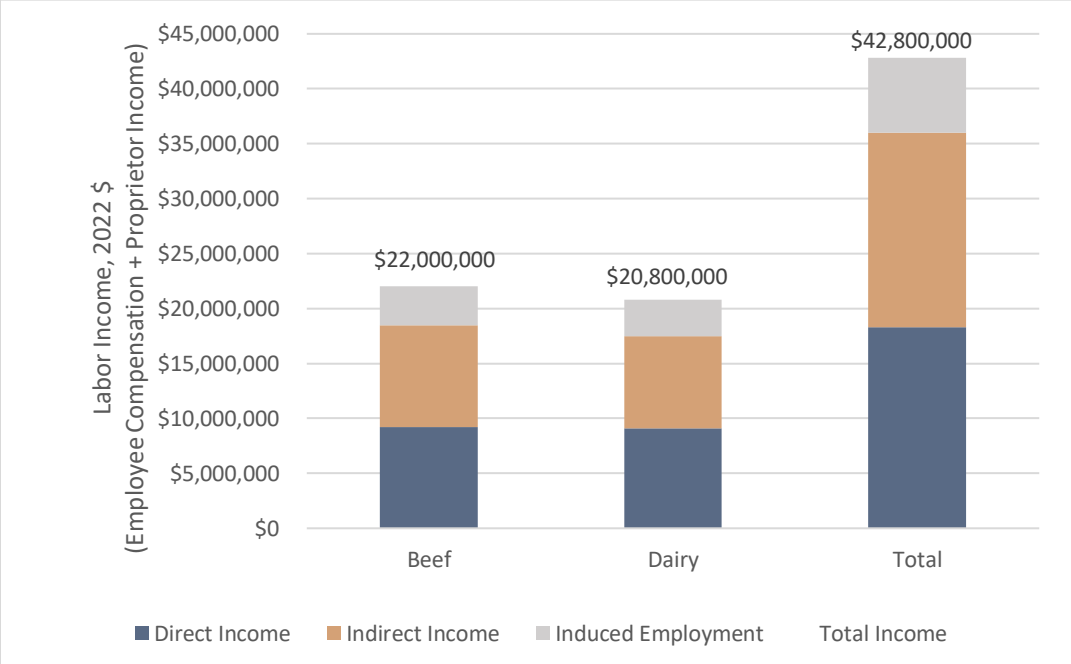
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Figure 4-5: Employment Supported by Klamath County Livestock Production



Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Figure 4-6: Labor Income Supported by Klamath County Livestock Production



Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5 Economic Impacts of Reduced Project Water Supply to Agriculture

This section estimates how reductions in water supply affect farm production value, and then how these reductions in farm income and farm spending ripple through the local economy and affect income and employment in other sectors. Consistent with standard economic impact modeling practices, this analysis estimates the change in total employment and income in the local economy based on the current relationship between agricultural production levels and employment and income. In other words, the analysis models impact by assuming employment and income respond proportionately to a change in farm output. For example, if farm output falls by 10 percent, the level of farm employment/income and spending in other sectors also falls by 10 percent. So if there are 10 jobs for every $1 million of output in a given sector, then a reduction of $100,000 in output would result in 1 job lost. Depending on proprietor management decisions, it may be that productivity per job simply decline with a decline in output, and actual employment does not proportionately decline. As such, the impacts presented in this section represent the estimated reduction in regional income and employment supported by agricultural production as water supplies decline.[8]

5.1 Water Supply Reduction Scenarios

To analyze the effects of reduced water supply, we develop four water supply scenarios. The scenarios modeled range from a 12 percent reduction (Scenario 1) to a 66 percent reduction (Scenario 4) in Klamath Project crop water supply, considering both surface and groundwater resources. The *modeled* water reduction scenarios are summarized in Table 5-1 below. We intend the four scenarios to represent the effects of reducing the surface water available to meet crop ET by 100,000 AF/year (Scenario 1), 225,000 AF/year (Scenario 2), and 350,000 AF/year (Scenario 3). Scenario 4 has the same reduction in surface water available to meet crop ET (350,000 AFY), but groundwater pumping is limited at the basin's sustainable yield. After an *estimated* accounting of how much each district can increase groundwater pumping to offset the reduction in its surface water supply, this translates into an expected reduction across all districts of water available to meet crop ET of 55,000 AF in Scenario 1 (12 percent crop ET reduction), 104,000 AF in Scenario 2 (34 percent crop ET reduction), 210,000 AF in Scenario 3 (47 percent crop ET reduction), and 296,000 AF in Scenario 4 (66 percent crop ET reduction).

[8] Actual changes in regional employment and income may be different. In the short term, employment effects can be 'sticky', in that reduced economic activity does not necessarily translate into reductions in the number of jobs immediately as employers may choose to retain employees in the short-term even with declines in economic activity (although the number of hours of employment or the productivity would decline in this case). Further, in the long-term total income and employment in the region may fall by less than this amount as people directly or indirectly employed in farm-related activities may find alternative income-generating economic activities in the region.

In constructing these scenarios and analyzing the effects of reduced water supplies on agricultural acreage, production values, and economic impacts, we make the following assumptions:

- Recent acreage in full irrigation years reported by Project Districts (which reflects the acreage irrigated with surface water) represents the level of crop ET demand that can be met by surface irrigation in full water years.
- Based on AgriMet station data for Klamath Falls, the cropping pattern for a full water year has an ET requirement of approximately 450,000 AFY.
- When surface water supplies decline, growers in each district in Scenarios 1, 2, and 3 can substitute groundwater up to the limit of each District's pumping capacity (144,000 AFY across all districts as provided through personal communication with KWUA, as shown in Table 5-1). In Scenario 4, the surface water supply reduction is the same as in Scenario 3, but the increased pumping is limited to the USGS estimate of sustainable yield for the Upper Basin: 54,000 AF per year (US Geological Survey, 2016).
- There is no exchange of water across districts during water short years; i.e., the analysis is conducted at the district level (with the exception of 'Other Oregon lands' that are treated as one entity).
- In terms of priority, we always keep Van Brimmer District Company whole with full water allocation; then KID/TID have next priority; then KDD/KBID/Other Oregon lands; and finally, USFWS Refuge (i.e., the refuge only gets water in full water years).

Table 5-1: Summary of Water Supply Scenarios by District, AF/Year in Crop ET

District	Full Water Year Crop Demand	Scenario 1 Water Supply		Scenario 2 Water Supply		Scenario 3 Water Supply		Scenario 4 Water Supply	
		Project Surface Water (AF/Year)	Increased Groundwater Pumping (AF/Year)	Project Surface Water ET (AF/Year)	Increased Groundwater Pumping (AF/Year)	Project Surface Water (AF/Year)	Increased Groundwater Pumping (AF/Year)	Project Surface Water (AF/Year)	Increased Groundwater Pumping (AF/Year)
Tulelake Irrigation District (TID)	134,000	134,000	0	119,400	14,600	49,300	45,000	49,300	17,400
Klamath Irrigation District (KID)	104,700	104,700	0	93,300	11,400	38,500	50,000	38,500	19,300
Klamath Drainage District (KDD)	38,300	20,200	0	0	0	0	0	0	0
Klamath Basin Improvement District (KBID)	21,100	11,100	10,000	0	10,000	0	10,000	0	3,900
USFWS Refuge	10,900	0		0		0		0	0
Van Brimmer District Company	12,200	12,200	0	12,200	0	12,200	0	12,200	0
Other Oregon Lands	128,600	67,800	35,000	0	35,000	0	35,000	0	13,500
Klamath Project Total	**450,000**	**350,000**	**45,000**	**225,000**	**71,000**	**100,000**	**140,000**	**100,000**	**54,000**
Reduction in Water Available for Crop ET	**0**	**55,000**		**154,000**		**210,000**		**296,000**	
% Reduction in Crop Water Supply		**12%**		**34%**		**47%**		**66%**	

Note: Totals may not sum due to rounding.

Sources: Groundwater pumping capacity by district provided by KWUA through personal communication, full water year demand as analyzed by Highland Economics (see Table 2-4 for more detail).

Based on 2011 to 2019 crop and water data (and the relationships in the data on how cropping patterns have responded to changes in water supplies) as well as economic logic, we modeled farmer response to water shortages (through fallowing or deficit irrigation). Farmers in the model first reduce pasture and grain water use, then hay water use, and then finally vegetable/mint water use. Specifically, we assumed farm production value fell based on the following adjustments in crop water use:

1. First: Farmers in each district affected by water shortages will reduce pasture water use by up to 80 percent of pasture ET and reduce grain water use by up to 50 percent of grain ET before reducing water use on other crops. We assume water applications to pasture drop less than applications to grain due to livestock owners' expected reluctance to reduce pasture grazing. Both pasture and grains are impacted simultaneously, with grain impacted more than pasture for a given reduction in water supply.[9] If, for a given scenario, the required ET water reduction for a district is less than 80 percent of grain ET and 50 percent of pasture ET, then no other crops are impacted (and grain and pasture are affected by much less than the 80 percent/50 percent limit). If the required water reduction for a district exceeds 80 percent grain ET and 50 percent pasture ET, then other hay is impacted.
2. Second: Farmers in each district will reduce "other hay" water use, with up to 30 percent reduction in other hay ET.
3. Third: Farmers in each district will reduce alfalfa hay water use, with up to 30 percent reduction in alfalfa ET.
4. Fourth: Farmers will reduce crop ET across all crops by the same percentage reduction[10] until the required reduction is met.

The analysis estimates the effect of changes in water on crop production value by assuming that, whether through fallowing or deficit irrigation, the reduction in crop production value equals the reduction in water available to the crop (i.e., a 10 percent reduction in irrigation water to alfalfa is a 10 percent reduction in alfalfa production value).

5.1 Summary of Economic Impacts by Scenario

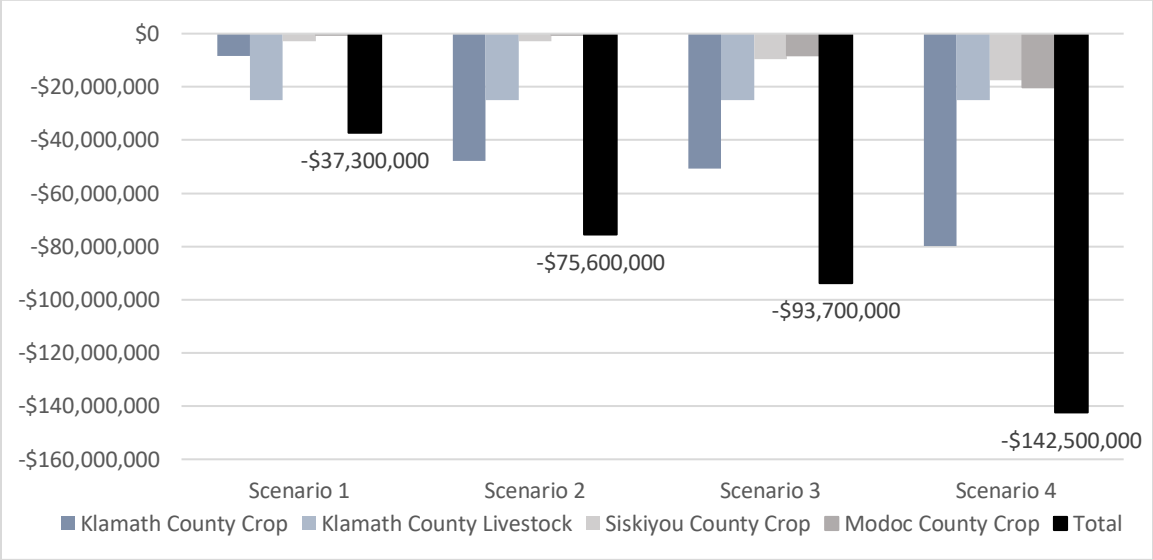
As shown in Figure 5-1, we project annual agricultural sales (livestock and crop farm sales) to decline by $37.3 million in Scenario 1 (12 percent crop water supply reduction) to up to $142.5 million in Scenario 4 (66 percent crop water supply reduction). These values include the estimated annual reduction in Klamath Project crop production values in each county due to the modeled decrease in water supply, plus an estimated $25 million long-term annual change in

[9] For a simple example, if grain ET in a district is 100 AF and pasture ET is 100 AF, then the maximum ET drop would be 80 AF for grain and 50 AF for pasture before other crops are affected. If the reduction in water supply is 65 AF for that district, then grain ET would drop by 40 AF and pasture ET will drop by 25 AF. This represents 50 percent of each crops' maximum ET drop in this first step.

[10] For crops with already reduced ET, we apply the percentage reduction to the crop ET remaining after the preceding steps. For example, if grain ET started at 100 AF and is at 20 AF, and other hay was at 100 and is now at 30 AF, and across all crops there needs to still be a 10 percent water reduction, then grain would be reduced by an additional 2 AF and hay by an additional 3 AF, and so on.

Klamath County livestock production values (primarily Off-Project value) that we include in every water supply reduction scenario. As discussed in Section 5.3, the data indicate that there has been a shift in beef cattle ranching activity in Klamath County in response to long-term (i.e., all water years) reduced availability of water to irrigate forage, particularly in Off-Project areas. While we hold constant the reduction in livestock value in all scenarios, crop production values increasingly decline as water supplies decrease, and higher value crops are increasingly impacted with more severe cuts in Klamath Project crop water supply.

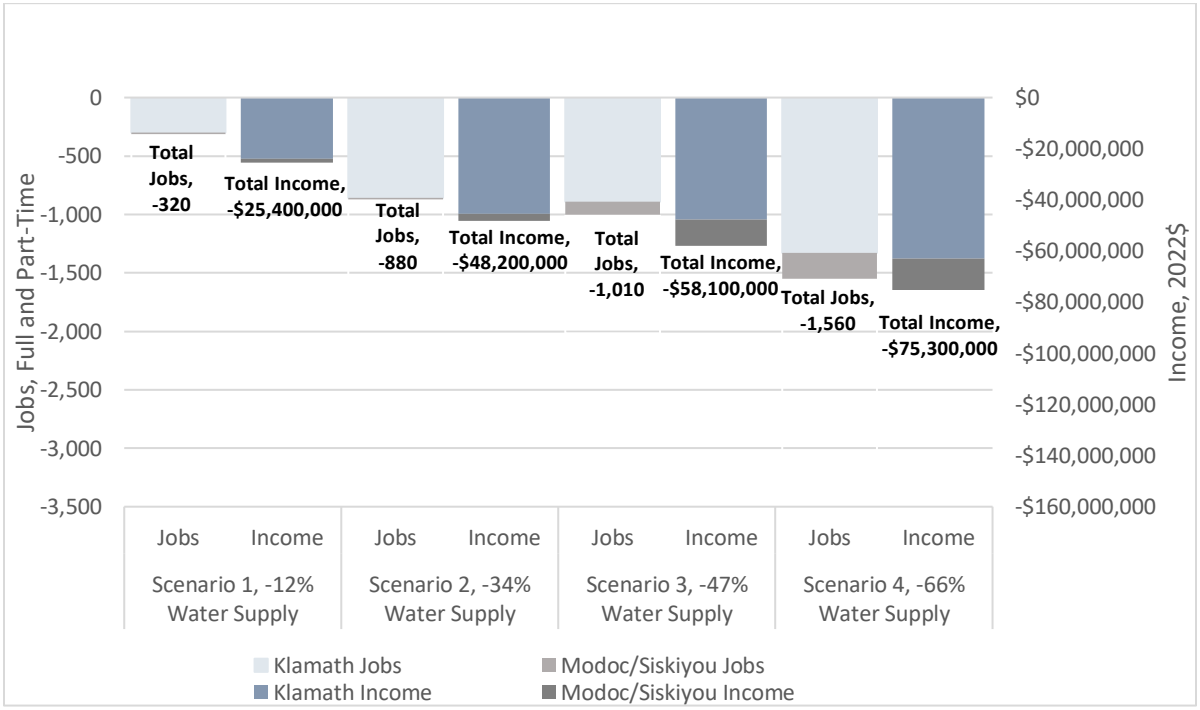
Figure 5-1: Estimated Annual Effects on Crop and Livestock Farm Sales by Water Reduction Scenario (2022$)



Source: Highland Economics analysis

As shown in Figure 5-2 and Figure 5-3, as water supply available to Klamath Project crops falls by 12 percent, impacts are estimated at approximately 330 jobs and $25.7 million in income effects. These impacts rise to 880 jobs and $48.2 million in reduced regional income supported when crop water supply falls by 34 percent. When Klamath Project crop water supply drops by nearly one-half (47 percent), impacts rise to 1,010 jobs and $58.1 million in reduced employment and income supported. Finally, when crop water supply drops by two-thirds (66 percent), then employment supported falls by 1,560 jobs and $75.3 million in income. In every scenario, effects in Klamath County account for over 80 percent of impacts (including both crop and livestock-related effects).

Figure 5-2: Summary of Economic Impacts by Scenario



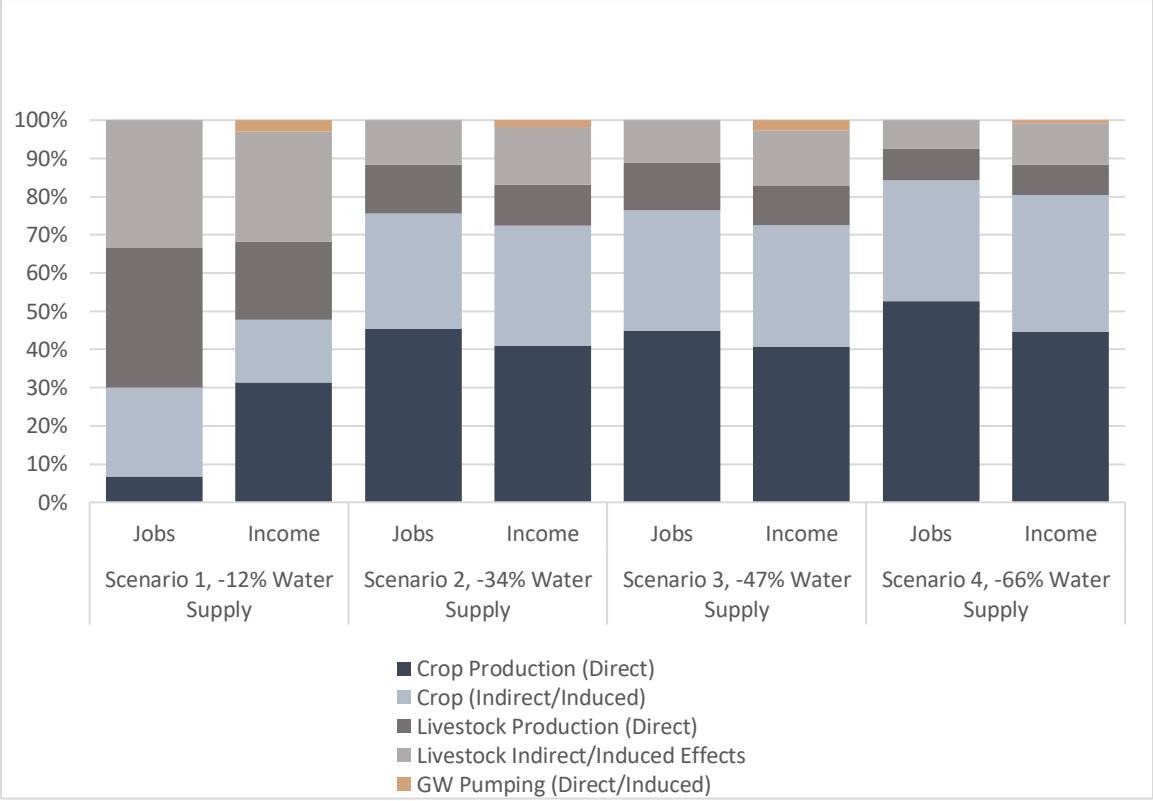
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

Klamath County is where most of the impacts are expected to be experienced since California districts have contracts with higher priority for Project water. Figure 5-3 summarizes the distribution of impacts by source in Klamath County. This analysis quantifies five sources or types of economic impacts:

1. **On-farm direct job and employment impacts of reduced crop production** (fallowing or deficit irrigation), resulting from reduced irrigation water supplies. Crop production values increasingly decline as water supplies decrease, and higher value crops are increasingly impacted.
2. **Indirect and induced job and employment impacts of reduced crop production,** resulting from reduced farm spending on inputs from local businesses and from reduced household spending by affected employees and proprietors.
3. **Direct job and employment impacts of reduced livestock production** due to reduced irrigated forage production, particularly in Off-Project areas of Klamath County**.** We hold this constant in all water reduction scenarios as it reflects a long-term change in availability of water for irrigation of forage, particularly in Off-Project areas.
4. **Indirect and induced job and employment impacts of reduced livestock production,** resulting from reduced farm spending on inputs from local businesses and from reduced household spending by affected employees and proprietors.
5. **Direct and induced job and employment impacts of increased groundwater pumping costs.** Klamath Project irrigators are expected to increase groundwater pumping to reduce the economic effects of reduced surface water supplies; this increased

groundwater pumping reduces farm net income (direct effect) and also reduces the amount of disposable income that farmers can spend in the local economy, thereby affecting income and employment in other sectors as well (induced effect).

Figure 5-3: Klamath County Economic Impacts by Source by Scenario



Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.2 Crop Production Impacts by Scenario

This section describes the estimated change in crop production value for each water reduction scenario.

5.2.1 Scenario 1 Water Reduction

This scenario represents a reduction in surface water supply to crops (in terms of crop ET) of 100,000 AFY (~22 percent reduction in Project surface water), but with an increase in groundwater pumping of 45,000 AFY, the net change is 55,000 AFY or a 12 percent reduction in supply. Under this scenario, we estimate the primary impacted crops to be pasture (24 percent reduction) and grains (33 percent reduction), for a total reduction in value of 5 percent (Table 5-2).

Table 5-2: Reduction in Annual Crop Production Value in Scenario 1 (12% Reduction in Water Supply)

Crop Type	Klamath County	Siskiyou County	Modoc County	3-County Total	% Change from Full Water Year
Pasture	-$1,300,000	-$180,000	$0	-$1,500,000	-24%
Other	$20,000	$50,000	$50,000	$0	0%
Grains	-$7,120,000	-$2,570,000	-$460,000	-$10,800,000	-33%
Hay (Alfalfa and Other Hay)	$30,000	-$30,000	$0	$0	0%
Onions, Garlic, Potatoes	-$50,000	-$30,000	-$50,000	$0	0%
Total	-$8,410,000	-$2,770,000	-$470,000	-$12,300,000	-5%
% Change from Full Water Year	-6%	-6%	-1%	-5%	

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis

This reduction of $12.3 million in grain and pasture production value will affect farm employment and income. Further, as farm-related spending in the local economy declines (on seeds, fertilizer, etc.), other sectors will be affected as well. Assuming that employment and income respond proportionately to this change in farm output[11], then the reduction of $12.3 million in agricultural output value would result in a total reduction of $12.5 million in annual income across all sectors in the three counties and jeopardize approximately 120 jobs (Table 5-3).

[11] Total income and employment in the region may fall by less than this amount as some people directly or indirectly employed in farm-related activities may find other income-generating economic activities, and employers may choose to retain the same number of employees even with declines in economic activity.

Table 5-3: Estimated Economic Impact of Scenario 1 (12% Reduction in Water Supply)

Type of Impact	Employment (Full and Part Time Jobs)	Annual Labor Income (2022 Dollars)
Klamath County		
Direct	-20	-$7,500,000
Indirect	-30	-$2,100,000
Induced	-40	-$1,800,000
Total	-100	-$11,400,000
Modoc County		
Direct	0	$0
Indirect	0	$0
Induced	0	$0
Total	0	$0
Siskiyou County		
Direct	-10	-$400,000
Indirect	0	-$500,000
Induced	0	-$100,000
Total	-10	-$1,000,000
Total, 3-County Area		
Direct	-40	-$7,900,000
Indirect	-50	-$2,600,000
Induced	-40	-$2,000,000
Total	-120	-$12,500,000

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.2.2 Scenario 2 Water Reduction

This scenario represents a reduction in surface water supply to crops (in terms of crop ET) of 225,000 AFY (~34 percent reduction in Project surface water), but with an increase in groundwater pumping of 71,000 AFY, the net change is 154,000 AFY or approximately 34 percent reduction in supply.

Under this scenario, the primary impacted crops are pasture (56 percent reduction), grains (48 percent reduction), and hay (21 percent reduction). Vegetables such as onions, garlic, and potatoes are also affected, with a reduction in 9 percent of value, for a total reduction in value of 19 percent (Table 5-4).

Table 5-4: Reduction in Annual Crop Production Value in Scenario 2 (34% Reduction in Crop Water Supply)

Crop Category	Klamath County	Siskiyou County	Modoc County	3-County Total	% Change from Full Water Year
Pasture	-$3,400,000	-$180,000	$0	-$3,500,000	-56%
Other	$20,000	$50,000	$50,000	$0	0%
Grains	-12,920,000	-$2,570,000	-$460,000	-$15,600,000	-48%
Hay (Alfalfa and Other Hay)	-22,070,000	-$30,000	$0	-$22,000,000	-21%
Onions, Garlic, Potatoes	-$9,550,000	-$30,000	-$50,000	-$9,500,000	-9%
Total	-47,910,000	-$2,770,000	-$470,000	-$50,600,000	-19%
% of Full Water Year Value	-33%	-6%	-1%	-19%	

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis

This reduction of $50.6 million in agricultural production value, nearly all of which is in Klamath County, would affect income and employment in the farm sector and in other, related sectors. Currently, this level of agricultural output supports approximately $33.9 million in local income and 660 jobs, of which $32.8 million in income effects and 650 jobs are in Klamath County (Table 5-5). Thus, when total water supply to Project cropland declines by approximately one-third, this is the level of annual income and employment that is jeopardized.

Table 5-5: Estimated Reduction in Employment and Annual Income Supported in Scenario 2
(34% Reduction in Water Supply)

Type of Impact	Employment (Full and Part Time Jobs)	Annual Labor Income (2022 Dollars)
Klamath County		
Direct	-390	-$18,600,000
Indirect	-150	-$9,100,000
Induced	-110	-$5,200,000
Total	-650	-$32,800,000
Modoc County		
Direct	0	$0
Indirect	0	$0
Induced	0	$0
Total	0	$0
Siskiyou County		
Direct	-10	-$400,000
Indirect	0	-$500,000
Induced	0	-$100,000
Total	-10	-$1,000,000
Total, 3-County Area		
Direct	-400	-$19,000,000
Indirect	-170	-$9,600,000
Induced	-100	-$5,300,000
Total	-670	-$34,000,000

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.2.3 Scenario 3 Water Reduction

This scenario represents a reduction in surface water supply to crops (in terms of crop ET) of 350,000 AFY (~78 percent reduction in Project surface water), but with an increase in groundwater pumping of 140,000 AFY, the net change is 210,000 AFY or an approximate 47 percent reduction in supply.

Under this scenario, the primary impacted crops are pasture (70 percent reduction), grains (86 percent reduction), and hay (25 percent reduction). Vegetables such as onions, garlic, and potatoes are also affected, with a reduction in 9 percent of value (this is the same reduction as in Scenario 2 as increased groundwater pumping prevents further drops in vegetable production). Overall, this reduction of nearly half of crop water supply is estimated to reduce total agricultural production value by approximately 26 percent (Table 5-6).

Table 5-6: Reduction in Annual Crop Production Value in Scenario 3 (47% Reduction in Crop Water Supply)

Crop Category	Klamath County	Siskiyou County	Modoc County	3-County Total	% Change from Full Water Year
Pasture	-$4,100,000	-$180,000	$0	-$4,400,000	-70%
Other	$20,000	$50,000	$50,000	$0	0%
Grains	-$14,860,000	-$8,470,000	-$4,760,000	-$28,200,000	-86%
Hay (Alfalfa and Other Hay)	-$22,170,000	-$1,030,000	-$3,300,000	-$26,600,000	-25%
Onions, Garlic, Potatoes	-$9,550,000	-$30,000	-$50,000	-$9,500,000	-9%
Total	-$50,650,000	-$9,670,000	-$8,070,000	-$68,700,000	-26%
% of Full Water Year Value	-35%	-20%	-12%	-26%	

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis

This reduction of $68.7 million in agricultural production value, of which $50.65 million is in Klamath County, would affect income and employment in the farm sector and in other related sectors. Currently, this level of agricultural output supports approximately $41.3 million in local income and 790 jobs, of which $34.6 million in income effects and 680 jobs are in Klamath County (Table 5-7). Thus, when total water supply to Project cropland declines by approximately one-half, this is the level of annual income and employment that is jeopardized.

Table 5-7: Estimated Reduction in Employment and Income Supported in Scenario 3 (47% Reduction in Water Supply)

Type of Impact	Employment (Full and Part Time Jobs)	Annual Labor Income (2022 Dollars)
Klamath County		
Direct	-400	-$19,400,000
Indirect	-160	-$9,700,000
Induced	-120	-$5,500,000
Total	-680	-$34,600,000
Modoc County		
Direct	-20	-$1,400,000
Indirect	-20	-$1,200,000
Induced	-10	-$100,000
Total	-40	-$2,800,000
Siskiyou County		
Direct	-30	-$1,500,000
Indirect	-30	-$1,800,000
Induced	-10	-$300,000
Total	-60	-$3,800,000
Total, 3-County Area		
Direct	-450	-$22,400,000
Indirect	-220	-$12,800,000
Induced	-120	-$6,000,000
Total	-790	-$41,300,000

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.2.4 Scenario 4 Water Reduction

This scenario represents a reduction in surface water supply to crops (in terms of crop ET) of 350,000 AFY (~78 percent reduction in Project surface water) as in Scenario 3. However, it differs from Scenario 3 in that the increase in groundwater pumping is limited to 54,000 AFY (the level of sustainable yield as estimated by USGS), so the net change in crop water availability is 296,000 AFY or an approximate 66-percent reduction in supply.

Under this scenario, the primary impacted crops are pasture (84 percent reduction), grains (93 percent reduction), and hay (53 percent reduction). Vegetables such as onions, garlic, and potatoes are also affected, with a reduction in 24 percent of value. Overall, this reduction of nearly half of crop water supply is estimated to reduce total agricultural production value by approximately 45 percent (Table 5-8).

Table 5-8: Reduction in Crop Production Value in Scenario 4 (66% Reduction in Crop Water Supply)

Crop Category	Siskiyou County	Modoc County	3-County Total	Klamath County	% Change from Full Water Year
Pasture	-$5,000,000	-$280,000	-$100,000	-$5,300,000	-84%
Other	$20,000	-$50,000	-$450,000	-$500,000	-4%
Grains	-$15,560,000	-$9,370,000	-$5,460,000	-$30,500,000	-93%
Hay (Alfalfa and Other Hay)	-$40,270,000	-$4,830,000	-$10,700,000	-$55,800,000	-53%
Onions, Garlic, Potatoes	-$19,050,000	-$2,930,000	-$3,350,000	-$25,400,000	-24%
Total	-$79,850,000	-$17,470,000	-$20,070,000	-$117,500,000	-45%
% of Full Water Year Value	-55%	-36%	-30%	-45%	

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis

This reduction of $117.5 million in agricultural production value, of which $79.8 million is in Klamath County, would affect income and employment in the farm sector and in other related sectors. Currently, this level of agricultural output supports approximately $64.1 million in local income and 1,340 jobs, of which $50.7 million in income effects and 1,110 jobs are in Klamath County (Table 5-9). Thus, when total water supply to Project cropland declines by approximately one-half, this is the level of annual income and employment that is jeopardized.

Table 5-9: Estimated Reduction in Employment and Income Supported in Scenario 4 (66% Reduction in Water Supply)

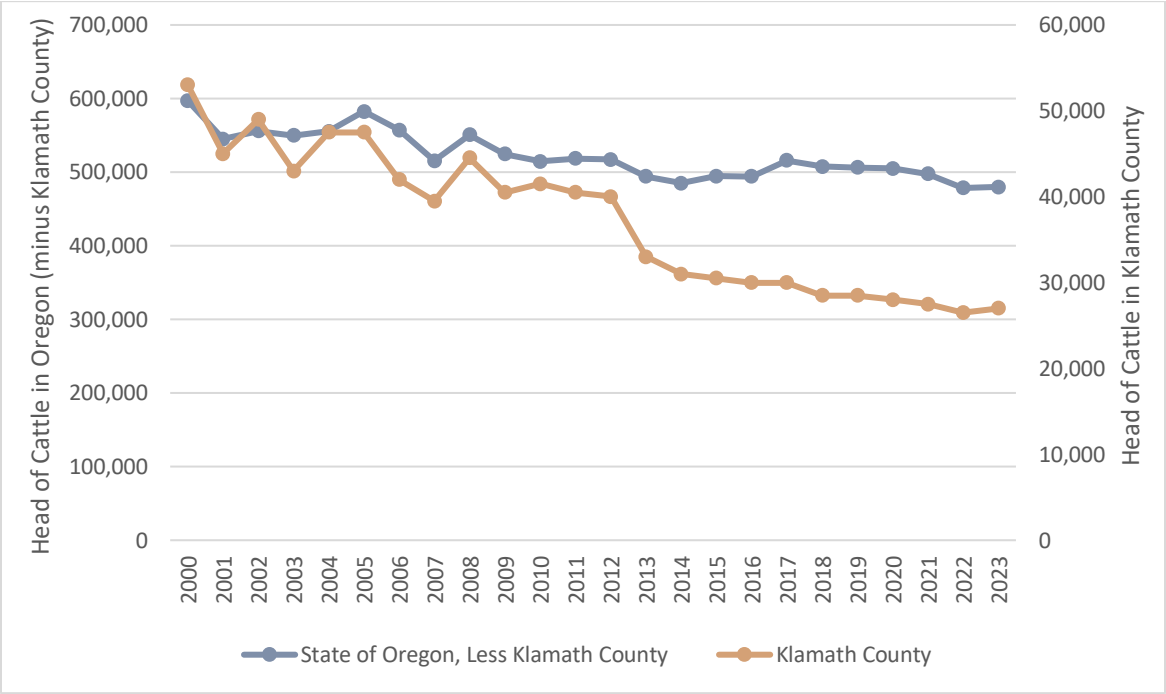
Type of Impact	Employment (Full and Part Time Jobs)	Labor Income (2022 Dollars)
Klamath County		
Direct	-700	-$28,100,000
Indirect	-250	-$14,600,000
Induced	-170	-$8,000,000
Total	-1,110	-$50,700,000
Modoc County		
Direct	-50	-$3,900,000
Indirect	-40	-$2,400,000
Induced	-10	-$400,000
Total	-100	-$6,700,000
Siskiyou County		
Direct	-70	-$3,200,000
Indirect	-40	-$2,700,000
Induced	-10	-$600,000
Total	-120	-$6,700,000
Total, 3-County Area		
Direct	-820	-$35,200,000
Indirect	-340	-$19,800,000
Induced	-190	-$9,100,000
Total	-1,340	-$64,100,000

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.3 Livestock Production Impacts by Scenario

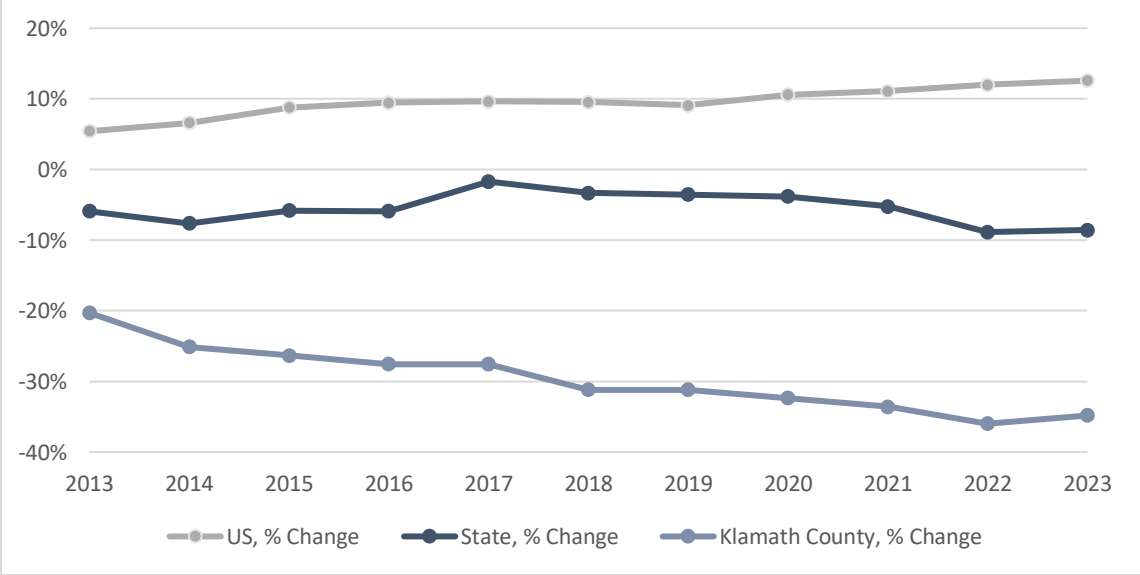
As shown in Figure 5-4 below, the number of beef cows supported in Klamath County has declined over the last 10 to 15 years. As highlighted in Figure **5-5**, in recent years the herd size has averaged 27,000 head of beef cows, which is 34 percent lower than it was in the 2008-to-2012 period (when it averaged approximately 41,400 beef cows). We expect this decline to be in large part due to the reduced water availability for pasture in the county in recent years, particularly for the Off-Project irrigators. In contrast, during the same timeframe, the inventory of beef cattle has increased nationwide and dropped slightly elsewhere in the state. Similarly in Modoc and Siskiyou Counties, the inventory of beef cattle has been steady throughout this timeframe. This comparison to other geographies indicates that it is not general market conditions that have been driving the decline in beef cattle in Klamath County, but rather local conditions, likely related to the reduction in irrigation water supply.

Figure 5-4: Beef Cow Inventory, Klamath County



Source: National Agricultural Statistics Service, 2023

Figure 5-5: Beef Cow Inventory, Klamath County, Percent Change Relative to 2008-2012 Average



Source: National Agricultural Statistics Service, 2023

As discussed in Section 3.2, we estimate the current annual sales of beef cattle in Klamath County (with the current inventory of approximately 27,000 beef cows) at approximatley $46.9 million. If herd size had been maintained at approxmately 41,400, as it was in the period 2008 to 2012, then the value of Klamath County beef cattle production would likely be approximately

$71.9 million, or $25.0 million greater. We model the economic impacts to the region of a $25 million-change in beef cattle production value in Klamath County as the likely effects of changes in Off-Project (and on-Project) reduced irrigated forage production. As the dairy cow inventory in Klamath County has remained steady, or even increased slightly in the last 10 years, we do not model a change in dairy production. As the inventory of beef cows in Siskiyou and Modoc counties has been steady, we do not model a long-term decrease in the beef cattle ranching industry in those counties. However, due to spillover effects from Klamath County beef production on the economy in those counties, there are some adverse effects on the Siskiyou and Modoc county economies from the reduction in beef cattle ranching in Klamath County. In total, the effects are estimated as a reduction of 210 jobs and $12.2 million annual income supported in the three-county area (nearly all in Klamath County, as shown in Table 5-10).

Table 5-10: Estimated Reduction in Employment and Income from Decreases in Long-Term Klamath County Beef Cattle Inventory (Multi-Year Reductions in Water Supplies – All Scenarios)

Type of Impact	Employment (Full and Part Time Jobs)	Labor Income (2022 Dollars)
Klamath County		
Direct	-110	-$4,900,000
Indirect	-60	-$5,000,000
Induced	-40	-$1,900,000
Total	-210	-$11,700,000
Modoc County		
Direct	0	$0
Indirect	0	-$100,000
Induced	0	$0
Total	0	-$200,000
Siskiyou County		
Direct	0	$0
Indirect	0	-$300,000
Induced	0	-$100,000
Total	0	-$300,000
Total, 3-County Area		
Direct	-110	-$4,900,000
Indirect	-60	-$5,300,000
Induced	-40	-$1,900,000
Total	-210	-$12,200,000

Note: Totals may not sum due to rounding.

Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

5.4 Groundwater Pumping by Scenario

As described in Section 5.1, in the four water reduction scenarios, we anticipate that farmers will at least partly offset reduced surface water availability from the Klamath Project by increased groundwater pumping. As provided by KWUA and presented in Table 5-1, the total increase in groundwater pumping varies by scenario. In Scenarios 1 through 3, districts/irrigators in each district are allowed to pump to the current maximum capacity within each district (144,000 AF per year across all Project lands). In Scenario 4, we limit pumping to 54,000 AF per year (37.5 percent of current capacity), as this is the sustainable yield for irrigation pumping in the basin as estimated by USGS (US Geological Survey, 2016). We assume that each district is limited to 37.5 percent of its current pumping capacity.

This analysis focuses solely on the energy costs directly borne by farmers due to increased pumping. Based on data from KWUA on the pumping depth in each district (approximately 60 to 75 feet), electricity costs per kWh for agricultural pumping in Oregon and California, and an estimated pumping efficiency of 60 percent, we estimate an energy cost of approximately $10 to $15 per acre-foot for pumping in all districts except Tulelake Irrigation District. The cost of pumping in Tulelake Irrigation District is estimated at approximately $75 per acre-foot, based on pumping charges published by that district (Tulelake Irrigation District, 2022).

Table 5-11: Energy Cost of Additional Groundwater Pumping (2022$) by Scenario and District

District/Entity	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tulelake Irrigation District (TID)	$0	$1,100,000	$3,400,000	$1,300,000
Klamath Irrigation District (KID)	$0	$100,000	$500,000	$200,000
Klamath Drainage District (KDD)	$0	$0	$0	$0
Klamath Basin Improvement District (KBID)	$100,000	$100,000	$100,000	$0
USFWS Refuge	$0	$0	$0	$0
Van Brimmer District Company	$0	$0	$0	$0
Other Oregon Lands	$500,000	$500,000	$500,000	$200,000
Total	$600,000	$1,800,000	$4,500,000	$1,700,000

Source: Highland Economics analysis

By increasing energy costs to farmers, their overall cost of agricultural production rises, thereby reducing their net income. By spending more on energy, farmers have less available to spend at businesses in their local community. As such, we model the increased energy costs for pumping as a decrease in household income, as the spending on electricity from a major utility is expected to support very little local economic activity. We present the results of this analysis in Table 5-11 and Table 5-12. Tulelake Irrigation District spans all three counties; however, for simplicity we model the effects of changes in groundwater pumping solely in Modoc County. (The acreage in Klamath is a very small portion of the total district acreage, and the 2021 Tule Lake Subbasin Groundwater Sustainability Plan indicates that 85 percent of the agricultural wells in the area are in Modoc County (MBK Engineers, 2021)). We model all other pumping costs as

incurring in Klamath County. Note that in addition to energy costs, farmers would also incur other operations and maintenance costs to pump groundwater.

Table 5-12: Total Economic Impact of Additional Groundwater Pumping by Scenario and District

Geography	Klamath County	Modoc County	3-County Area
Scenario 1			
Income	-$700,000	$0	-$700,000
Employment	Less than -5	0	Less than -5
Scenario 2			
Income	-$800,000	-$1,200,000	-$2,000,000
Employment	Less than -5	Less than -5	-10
Scenario 3			
Income	-$1,300,000	-$3,600,000	-$4,900,000
Employment	Less than -5	Less than -5	-10
Scenario 4			
Income	-$500,000	-$1,400,000	-$1,900,000
Employment	Less than -5	Less than -5	-5

Note: Totals may not sum due to rounding.
Source: Highland Economics analysis using a multi-regional input output model with 2021 IMPLAN software and data.

In addition to increased energy costs, there are other costs of increased groundwater pumping. As groundwater pumping has increased in and around the Klamath Project, groundwater levels have declined (US Geological Survey, 2016). In addition to increasing pumping costs, declining groundwater levels in the Klamath Basin can result in significant other costs. In the last several years, over 200 domestic wells in the basin have run dry (Baumhardt, 2022), resulting in costs to procure emergency water as well as to drill deeper wells. For example, in December of 2021, the State of Oregon allocated $4 million to assist people in Klamath County with the expense of drilling new wells. Further, in June 2022, the State of Oregon allocated $5 million to help Klamath County and residents of other counties with dry wells; this money pays for water tanks and delivery of emergency water to Klamath County residents with empty wells (Baumhardt, 2022). Water insecurity imposes not just these types of financial costs but also emotional costs as people face uncertainty in meeting basic needs. Finally, there are also concerns in the Klamath Basin that groundwater pumping may diminish flow in streams and springs, and harm groundwater-dependent ecosystems (US Geological Survey, 2016).

5.5 Irrigation Reliability & Klamath Basin Agricultural Processing Value

When water shortages reduce crop production, it can also reduce the value of processing activities that rely on the crops. Unreliable irrigation water not only impacts current year crop production but can also induce farmers to avoid growing water-dependent crops in the future.

By reducing the production of some crops, water shortages can reduce the value generated by food processing industries.

In the Upper Klamath Basin, uncertain water supplies seem to have negatively impacted contracted acreage for certain crops such as onions and garlic. Food processing contractors in the area report that a lack reliable water has made growers reluctant to take on contracts for garlic and onions (Dutra, 2023; Lopez, 2023). In water-short years, growers sometimes choose to grow other crops such as wheat, triticale, alfalfa, and potatoes rather than growing garlic and onions (Dutra, 2023).

District acreage data shows mixed trends in onion and garlic acreage in recent years. From 2011 to 2019, Project-irrigated onion acreage grew from about 2,000 acres to nearly 4,000 acres (U.S. Bureau of Reclamation, 2020). However, it is possible that even larger increases would be possible with a more abundant water supply. Over the same time period, Project-irrigated garlic acreage grew from 53 acres to 133 acres but experienced a high of nearly 1,600 acres in 2017, which was the most recent full water year. This provides some evidence that garlic acres could increase by roughly 12 times under a more reliable water supply. If that were the case, garlic value added processing activity could increase in the region. However, if water shortages continue to hamper production in the Klamath Basin, processors may seek to contract acreage in other areas with more reliable water supplies (Lopez, 2023). Processors interviewed for this study were not able to comment on how water shortages may impact facility size, economic activity, or location decisions.

6 TAX REVENUES & WATER AVAILABILITY

This section describes the tax base for the study area. Agricultural activity supports the tax base through increasing property values (which supports property taxes), stimulating the sale of goods (which results in sales taxes in California), and generating income (which results in income taxes). In the study area, governments levy property taxes and sales taxes at the local (city and county) and state level, while states and the federal government collect income taxes. This analysis focuses exclusively on local taxes.

6.1.1 Sales and Use Tax

Sales and use taxes are based on the sale and use of property and goods. The State of Oregon does not have a sales tax and neither does Klamath County. However, counties in California have a minimum sales tax rate of 7.25 percent, of which 6 percent is under the state jurisdiction and 1.25 percent is under local jurisdictions (California Department of Tax and Fee Administration, 2023). Modoc and Siskiyou Counties do not impose an additional sales tax, so the effective sales tax rate is 7.25 percent for both counties. Four cities with Siskiyou County impose their own sales taxes ranging from 0.25 percent to 0.50 percent: Dunsmuir (7.75 percent), Mount Shasta (7.5 percent), Weed (7.5 percent), and Yreka (7.75 percent) (California Department of Tax and Fee Administration, 2023). As Table 6-1 shows, the two California counties generate nearly $18 million in sales and use taxes annually, of which Siskiyou County accounts for nearly 80 percent.[12]

The general level of economic activity determines the amount of sales and use of property and goods, and consequently the level of sales and use taxes. As such, we roughly estimate the total sales and use tax supported by Project crop production based on the proportion of total county economic activity supported by Project crop production. We compare the total economic output in each county (based on the data in the 2021 IMPLAN model) to the total output estimated to be supported in Modoc and Siskiyou Counties by Project production on the total economic activity in each county (output is equal to the total of all production value in all industries and is a measure of overall economic activity). This indicates that all Project-supported economic activity (direct, indirect, and induced) is approximately 12.5 percent of the Modoc County economy and approximately 2.1 percent of the Siskiyou County economy. Assuming that this is the portion of sales and use tax that is supported directly and indirectly by the Project indicates that the Project supports approximately $785,000 annually in sales and use taxes in both counties (Table 6-1). In Scenario 4, the total output supported by Klamath Project in Modoc and Siskiyou counties drops by approximately one-third. As such, for the scenarios modeled, the sales and use taxes could drop by approximately $265,000 annually.

[12] Average values from 2015-2020, adjusted to 2022 dollars using the Gross Domestic Product Implicit Price Deflator.

Table 6-1: California Sales and Use Taxes

Category	Sales Tax Rate [1]	Sales & Use Tax Receipts [2]	Klamath Project-Supported County Output as a % of Total County Economic Output[3]	Approximate Sales & Use Tax Supported by Project Crop Production
Modoc County, CA	7.25%	$3,858,194	12.5%	$300,000
Siskiyou County, CA	7.25%	$14,005,127	2.1%	$485,000
Region Total	N/A	**$17,863,321**	**4.0%**	**$785,000**

1/ These do not include any sales taxes that other local entities (such as cities or transit districts) impose. Source: (California Department of Tax and Fee Administration, 2023)
2/ Average annual value from 2015-2020, adjusted to 2022 dollars using the Gross Domestic Product Implicit Price Deflator prior to averaging. Source: (County of Siskiyou, 2021; County of Modoc, 2020)
3/Output is equal to the total of all production value in all industries and is a measure of overall economic activity. The Klamath Project-supported output is the total (direct, indirect, and induced) output estimated in the IMPLAN model that is supported in Modoc and Siskiyou Counties for the full water year.

6.1.2 Property Tax

Property taxes are based on the assessed value of a property and the rate at which that value is taxed by various districts in the county. Common taxing districts include the county government, roads, cities, schools, hospitals, libraries, ports, fire departments, and parks & recreation. All else equal, irrigated land is more valuable (as discussed in Section 2) than dryland because it has a higher net income generation potential, and thus results in higher property taxes.[13] As such, Project and Off-Project irrigation water supplies increase agricultural land assessed value.

Agricultural land that typically is irrigated but does not receive water in a given year could, in theory, be assessed at a lower rate for that year. In practice in the Upper Klamath Basin, however, county assessors are not able to adjust the assessed values from year-to-year depending on the amount of water received by a given parcel of land (DePaul, 2023; Kenneally, 2023). However, the county assessors have taken some measures to alleviate the tax burden on farmers who face reduced revenues due to water supply shortages. For example, in the last six years, Klamath County has cut the assessed value of agricultural land by 50 percent in order to mitigate the burden on farmers in the Upper Klamath Basin who did not receive surface water (Kenneally, 2023).

The Klamath County Assessor's Office was not able to provide information on the actual change in property taxes (on a per acre or a cumulative basis). However, data from the Oregon Department of Revenue for 2020-2021 provides county-level property tax data. In total, in 2020/2021 there were 591,804 farm acres in Klamath County assessed at $79.736 million, out of total county assessed value of $6.341 billion (Oregon Department of Revenue, 2021). In other words, farmland accounted for 1.3 percent of total assessed value in 2021. Corresponding to the information from the County Assessor's office, farmland from approximately seven years ago was assessed at nearly double this amount (data from 2015-2016 indicates there 601,764 acres

[F]The assessed value of lands qualifying for farm-use special assessment is based on the farm-use value, determined based on the estimated net income (gross annual return minus expenses) potential of the land.

assessed at $139.4 million in Klamath County, with farmland accounting for 2.6 percent of assessed value) (Oregon Department of Revenue, 2016). The average property tax rate for fiscal year 2020 to 2021 in Klamath County is $0.01199 per dollar of assessed value. Applying this average tax rate to the value assessed value in 2020 to 2021 indicates that Klamath County taxpayers paid approximately $960,000 in property taxes on agricultural lands. This is down from the $1.9 million that taxpayers would have paid if the County Assessor's office had not reduced the assessed value by 50 percent due to water supply reductions. In summary, the reduced water supplies to irrigators in Klamath County have resulted in a reduction in county property taxes of approximately $1 million annually (a reduction of 1.3 percent of total county property taxes) in the last six years due to reduced water supplies.

Effects of Klamath Project water supplies on total property taxes in Modoc and Siskiyou Counties would have been proportionately less as the proportion of acres in these counties irrigated with Klamath Project water is much lower (24 percent and 26 percent) compared to nearly all lands in Klamath County being irrigated by Klamath Project or Off-Project water. In Modoc County, the Assessor's Office did not increase the assessed value of agricultural land that constructed groundwater wells (which would typically result in a higher assessment) because the losses from surface water shortages were considered roughly equal to the value of improvements (DePaul, 2023). As such, reduced water supplies resulted in increased costs to the farms in the form of groundwater well investments but did not change the overall property tax payments.

7 REFERENCES

AgriMet. (2015). *Evapotranspiration Totals and Averages*. Retrieved November 2021, from https://www.usbr.gov/pn/agrimet/ETtotals.html

Baumhardt, A. (2022, June 22). *Oregon Capital* . Retrieved from As wells run dry, Oregon residents depend on a state program that trucks in water: https://oregoncapitalchronicle.com/2022/06/30/emergency-board-approves-millions-to-get-water-to-oregonians-with-dry-wells/

Bureau of Reclamation. (2020, April). *Draft Environmental Assessment: Implementation of Klamath Project Operating Procedures 2020-2023.* Retrieved from US Burea of Reclamation: https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=42944

Bureau of Reclamation. (n.d.). *Klamath Project.* Retrieved from Bureau of Reclamation: https://www.usbr.gov/projects/index.php?id=470

California Department of Tax and Fee Administration. (2023, April 1). *California Sales and Use Tax Rates by County and City.* Retrieved from https://www.cdtfa.ca.gov/formspubs/cdtfa95.pdf

California Department of Tax and Fee Administration. (2023). *Detailed Description of the Sales & Use Tax Rate*. Retrieved from https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm

County of Modoc. (2020). *Single Audit Reports, 2013-2020.* Retrieved from https://www.co.modoc.ca.us/departments/financial_reports.php#revize_document_center_rz323

County of Siskiyou. (2021). *Annual Financial Reports, 2016-2021.* Retrieved from https://www.co.siskiyou.ca.us/auditor-controller/page/county-single-audits-and-financial-statements

County of Siskiyou Department of Agriculture. (2020). *Annual Crop & Livestock Reports, 2014-2020.* Retrieved from https://www.co.siskiyou.ca.us/agriculture/page/crop-report

DePaul, K. (2023, May 25). Modoc County Assessor. (W. Oakley, Interviewer)

Dutra, C. (2023, June 15). Olam Crop Supervisor. (W. Oakley, Interviewer)

IMPLAN. (2021). IMPLAN software. Retrieved from https://www.implan.com/

Kenneally, M. (2023, May 22). Chief Appraiser, Klamath County Assessor's Office. (W. Oakley, Interviewer)

Klamath County. (2021). *Annual Financial Reports, 2010-2021.* Retrieved from https://www.klamathcounty.org/Archive.aspx?AMID=41

Lopez, J. (2023, June 12). Spice World. (W. Oakley, Interviewer)

MBK Engineers. (2021, September 17). *Draft Tule Lake Subbasin Groundwater Sustainability Plan.* Retrieved from Tulelake Irrigation District: https://tulelakeid.com/wp-content/uploads/2021/09/CORE-TEAM-Packet-09-21-2021.pdf

Modoc County Department of Agriculture. (2021). *Crop and Livestock Reports, 2016-2021.* Retrieved from https://www.co.modoc.ca.us/departments/agricultural/crop_reports_2.php

MRSC. (2020, July 1). *Local sales tax rates & components – effective July 1, 2020.* Retrieved from Tax and Population Data: https://mrsc.org/Home/Explore-Topics/Finance/Economic-and-Population-Data/Population-Property-and-Sales-Tax-Archive.aspx

National Agricultural Statistics Service. (2017). *2017 Census of Agriculture, Volume 1, Chapter 2 (County Level), Tables 8 and 10.* U.S. Department of Agriculture. Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/

National Agricultural Statistics Service, US Department of Agriculture. (2023). *Price Survey Data from Quick Stats*. Retrieved from Quick Stats: https://quickstats.nass.usda.gov/

National Oceanic and Atmospheric Administration. (2020). *U.S. Climate Normals Quick Access*. Retrieved from https://www.ncei.noaa.gov/access/us-climate-normals/

Oregon Department of Revenue. (2016). *Oregon Property Tax Statistics: Fiscal Year 2015-16, 150-303-405 (Rev. 8-16).* Salem, OR: Oregon Department of Revenue. Retrieved from https://www.oregon.gov/DOR/programs/gov-research/Documents/publication-or-pts_303-405_2015-16.pdf

Oregon Department of Revenue. (2021). *Oregon Property Tax Statistics: Fiscal Year 2020-21, 150-303-405 (Rev. 4-21).* Salem, OR: Oregon Department of Revenue. Retrieved from https://www.oregon.gov/dor/programs/gov-research/Documents/Property-tax-report-2020-21.pdf

Tulelake Irrigation District. (2021). *2021 Crop Report.*

Tulelake Irrigation District. (2022, April). *TID-Well-Irrigated-Acres-Program-and-Charges-2022-Adopted-4-27-2022.* Retrieved from Tulelake Irrigation District: https://tulelakeid.com/wp-content/uploads/2022/04/TID-Well-Irrigated-Acres-Program-and-Charges-2022-Adopted-4-27-2022.pdf

U.S. Bureau of Economic Analysis. (2021). National Income and Product Accounts - Table 6.4D. Full-Time and Part-Time Employees by Industry.

U.S. Bureau of Economic Analysis. (2021). Total Full-Time and Part-Time Employment and Income by NAICS Industry (CAEMP25N, CAINC5N, SAINC5N, & SAEMP25N).

U.S. Bureau of Labor Statistics. (2022). Quartery Census of Employment and Wages. Retrieved from https://www.bls.gov/cew/downloadable-data-files.htm

U.S. Bureau of Reclamation. (2019). *Klamath Project Crop Reports, 2015-2019.*

U.S. Bureau of Reclamation. (2020). *Crop Reports, Klamath Project, Oregon-California, 2011-2020.*

U.S. Census Bureau. (2021). 2021 American Community Survey 5-year estimates: Table S1901. Retrieved from data.census.gov

US Bureau of Reclamation. (2016, December). *Klamath River Basin Study Summary Report.* Retrieved from US Bureau of Reclamation: https://www.usbr.gov/watersmart/bsp/docs/klamath/summaryreport.pdf

US Bureau of Reclamation, KLamath River Basin Study Technical Working Group. (2016, March). *Klamath River Basin Study: Technical Memorandum 86-68210-2016-06.* Retrieved from https://www.usbr.gov/watersmart/bsp/docs/klamath/fullreport.pdf

US Department of Agriculture. (2021). *Compilation of Statistical Material Pacific Northwest Federal Milk Marketing Order.* Seattle: USDA Agricultural Marketing Service.

US Geological Survey. (2016, December 21). *US Geological Survey*. Retrieved from Upper Klamath Basin Groundwater Study: https://or.water.usgs.gov/projs_dir/or180/background.html

US Geological Survey. (2016, December 21). *US Geological Survey*. Retrieved from Upper Klamath Basin Regional Groundwater Studie: https://or.water.usgs.gov/projs_dir/or180/

US Geological Survey. (2016, December 20). *USGS Oregon Water Science Center*. Retrieved from Hydrological Information to Support the Off-Project Water PRogram of the Klamath Basin Restoration Agreement: https://or.water.usgs.gov/proj/Klamath_off_project/

USDA NASS. (2019). *2017 Census of Agriculture, Oregon State and County Data, Volume 1, Geographic Area Series, Part 47.* USDA. Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Oregon/

APPENDIX A: AGRICULTURAL DATA

The key data for the economic analysis of agricultural production are provided below.

A.1 FARM LEVEL EMPLOYMENT AND INCOME

In the table below, and others that follow, data for some counties is suppressed (indicated by an 'S' in the table); so for regional totals including such counties, we include a '+' after the estimate to indicate that the sum of the available data is the minimum, and that the actual value may be higher due to suppressed values.

Table A-1: Wage and Salary Employment in Farming Industries, 2022

Industry	Klamath	Siskiyou	Modoc	Three County Area
Total, all industries (private/non-governmental)	18,823	1,603	9,952	30,378
NAICS 11 Agriculture, forestry, fishing, and hunting	956	352	S	*1,308+*
NAICS 111 Crop production	**540**	**170**	**602**	***1,312***
NAICS 1111 Oilseed and grain farming	S	S	S	*0+*
NAICS 1112 Vegetable and melon farming	230	S	38	*268+*
NAICS 1113 Fruit and tree nut farming	35	S	S	*35+*
NAICS 1114 Greenhouse and nursery production	S	S	S	*0+*
NAICS 1119 Other crop farming	195	S	130	*325+*
NAICS 112 Animal production and aquaculture	**168**	**S**	**74**	***242+***
NAICS 1121 Cattle ranching and farming	159	51	71	*281*
NAICS 11211 Beef cattle ranching, farming, and feedlots	59	51	S	*110+*
NAICS 11212 Dairy cattle and milk production	100	S	S	*100+*
NAICS 1129 Other animal production	S	S	S	*0+*
Total Farm Proprietor Employment, All Sectors	**944**	**310**	**668**	***1,922***
TOTAL FARM EMPLOYMENT	**1,652**	**480+**	**1,344**	**3,234+**

Note: "S" indicates the value was suppressed in the original dataset to protect the identity (or identifiable information) of cooperating employers, or to protect sensitive information from another industry or area.
Sources: (U.S. Bureau of Labor Statistics, 2022) *and* (U.S. Bureau of Economic Analysis, 2021). *Proprietor employment was from 2021 since 2022 data was unavailable.*

Table A-2: Employment in Agricultural Support and Processing Industries, 2022

Industry	Klamath	Siskiyou	Modoc	Three County Total
Total, all industries (private/non-governmental)	18,823	1,603	9,952	30,378
NAICS 115 Support activities for agriculture and forestry	171	115	211	497
NAICS 1151 Support activities for crop production	69	113	S	182+
NAICS 11511 Support activities for crop production	69	113	S	182+
NAICS 311 Food manufacturing	165	S	14	179+
NAICS 3111 Animal food manufacturing	S			0+
NAICS 31111 Animal food manufacturing	S			0+
NAICS 3114 Fruit and vegetable preserving and specialty	S		S	0+
NAICS 311421 Fruit and vegetable canning			S	0+
NAICS 42382 Farm and garden mach. and equip. merch. wholesalers	99		S	99+
NAICS 4244 Grocery and related product wholesalers		15		15
NAICS 42448 Fresh fruit and vegetable merchant wholesalers	S		S	0+
NAICS 4245 Farm product raw material merchant wholesalers	S	S	S	0+
NAICS 42451 Grain and field bean merchant wholesalers	S		S	0+
NAICS 42491 Farm supplies merchant wholesalers	S	S	14	14+
NAICS 44523 Fruit and vegetable retailers			S	0+

Note: "S" indicates the value was suppressed in the original dataset to protect the identity (or identifiable information) of cooperating employers, or to protect sensitive information from another industry or area.
Source: (U.S. Bureau of Labor Statistics, 2022)

Table A-3: Wages in Support and Processing Industries, 2022 (in millions)

Industry	Klamath	Siskiyou	Modoc	Three County Total
Total, all industries (private/non-governmental)	$860.5	$69.5	$456.9	$1,386.9
NAICS 115 Support activities for agriculture and forestry	$9.3	$5.5	$12.6	$27.4
NAICS 1151 Support activities for crop production	$2.5	$5.4	S	$7.9+
NAICS 11511 Support activities for crop production	$2.5	$5.4	S	$7.9+
NAICS 311 Food manufacturing	$6.5	S	$0.3	$6.8+
NAICS 3111 Animal food manufacturing	S			$0+
NAICS 31111 Animal food manufacturing	S			$0+
NAICS 3114 Fruit and vegetable preserving and specialty	S		S	$0+
NAICS 311421 Fruit and vegetable canning			S	$0+
NAICS 42382 Farm and garden mach. and equip. merch. wholesalers	$6.3		S	$6.3+
NAICS 4244 Grocery and related product wholesalers		$0.7		$0.7+
NAICS 42448 Fresh fruit and vegetable merchant wholesalers	S		S	$0+
NAICS 4245 Farm product raw material merchant wholesalers	S	S	S	$0+
NAICS 42451 Grain and field bean merchant wholesalers	S		S	$0+
NAICS 42491 Farm supplies merchant wholesalers	S	S	$0.6	$0.6+
NAICS 44523 Fruit and vegetable retailers			S	$0+

Note: "S" indicates that the Bureau of Labor Statistics suppressed a value in the original dataset to protect the identity (or identifiable information) of cooperating employers, or to protect sensitive information from another industry or area. We adjusted all values to 2021 dollars using the Consumer Price Index.
Source: (U.S. Bureau of Labor Statistics, 2022)

A.2 Crop Price and Yield Data

For crop yields, we used data provided by the irrigation districts to the Bureau of Reclamation (U.S. Bureau of Reclamation, 2020). This data was available from 2011 to 2019 and was split between Project acres in California and Oregon. To model the expected yields per acre for each crop modeled, we took the five-year average by state (as summarized in the table below). We applied the respective average to the acreage in each district (or district sector) based on the state in which it is located.

Table A-4: Modeled Yields per Acre by Crop and State

Crop	Unit	California 5-year Average	Oregon 5-year Average
Alfalfa Hay	ton	6.5	5.7
Barley	bu	109.6	99.1
Irrigated Pasture	aum	5.0	4.6
Oats	bu	147.2	134.3
Onions	cwt	451.2	415.6
Other Hay	ton	4.7	3.9
Mint	lbs	88.0	79.9
Potatoes, Chip	cwt	480.0	435.1
Potatoes, Fresh	cwt	477.6	443.8
Strawberry Rootstalk	plnt	310,000.0	325,000.0
Wheat	bu	112.2	101.7

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2020)

For data on the price received per unit of crop, we used the Agricultural Commissioners' reports from Siskiyou and Modoc Counties. For each crop, we averaged the prices between the two counties for each year from 2012 to 2021 (where data was available). Due to a variety of factors, crop prices have increased substantially in recent years, and it is important to account for these increases in the total value of the region's agriculture. For that reason, where data was available, we estimated the local prices of crops in 2022 using the historic relationship between local prices and national prices.[14] We then incorporated this estimated 2022 price into the five-year average price, which we used to estimate the revenue generated by each crop.[15] We

[14] Specifically, we calculated the average ratio of county prices (the average of Siskiyou and Modoc Counties in the Agricultural Commissioners' reports) to national prices from 2017-2021, and then multiplied this average ratio by the national price in 2022 to estimate the local price in 2022.

[15] We used the most recent five years of available data for each crop. Missing data resulted in adjustments to the method in some cases. There were no 2022 data available for fresh market and processing potatoes, and the Agricultural Commissioner reports grouped all potatoes together. For those reasons, we used the average national price for fresh market and processing potatoes from 2017 to 2021.

adjusted all prices for inflation to 2022 dollars prior to averaging. The prices used in the analysis are summarized in the table below.

Table A-5: Modeled Prices Received by Crop

Crop	Unit	Price Received (2022$)
Alfalfa Hay	ton	$237.30
Barley	ton	$217.73
Dry Onions	cwt	$11.01
Garlic	cwt	$24.89
Irrigated Pasture	AUM	$31.16
Mint	lbs	$24.21
Oats	ton	$237.27
Other Hay	ton	$305.31
Potatoes, Chip	cwt	$9.15
Potatoes, Fresh	cwt	$14.13
Strawberry Plants	count	$0.16
Wheat	ton	$245.49

Sources: Highland Economics analysis of (Modoc County Department of Agriculture, 2021; County of Siskiyou Department of Agriculture, 2020; National Agricultural Statistics Service, US Department of Agriculture, 2023)

Combining the yield and price data from the tables above provides a value of gross revenue per acre by crop and state. We applied these values to the acres in each district (or district sector) based on the state in which they are located.

Combining the yield and price data from the tables above provides a value of gross revenue per acre by crop and state (summarized in Table A-6). We applied these values to the acres in each district (or district sector) based on the state in which they are located. The total revenue by crop type is shown below.

Table A-6: Modeled Per-Acre Revenue by Crop and State in Full Water Year

Crop	Revenue per Acre	
	CA	OR
Alfalfa Hay	$1,542	$1,357
Barley	$573	$518
Dry Onions	$4,969	$4,576
Garlic	$3,484	$3,235
Irrigated Pasture	$156	$142
Mint	$2,130	$1,934
Oats	$559	$510
Other Hay	$1,420	$1,205
Potatoes, Chip	$4,394	$3,983
Potatoes, Fresh	$6,749	$6,270
Strawberry Rootstalks	$49,290	$51,675
Wheat	$826	$749

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019)

A.3 Irrigated Acreage Data

Irrigation districts supported by the Klamath Project are required to report the acreage by crop each year to the U.S. Bureau of Reclamation. This data was available to us in two forms: 1) District-level data from 2015 to 2020, and 2) State-level data from 2011 to 2019. These data aligned very closely, with differences in total acreage that amounted to less than one-half of one percent in years where data overlapped. Total irrigated land from 2011 to 2021 varied from a low of 157,403 acres in 2015 to a high of 193,562 acres in 2012. Our analysis primarily relied upon the district-level crop reports, which varied from a low of 157,402 acres in 2015 to a high of 190,293 acres in 2019. These reports include acreages associated with 34 different crops.

Our analysis relied on modeling a "full water" year for the Project acreage, or the acreages by crop that would be expected when all districts received a full supply of surface water. We chose to use 2017 as the primary model for a full water year since it was the most recent year with a full water supply. Accordingly, our full water year crop mix consists primarily of the crop acreages by district in 2017. However, some high-value crops (including potatoes, lettuce, and onions) were more prevalent in 2019 than 2017, while others declined (including garlic and seed vegetables). To reflect these more recent changes, our full crop year incorporated 2019 acreages for potatoes, lettuce, onions, garlic, and seed vegetables.[16] The total acreage for the full water year model is 193,450 acres (see Table A-7 below), which is slightly less the observed maximum acreage in the available data (193,562 acres in 2012). While the original data contained 34 crops, only 24 crops had acreages greater than zero our full water year model.

Our full water year model estimates the revenue generated from 193,450 irrigated acres in the Project area. Due to limited data on prices and yields, it was not possible to estimate the per-acre value for all crops using their crop-specific price and yield. For this reason, our analysis

[16] The specific crop categories included "Other Seed (Garlic/ Carrots)", "Other Vegetables (Garlic, Turnips or Garbanzo Beans)", and "Potato Seed".

grouped some crop acreages under other "model" crops to estimate the revenue generated by their associated production. The substitutions are shown in the second column in Table A-8 below. Overall, these "substitute" acres represented about 1.8 percent of the total irrigated acres. The modeled full water year acreage by crop and state is shown in Table A-7 below.

Table A-7: Modeled Acreage by Crop and State in Full Water Year

Crop	Acres		
	CA	OR	Total
Alfalfa Hay	22,305	42,332	64,636
Barley	15,346	12,602	27,948
Dry Onions	2,781	1,208	3,989
Garlic	133	210	343
Irrigated Pasture	2,435	41,600	44,035
Mint	2,209	63	2,272
Oats	149	1,596	1,745
Other Hay	2,630	8,816	11,446
Potatoes, Chip	3,832	7,054	10,886
Potatoes, Fresh	3,699	2,527	6,226
Strawberry Rootstalks	0	125	125
Wheat	8,471	11,329	19,800
Total	**63,989**	**129,461**	**193,450**

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019)

Table A-8: Modeled Crop Acreage in Full Water Year

Crop Name	Modeled Crop	Acres
Alfalfa Hay	Alfalfa Hay	64,636
Apples	Potatoes, Fresh	2
Barley (Feed)	Barley	16,855
Barley (Malt)	Barley	8,540
Carrots	Dry Onions	31
Potatoes, Chip	Potatoes, Chip	10,876
Flax	Barley	20
Potatoes, Fresh	Potatoes, Fresh	5,544
Irrigated Pasture	Irrigated Pasture	44,035
Lettuce	Potatoes, Fresh	680
Multi-Cropped Acres	Barley	116
Oats	Oats	1,745
Dry Onions	Dry Onions	3,958
Other Cereals	Barley	1,649
Other Field Crops (Horseradish, LVID Industrial Hemp)	Barley	450
Other Forage (Peas, Triticale, Or Corn)	Barley	132
Other Hay	Other Hay	11,293
Other Vegetables (Garlic, Turnips or Garbanzo Beans)	Garlic	343
Pea Seed	Barley	186
Pepper- Mint	Mint	2,272
Silage / Ensilage	Other hay	153
Strawberry Rootstalks	Strawberry Plants	125
Wheat	Wheat	19,800
Wine Grapes	Potatoes, Chip	10
Total		*193,450*

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019)

To estimate the production value from Project-supported crops under a full water year, our analysis started with the 2017 acreage data provided by the irrigation districts to the Bureau of Reclamation. We used 2017 acreage data since it was the most recent year with a full water supply and data available. To incorporate more recent trends in high-value crops, the acreage for potatoes, onions, lettuce, garlic, and seed vegetables were taken from the 2019 crop year.

Due to limited data on prices and yields, it was not possible to estimate the per-acre value for all crops using their crop-specific price and yield. For this reason, our analysis grouped some crop acreages under other "model" crops in order to estimate the revenue generated by their associated production. The substitutions are shown in Table A-8 of the Appendix. Overall, these "substitute" acres represented about 1.8 percent of the total irrigated acres. In cases where similar crops have a lower production value per acre than the actual crop, it would lead to an underestimate of Klamath Project impacts; in cases where the production value was higher, it would lead to an overestimate of Klamath Project impacts. However, we took care to assign the most relevant substitute crops based on available price and yield data, and we consider the

resulting overall estimated production value a good approximation for the actual value produced on Klamath Project-irrigated agricultural lands. The modeled crop acreage in a full water year is shown in Table A-9 below.

Table A-9: Modeled Acreage by Crop and County in Full Water Year

Crop	Acres			
	Klamath	Siskiyou	Modoc	Total
Alfalfa Hay	42,332	7,809	14,495	64,636
Barley	12,602	10,979	4,367	27,948
Dry Onions	1,208	546	2,235	3,989
Garlic	210	0	133	343
Irr. Pasture	41,600	1,779	656	44,035
Mint	63	212	1,997	2,272
Oats	1,596	149	0	1,745
Other Hay	8,816	133	2,497	11,446
Potatoes, Chip	7,054	2,183	1,649	10,886
Potatoes, Fresh	2,527	2,064	1,635	6,226
Strawberry Rootstalks	125	0	0	125
Wheat	11,329	4,359	4,112	19,800
Total	129,461	30,212	33,777	193,450

Source: Highland Economics analysis of (U.S. Bureau of Reclamation, 2019)