Public Action and Government Reaction to state-wide Water Crises:

A Comparison of Punjab and California

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List of Abbreviations

Abbreviation	Definition
BCM	Billion Cubic Meter
CDWR	California Department of Water Resources
CVP	Central Valley Project
GEC	Groundwater Estimation Committee
GSA	Groundwater Sustainability Act
GSP	Groundwater Sustainability Plan
HYV	Hybrid Yielding Variety
MSP	Minimum support price
SAPCC	State Action Plan on Climate change
SGMA	Sustainable Groundwater Management Act
USDA	United States Department of Agriculture

Water Crises, Public Action and Government Reaction

Executive summary

The states of Punjab and California have different histories, culture and politics, yet are both relied upon for their agricultural provisions. The output from these states are essential to meeting the food demands in their respective state, but also in national and international markets. While the intensification of agriculture in each state was driven by different motives, they both resulted in mechanization that surpassed the rest of the country and a large portion of population that depends on the agricultural economy. Over the past two decades, the people working in this industry have been severely challenged by climate change. Rising temperatures and shorter, more intense precipitation periods have made it difficult for farmers in these states to meet harvest quotas. The overuse of water and other inputs for agricultural production, paired with changing temperature and precipitation patterns, are the root causes for the ongoing water crises in each state. The hardships that small farm workers endure as a result of this have spurred many recent public efforts to push the government to adapt their water policies to account for these climatic changes.

This paper details each state's physical and historical context that situates it in its current water crisis. Since past decisions continue to influence production today, the state's geography and history of governance are important for understanding the current complex farming struggles. Following the description of each state is a detailed comparison of how their agricultural industries differ from one another. The colonial history, labour supply, and availability of subsidies are found to set these two states apart. Meanwhile, similarities between overuse of input, water-intensive crops and poorly managed water rights are revealed as common problems that farmers face in both states.

Next, water availability is reviewed by identifying the worsening effects of climate change in Punjab and in California. Shrinking snowpack, rising temperatures, irregular rainfall and drought are found to be shared realities that the states must adapt to. Significant funding is needed in both states to be able to transition to sustainable agriculture.

While many articles have compared Punjab and California's agricultural crises before, none have explored how public intervention has played a part in affecting government policy. This paper therefore aims to analyze the efforts taken, namely protests and lawsuits, to gain political attention and to fight this pressing issue. In California, farmers who have been denied access to water often take matters up in court. In Punjab, farmers assembled to create the largest protest known to human history. Their success in eliminating three farm laws that would be detrimental to the livelihood of small-scale farms took over a year and may not keep them protected for very long as mega farms infiltrate the export industry. Government reaction to the public's demands is then studied by identifying any shifts in water rights, harmful subsidies and other related policy. By doing so, the differences and complementarities between each population's approach is analyzed to reveal which public action methods are most effective. Small protests that do not impose any consequences are found to be ineffective. In California, court cases can end in farmers' favour, but tend to take long periods of time. In all scenarios, media coverage that draws attention to the issue at stake is beneficial for influencing government decisions.

Physical and Historical Context of Punjab and California

To better understand the decisions and difficulties taking place in either state, their physical landscapes and agricultural histories must be laid out. This section provides the necessary context for analyzing their current situations and possible future scenarios.

Punjab

Geography of Punjab

Punjab is a state located in North Western India, bounded by Pakistan on the West, the states of Jammu & Kashmir on the North, Himachal Pradesh on the East and Haryana and Rajasthan on the South. The word Punjab combines the Persian words *punj* and *ābthat* meaning *five* and *water*. Together, Punjab translates to Land of Five Rivers (Neelima et al., 2014). The five rivers are the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum. These five tributaries of the Indus river are now divided between India and Pakistan, a result of the British annexation of greater Punjab. The Indus water treaty, signed in 1960, left Pakistan with Chenab and Jhelum, which accounts for roughly 80% of the water inflow, and India with Sutlej, Beas and Ravi (Kumar et al, 2018). Many towns are located along these three rivers. Dams, such as the 168 km^2 Bhakra dam, have been built nearby to facilitate irrigation needs in the farmlands (Neelima et al., 2014). The state's surface water is not limited to rivers; between the Sutlej and Beas rivers many lakes and ponds created by abandoned river channels can also be found.

As seen in Figure 1, Punjab is divided into three regions: Malwa, Majha and Doaba. The two biggest regions, Malwa and Doaba, lay on fertile soil formed of alluvium deposited by the Indus river system. These alluvial soils account for 90 % of the state area. The agricultural opportunities provided by the soil in these regions are reflected in the population distribution, in which more than half of the population practises an agrarian lifestyle (Neelima et al., 2014). In

2018-2019, the GDP produced by the agricultural sector accounted for 25% of the states' GDP (Punjab Budget Analysis, 2021).

The terrain in this Northern state is not entirely flat; the Sivalik hills can be found towards the North and North East, bordering the Himalayan mountains (Neelima et al., 2014). Elevated areas are important to the hydrological cycle as they affect the availability of water during spring and summer months[1]. More than half of the annual stream inflow into the Sutlej river, the largest river in Punjab, is made up of snowmelt from the Himalayan mountains. Glacier melt is also a significant surface and groundwater source. In the Bhakra river and accordingly in the Bhakra dam 60% of the inflow comes from glacier melts (Neelima et al., 2014).

The state's annual average temperature range is from -2 to 40 °C (min/max) (Neelima et al., 2014). The hottest season is from April to June, when temperatures can reach a high of 47°C. The monsoon period starts in July and lasts until September. Winds from the Bay of Bengal cause these intense precipitation periods. The average rainfall is around 480 mm except in sub-mountainous regions where it averages 960 mm. During these months, Punjab receives 70% of its annual rainfall. These rains can cause flooding, soil erosion and waterlogging[2].

Most of Punjab is underlain by groundwater deposits that connect through channels (Kumar et al, 2018). Groundwater in most parts of the state range between 5 to 20 meters below ground level, except in the southwestern parts where it lays less than 5 metres below ground level. The state's 12 natural wetlands and 9 man-made wetlands help manage the land during monsoon period and are important to biodiversity protection[3] (Neelima et al., 2014).

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[1] Snow accumulated on mountain tops eventually melts and trickles down, feeding into the river the system

[2] Moonsoon winds arise when hot over land rises, causing prevailing winds to reverse direction and flow from the ocean towards the land.

[3] Waterlogging is the saturation of soil with water, usually causing anaerobic conditions.

[4] Wetlands regulate water flow by storing large amount surface water to accumulate during high precipitation periods, reducing the chances of flooding.

History of Punjab

The land of five rivers was an agriculturally focussed region long before the arrival of the British colonies and the Green Revolution in the 20th century. Traditional farming practises relied upon rivers, lakes, ponds, and rain as their water sources. Farmlands were filled with indigenous crops, namely maize, barley, pulses, groundnut, millet and sorghum (Neelima et al., 2014). These crops do not require highly intensive inputs since they are naturally suited to existing climatic and soil conditions. The annexation of Punjab by the East India Company in 1849 year and later by the British Empire changed the landscape, as focus was put on crops that would benefit the British markets (Singh S., 1982). Experimentation with popular higher value crops such as tobacco, sugarcane and cotton took place in the colonies, which served as a model for the rest of Punjab (Singh S., 1982). High yielding varieties of wheat, cotton, sugarcane, flax and rice were encouraged, and offered more income to farmers than the indigenous crops. Additionally, new cultivation machines, like the plough, harrow and drill came into use (Singh S., 1982). Punjabi farm workers were taught to adopt these modern tools making them more adept with the Westernization of agriculture (Singh S., 1982). During this period, a 14,500 km long canal structure[5] was introduced to help irrigate the farmlands needed to produce these crops (Neelima et al., 2014). But even in the mid 1900s when the effects of climate change were not nearly as prevalent as they are today, surface water-sourced irrigation was proving to be impractical; inflow of water into the canals was too irregular, supplied inadequate quantities of water and required lots of maintenance (Dhiman et al., 2015). As a result, a decade after India gained independence, they began the switch towards tube wells[6] which pump groundwater for irrigation.

[5] This canal system, largest in the country, is accompanied by an 8000 km long drainage system that helps release runoff during intense precipitation periods, preventing water logging (Neelima et al., 2014).

[6] To draw out groundwater into the tube well, centrifugal pumps are used. They exert pressure on water outside of the well allowing for the low-pressure water inside the well to ascend.

Since 1970-71 the canal-irrigated area in Punjab has shrunk from 44.5% to 27.4% (Dhiman et al., 2015). Meanwhile, the number of wells has increased from one 192,000 in 1970 compared to 1,380,000 in 2011 (Kumar et al., 2018). Tube wells give farmers greater access to water at the time that they choose but has unfortunately resulted in excessive exploitation of groundwater sources. The water table has been declining over the past 3 decades and has now dropped by 150 metres in most areas of central Punjab (Dhiman et al., 2015). Because of this, farmers must invest in submersible pumps which are able to reach deeper water deposits. This adds economic burden on farmers, particularly small farmers, who become indebted (Dhiman et al., 2015). Submersible pumps also further stress the water table, taking what little water remains.

The introduction of tube wells, in addition to the mechanization of labour-intensive agricultural practices marked the beginning of India's Green Revolution. Mainly due to the rising population, focus on export crops, and lack of transportation infrastructure, India had been experiencing a food shortage. Punjab was chosen as the region that would solve the food deficit, by becoming the country's 'breadbasket'. The state was a good option as it had well established water systems and railways, and an educated labour force (Singh S., 1982). Additionally, the hydropower generated by the Bhakra dam, completed in 1963, became a cheap source of electricity that could be used extensively for irrigation (Dhiman et al., 2015). Hybrid high yielding variety (HYV) of seeds were also crucial in transforming Punjab's agricultural economy. These seeds, developed in North America during the 1950s's, were introduced as a way to obtain increased agricultural output (Jhodka, 2021). While they are marketed as a higher yielding, disease resistant, standardized in shape and color alternative to traditional seeds, they also require high levels of input. The adoption of HYV seeds was extensive in Punjab; the total area covered by HYV was 73% in 1974 and up to 95% just under a decade later in 1983 (Jhodka, 2021). These

advancements allowed for Punjab's agriculture to grow at the remarkable rate of 5.7% between 1972 and 1856 (Pandey & Bhardwaj, 2021). The state's agriculture transformed the country, making it resistant to famines, self-reliant in food production and able to sell surplus grain as export.

The mechanization of agriculture, particularly due to tools like the tractor and the thresher, meant that fewer hands were needed, decreasing the necessary workforce (Singh, 1982). The effect was a labour surplus, which had an impact on the movement of people towards the cities for work. Increase in population, industrialization, and intensive agricultural practises are some of Punjab's realities that have led to the decline in water quality. The salinity, electrical conductivity and chloride and nitrate contents have surpassed the maximum allowable limits in most parts of the state (Kumar et al. 2018). Additionally, toxic heavy metals such as selenium, uranium, arsenic, and lead, and pesticides have also been found to degrade the groundwater. Researchers have come across prevailing health issues that may be linked to the consumption of these contaminated water sources (Kumar et al. 2018). The increased commercialization of grain, which shifted agriculture away from subsistence production, changed Punjab's landscape forever.

Policy in Punjab

Once Punjab gained independence, a number of policies were put in place that would help the state accelerate their economy by stimulating growth in the agricultural sector. Some of these policies, however, were harmful in the long run, particularly for small landholders and for the surrounding environment.

The Indian government's decision to incentivise HYV seeds by subsidizing their accompanying fertilizers, pesticides and herbicides lock farmers into a constant dependency on the market

(Jhodka, 2021). Small landowners, who often lack the funds to be able to buy inputs directly from the market, are given loans from commercial banks (Jhodka, 2021). These loans can be repaid only at the end of the harvest season in the fall, when farmers can sell their grain. Because they can only acquire HYV seeds from the market, more have to be purchased each following year, restarting the loan cycle. This system makes it difficult for farmers to pull themselves out of debt.

The state's engagement in the export of rice and wheat have made growing other crops an unattractive option for farmers. Because the government helps fund the water, energy and chemicals needed to produce these two crops, they are used in excess. This has contributed to the critical state of Punjab's water resources[7]. A comparison of rice and wheat's inputs are shown in Table 1.

Up until 2021, every farming household in the state that had a tube well used for paddy[1] irrigation was guaranteed at least 45,000 rupees of electricity annually (Pandey & Bhardwaj, 2021). This allowed farmers to pump ample amounts of water at no cost (Pandey & Bhardwaj, 2021). And before the enactment of the 2009 Punjab Preservation of Sub-Soil Water Act[8] water resources were even more accessible. Farmers could extract as much water as they needed even during the month of June, when temperatures are at their peak, and the rate of evapotranspiration is high (Kumar et al., 2018). The Electricity Amendment Bill, proposed in 2020, helps move away from these excessive input uses by rationing power consumption (Pandey & Bhardwaj 2021). It gives farmers a certain amount of free power, after which they have to pay for further usage.

[7] Rice in particular is demanding, it requires 5,377 litres of water per kilogram of produce, which is significantly higher than what is needed for traditional grains (Pandey and Bhardwaj 2021).

[8] The Presevation of Sub-Soil Water Act prohibits farmers from sowing paddy nursery before May 10 and transplantation of paddy before June 10.

While wheat requires less resources than rice does, it does not have the same nitrogen fixing qualities that pulses do, meaning that it still requires high fertilizer input. To continue to promote the growth of rice and wheat despite their input needs, the government subsidizes their pesticides, herbicides and fertilizers (Neelima et al., 2014). Consequently, Punjab's fertilizer consumption is nearly double the national average (Neelima et al., 2014). This excessive use has decreased the soil's nutrient holding capacity, forcing farmers to use even more chemical inputs. These two input-intensive grains are also a sure option for farmers considering that the government agrees to buy all of their surplus at a minimum support price (MSP) (Pandey & Bhardwaj, 2021). The MSP acts as a price floor[9], a government intervention that protects the supplier by ensuring a set price and the purchase of all of their surplus. This makes other crops less profitable and virtually unfeasible to gain returns from (Singh S.K., 2022). As a result, Punjab moved away from its agro-climatically suited crops to the water-intensive paddy-wheat cropping pattern, which is unsustainable in the long run.

According to the Groundwater Estimation Committee (GEC), a committee that estimates available groundwater resources, the state's level of groundwater development was 170% leading it to fall under the "over exploited" category (Neelima et al., 2014). In the most affected regions, restrictions have been imposed on the construction and installation of new structures for ground water extraction without prior approval of the Deputy Commissioner (Neelima et al., 2014). Only wells with hand pumps and open wells without pumps used for domestic and drinking purposes have been allowed. For those with existing well access, no laws other than the Sub-Soil Water Act (which only restricts the time of groundwater consumption) restrict the quantity of groundwater landowners can extract from their tube wells (Dhiman et al., 2015).

[9] A price floor is the lowest possible price producers are allowed to charge. It lays above the equilibrium price and leads to excess supply.

There are also no restrictions on how close tube wells can be placed from one another. This can lead to well interference[10], which further stresses the water table (Dhiman et al., 2015). And while the government provides subsidies to farmers who invest in underground pipelines, drip, and sprinkler systems, many researchers believe that these measures should instead be made mandatory (Kumar et al., 2018). Kumar et al. (2018) also note that the monitoring of water use would help in ensuring that water is not being pumped excessively. The stresses on water resources have led to the recent ban on wheat exports. The 2022 harvest was smaller than expected which decreased the government's wheat procurement under the MSP (Singh, S. K., 2022). This ban was made so that India could meet its own food security requirements by continuing to supply wheat to its domestic food assistance programs.

The policy in Punjab has helped farmers in the short term by providing them with subsidies, but simultaneously forces them into unsustainable agricultural practises.

California

Geography of California

California is an American state bordering the Pacific Ocean to the west, Oregon to the north, Nevada and Arizona to the east, and Baja California to the south. Home to nearly 40 million residents, it is the country's most populated state. California has a large, diverse economy, making up one seventh of the country's GDP (Ullrich et al., 2018). It is a leader in tech advancements, and major film and entertainment hub, but also supplies the most agricultural output of any U.S. state. California's central valley, also called the Sacramento-San Joaquin Delta, produces more than 55% of the nation's fruits, nuts, and vegetables, and is the national leader in dairy production (Ullrich et al., 2018).

[10] The operation of several wells within the radius of influence of each other, increasing tube well density (Dhiman et al., 2015).

California's climate ranges from the warm, Mediterranean climate along the pacific coast, to the temperate rainforest in the north, the snowy sierra Nevada mountains towards the east, and the arid desert in middle and southern California. The immense variation in regional climates means that low lying parts of the state, like the Colorado desert, can experience temperatures 30 °C higher than areas at high altitudes at a single point in time (Kauffman, 2003). California receives most of its precipitation during the winter months. High altitude areas generally do not suffer from this because they typically receive more rain to begin with. But in the state's warmest regions, this lack of precipitation causes the summer to be very dry. Additionally, the mountain ranges cause rain shadows[11] to form towards the east, contributing to desert areas.

This western American state is subject to a number of natural disasters. The state experiences severe wildfires, floods, strong winds and, most importantly for the purposes of this paper, droughts[12].

The Sacramento and San Joaquin valley is where most agriculture takes place. These regions are classified as Mediterranean and arid desert climates, respectively (Kauffman, 2003). These valleys get their names from the rivers that flow through them, the Sacramento river and the San Joaquin river seen in Figure 2. Snowmelt from the sierra Nevada are what feed these two rivers and their tributaries. The rivers join in the Sacramento-san Joaquin river delta, which passes by San Francisco and flows into the Pacific Ocean. A network of pumps and canals are used to draw water from the delta. This delta supplies fresh water to two thirds of the California's population, irrigates millions of acres of farmland, and is an important habitat to fish populations and other wildlife (Mount et al., 2018). Farms and cities rely upon water from this delta, rainfall and the watershed from snowmelt to fill the reservoirs throughout the year.

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[11] Estuary: coastal body of brackish water with one or more rivers flowing into it.

[12] Rain shadow: reduced precipitation on leeward side of mountain range.

Despite the state's large water grid, made up of surface basins, aquifers, canals and aqueducts, people's water needs are not always met during dry spells (Mount et al., 2018). To support the water demands in southern California, the Central Valley Project (CVP) was made to transport water from lake Shasta in the north to Bakersfield in southern San Joaquin Valley (California Department of Water Resources [CDWR], 2022). The state water project is another extensive water system that supplied water to nearly 27 million people. It comprises of dams, reservoirs, power plants and aqueducts. And lastly the Colorado aqueduct, built in the 1930s, carries the Colorado River's water towards the South. It is mainly used to source drinking water (CDWR, 2022). The state's coasts are regulated by the California Coastal Commission.

History of California

Around the time of the gold rush in the mid 1800s, the demand for food increased, providing more opportunities for farmers. California's flat terrain and fertile soil proved to be quite ideal for growing wheat. The Holt manufacturing company and other local manufacturers were able to complete the world's first combined grain harvester in 1880 (Olmstead & Rhode 2017). This technology saved on limited labour, allowing farmers to export their produce and expand operations.

The mild winters enabled farmers to grow spring-habit wheat (Olmstead and Rhode 2017). Unlike the wheat variety that was being grown in Eastern U.S.A, it could grow continuously without a vernalization[13] period. By 1890, California was the second largest wheat-producing state (Olmstead & Rhode 2017). This was a great feat considering the transcontinental railroad was only completed 20 years earlier. However, the wheat era did not last long. Because the focus

[13] A period of dormancy which shifts grain into its reproductive stage after being exposed to cold temperatures.

had been put on mechanization improvements, sustainable seed and soil practises were largely neglected (Olmstead & Rhode 2017). Fallowing and crop rotation were not used enough while fertilizer, monocropping and deep plowing were being used far too often (Olmstead & Rhode 2017). As a result, the quality of the soil and grain was depleted, and farmers switched from large scale grain production to intensive fruit cultivation. Grapes, citrus and deciduous fruits were particularly popular, and could be sold for a higher price than wheat. Because farmers need far less land to grow these plants than they do for wheat, most farms decreased in size by half, and the statewide land-to-labour ratio lowered from 43 acres harvested per worker in 1899 to 20 acres in 1929 (Olmstead & Rhode 2017). However, acreage of intensive crops, (fruits, nuts, vegetables) in absolute terms, increased tenfold between 1878 and 1929 (Olmstead & Rhode 2017). As barley and wheat production fell, the cultivation of these crops was able to expand dramatically. This is illustrated in Figure 3. During this time irrigation also became increasingly important, with the number of pumps, plants and wells doubling each decade.

As the Great Depression subsided, the most profitable crop transitioned once again, this time to cotton. There was a large demand for cotton, particularly at the end of the decade due to the war, and California's growing workforce was able to fill that interest. The cotton industry in California was high yielding because of the "favorable climate, rich soils, controlled application of irrigation water, use of the best agricultural practices and fertilizer, adoption of high-quality seeds, and a relative freedom from pests" (Olmstead & Rhode 2017). Additionally, by 1950, more than 50% California's cotton was being mechanically harvested compared to about 10% for the rest of the nation (Olmstead & Rhode 2017). Moreover, up until 1980, when the cotton industry reached its peak, Californian cotton-growers were making a gross income much higher than the national average. But changing environmental conditions caused a rapid reduction in

cotton farming, as problems of pests and water usage arose. The boll weevil, an insect that feeds on cotton flowers, required that farmers switch to a breed of cotton that matured more quickly (Olmstead & Rhode 2017). Growing one single cotton variety made the harvests even more susceptible to harsh weather and pests. The result was a decline in cotton acreage. This allowed for other products, such as nuts, to emerge in the market. Now, California is known worldwide for their almond industry which supplies roughly 80% of the world's almonds (Fulton et al., 2019).

California Policy

Historically, Californian farmers have had to adapt their practises to match precipitation levels, but in the past few decades this has becoming increasingly difficult. At the drought at the end of the 1980s, the state's government invested in the urban water infrastructure to decrease the challenges that city dwellers would have to face in times of drought (Mount et al., 2018). But the improved conveyance system and wastewater recycling strategies are not sufficient for farming populations, which continue to struggle due to the sheer lack of water resources. In recent years the government has had to seriously tighten their restrictions on water usage, forcing some farmers to stop producing altogether.

The sustainable groundwater management act (SGMA) was passed in 2014 to stop groundwater sources from being depleted (CDWR, 2022). This act requires local groundwater users to self-organize and achieve a set of sustainability goals, called Groundwater Sustainability Plans (GSPs), by the early 2040s (Mount et al., 2018). Then-Governor Jerry Brown believed self-organization into Groundwater Sustainability Agencies (GSAs) was the best way to establish sustainable groundwater usage while preserving the authority of cities and counties (CDWR,

2022). GSAs are required in high and medium priority basins. The GSPs that these organizations must implement are meant to prevent the exhaustion and degradation of water resources. Farmers who participate in agricultural education, training programs, input and greenhouse gas reductions can benefit from grants (California Department of Food and Agriculture [CDFR], 2022). For instance, the Biologically Integrated Farming Systems (BIFS) program is designed to foster innovative plant-based farms that reduce chemical pesticide inputs. Small and medium sized farms can benefit from the California Underserved and Small Producers (CUSP) Grant. It is meant to provide direct assistance to socially disadvantaged farmers and ranchers who "need support applying for economic relief grant programs and assistance with business planning and marketing strategies" (CDFR, 2022). While these grants exist and should be used whenever they can, there is still a massive income discrepancy between small and large-scale farms. According to the USDA's economic research service, most small-scale farms rely on off-farm labour for most of their household income. Large-scale farms, which had a median gross income of $402,780 in 2021, earn most of their income from farming (USDA, 2021). With more workers and greater resource access, large-scale farms typically have more time to apply to grants and optimize their operations.

Groundwater access throughout the Sacramento-San Joaquin valley is not equal among all users. Anyone that takes water from a lake, river, stream or the ground requires a water right or a water permit. Those that have property connected to a river are granted riparian water rights (California Waterboards, 2021). These rights are given to those that have land that directly touches an above ground water source. The specific regulations regarding riparian rights cover scenarios of ephemeral streams, irregular usage, and other particularities regulated by the California Waterboards. Rights are also given to those that have been using water before 1914 (California

Waterboards, 2021). Over a hundred years later, they are given the legal permission to use the source, while other districts remain quite limited. This raises the question, how do farmers who have not had long term access to water access the resource? They must buy water from someone that has a water right, granting them appropriative water rights (California Waterboards, 2021). Holders of appropriative rights rely on annual contracts between water agencies and federal government, which announce how much water will be given to each sector (Canon, 2022). Water allocations are subject to change throughout the year depending on the weather. Oftentimes, the initial quantity allotted in early February will change if unexpected precipitation — or more likely a lack of precipitation — occurs. In 2022, the government announced that the amount allocated from the CVP's agricultural belt was zero percent, while drinking and industry use were set at 25% (Canon, 2022). This is the fourth time in the last decade that the region that produces one quarter of the country's food is not granted water from the CVP. When this allocation choice was made in previous years, it led to higher unemployment rates in rural areas because farmers were forced to fallow their land. This choice was made because the Sierra Mountains had only 1.7 inches of rain in the first two months of 2022, which would not be enough watershed to fill the state's reservoirs (Canon, 2022). During drought years, restrictions on commercial and recreational fishing are also usually put in place to allow fish populations to recover (CDWR, 2022). Drought years like these reveal how limited the water sources really are, and highlight the competing needs of cities, farms and the environment.

Comparison of Punjab and India

Throughout the stages of Punjab's agricultural history, farmers moved away from subsistence and small-scale farming towards cash cropping for an income. While Californian farmers did not endure the same colonization period, (but rather participated in the colonization process) they

had a similar movement towards the mass production of one crop. Both states went from small subsistence farms to profit-driven high yielding crop choices. This was facilitated by the mechanization booms that made these two states more technically advanced than others in their respective countries.

In Punjab, the Green Revolution caused an agrarian labour surplus, which forced populations towards the cities in search of other work. The opposite was true in California, where much of the settler population had initially moved to profit from the Gold Rush. Once the fertile soils were discovered, farming families emerged. When the shift from wheat to more profitable intensive fruit and nut cultivation occurred, more farmers could move into the rural settlements as less land was needed per farm. Still, the percentage of California's population that participates in agricultural production is minimal compared to Punjab.

Rice and wheat in Punjab, and almonds in California, are three highly water intensive crops that have become essential in the states' respective agricultural economies. The intensification of these crops, in addition to destructive farming practises, required both states to switch from their initial surface water reservoirs to groundwater resources. The effect is a declining water table in either state, better illustrated in the subsequent section covering climate change.

In California, farmers are supported by government grants rather than government subsidies. Grants typically have to be used towards a certain purpose and must be applied to every time. Even once the money is acquired, restrictions and conditions typically apply to ensure that money is spent to according to the plan. This generally ends up taking more of farmers' precious time. Also, if grant information is not easily accessible, farmers may be less inclined to take the time to find their applicable grant. Subsidies on the other hand, are given out regardless of farmer's circumstances. Government support of this kind can be easily abused and does not have

the deciphering ability to support only the marginalized farms. In Punjab, extensive subsidies are used for degrading practises like the overuse of fertilizer and pesticides. Once subsidies are given on a regular basis, it is difficult for the government to take them away without pushback from the receivers. Since grants must be re-applied to every year, the government has more leeway in changing the conditions. In California, the new grants generally support farmers by helping them transition towards sustainable land practices.

Climate change

Climate Change in India

According to the Germanwatch Climate Risk Index in 2018, India has been ranked as the sixth most climate change-vulnerable country in the world in terms of facing extreme weather events (Kumar, 2018). India is repeatedly hit by extreme weather, most notably extreme heat and flooding due to the monsoons, giving it little time to fully recover (Kumar, 2018). Because the majority of Punjab's population relies upon sectors like agriculture, fisheries and forestry, the state is highly sensitive to the effects of climate change (Kumar, 2018).

Global warming worsens the agricultural situation as it causes temperatures to rise and increases the likelihood of intense precipitation periods, particularly in West Punjab. As temperatures rise between +0.50 C to +2.00 C in the near future, rice yields are expected to decline by 0.16% to 9.6% (Neelima et al., 2014). Wheat is also susceptible to warming temperatures, looking at a decline of minimum 4.6% and maximum of 32% with respect to current normal yields (Neelima et al., 2014). As a result, farmers may have to shift their cropping patterns to the cooler seasons, and many will likely migrate to higher altitudes where the heat is less intense. Elevated CO_2 concentration may also damage plant growth due to the increase of weeds, insects, and diseases[14]

(Neelima et al., 2014). As seen in Figure 4, average annual rainfall in the state has actually decreased since 1998. This has caused periods of drought in which groundwater cannot be recharged. Drought is particularly severe in southwest Punjab, where rainfall is more irregular due to its distance from the Sivalik mountains. Despite annual decrease in precipitation, heavy rainfall events have actually been on the rise (Kumar et al., 2018). These periods increase water runoff[1] due to water logging[1] without actually replenishing water sources (Dhiman et al., 2015). Runoff can lead to soil erosion which can cause landslides, particularly on the outer edges of the state, where the land is naturally sloped. Runoff also carries fertilizer into surrounding bodies of water where it can contaminate and degrade the water quality. Climate change increases the likelihood of flash floods in urbanized areas, where water cannot percolate the soil[1] (Neelima et al., 2014)..

Reduced annual precipitation means that glacier melts and snowfall are also on the decline, affecting water inflow into the state's three largest rivers. This decreases surface water availability, affecting canal utility (Neelima et al., 2014). The irregularity of canal water is the reasoning for Punjab's switch from their canal system to the current vast landscape of tube wells. But in the past few decades, groundwater has also become increasingly scarce; underground water sources are not being recovered quickly enough to keep up with demand. The estimated net available groundwater is around 20.35 Billion Cubic Meter (BCM), which is less than annual demand of 34.66 BCM (Kumar et al., 2018). This causes an annual deficit of groundwater seen in Figure 5.

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[14]Weeds and insects are likely to inhabit new ecological niches[1] as temperatures rise. Additionally, many species will be able to reproduce during the warming winters, thus increasing their population expansion. Disease outbreak northwards is also expected to increase. All of these factors will contribute to the reduction of farmer's yields, causing economic burden that could potentially prevent them from continuing their agricultural livelihood.

[15] These floods often result in landslides which can cause the destruction of nearby buildings and more importantly, human casualties.

India's growing population poses further stress on the agricultural industry's water resources, as the demand for food and potable water rises. Farmers must deepen their tube wells and install new pumps to reach what groundwater is left, posing financial stress on their already tight budgets. The agricultural sector in Punjab needs massive adaptation strategies to be able sustainably support its own economy while providing food to the global markets.

Climate change in California

California's climate projections indicate that the state's water crisis is only expected to worsen in future years as temperatures continue to rise, making water less accessible. An increase in days over 40 °C, called extreme heat days, have already been felt and recognized by residents. But they are now predicted to become even more common (Mount et al., 2018) According to Ullrich et al. (2018), air temperatures are projected to warm between 1.4 and 6 °C by end of century. These factors will decrease air humidity and soil moisture and increase evapotranspiration. High pressure air pockets that redirect storms northward, are becoming more common. This process leaves the already rain heavy north with enhanced precipitation while contributing to the rainless dry climate in the south (Ullrich et al., 2018).

Projections point towards a significant increase in the frequency of extremely dry and extremely wet years happen in succession (Mount et al., 2018) Although the average annual precipitation is likely to stay the same, rain from intense storms cannot be captured in the same way due to waterlogging, and actually increases the risk of there being a saltwater intrusion[16]. Rising sea levels are also a factor in the increased likelihood of saltwater intrusions. If there is no delta water left to flush out and push back saltwater within the delta, the state's water supply would become unusable for irrigation and drinking water. Ullrich notes that "this change is further

16 Occurs when saltwater seeps into a freshwater aquifer, either laterally though coastal water or vertically through discharging wells, due to lack of fresh water.

enhanced in the winter season as a result of surface warming triggered by a loss of snowpack at higher elevations, namely, through snow-albedo feedback[17]" (Ullrich et al. 2018). Throughout the winter, more precipitation will come down as rain rather than snow. Reduced snowpack is detrimental to the annual water supply as it shortens the spring snowmelt, reducing water supply and contributing to soil aridity.

There is an order to the water sources that are first used, the first being surface water. Rivers, followed by reservoirs, are drawn upon as the main water sources. When droughts begin, urban areas are asked to reduce consumption by decreasing the water used for vegetation and unnecessary household purposes. Water suppliers often trade available water from low-revenue to high-revenue uses (Mount et al., 2018). But in the worst droughts, when surface water is not available for irrigation, groundwater from community or domestic wells become the main source (Mount et al., 2018). This is what has happened throughout the past decade, when groundwater pumping became the norm as an alternative water source. The problem is that these groundwater sources are less and less likely to be replenished from year to year and the water table declines consistently (Mount et al., 2018). During the 2012–16 drought, 150 community water systems had to request emergency support from the state to get water access as roughly 2,500 domestic wells ran dry (Mount et al., 2018). In the Central Valley, excessive pumping has led to land subsidence1 and problems of water quality. Particularly in rural water systems, where water supply is limited, arsenic and nitrate have been found at higher rates than what is allowed by federal drinking water standards (Costello et a., 2009). The Clean Water Act, the state's first modern environmental law, is supposed to prevent waters from contamination. But a number of

[17] Albedo is the reflectivity of a surface. Snow and ice have high albedo. When there is less snow to cover the ground more solar radiation is absorbed. This is a positive feedback loop because the less snow there is warmer it gets, melting even more snow.

[18] The river is made of fine sediment, without water it compresses and sink, called subsidence.

studies, like the 2009 rural well study, found that people who consumed contaminated well water from local wells had a higher rate of Parkinson's than the rest of the population[19] (Costello et a., 2009). Insecticides and pesticides were found to seep into groundwater, making residents of nearby crop fields sprayed with these chemicals 90% more likely to develop Parkinson's (Costello et a., 2009).

This illustrates how the effects of climate change are felt most strongly by the rural population. Not only are there reported health risks, but agriculturists and fishers find themselves out of work when leaving their fields to fallow and fish stocks to replenish. The changing temperature and hydrological patterns are severely affecting California's agriculture, and may require that the state rethink one of its main industries.

Comparison of climate change in either state

Despite their physical and cultural differences, Punjab and California are, and will continue to suffer from similar climatic catastrophes.

Most obviously are the rising temperatures, which have been felt by most of world in recent years. Both states will experience longer, warmer summers with a greater number of extreme heat days. The winters will be shorter, and while the amount of annual precipitation is not expected to decrease in either state, it will come in more condensed periods of time. This will cause two serious consequences that impact agriculture during the summer months. Firstly, the Shivalik hills and Sierra Nevada mountain chains will experience shrinking snowpack. As mentioned earlier, this reduces the amount of water available in the summertime because less water will trickle down into surface and underground reserves in the spring. Waterlogging is the second important issue that both states will endure. Because the rain will come in such high quantities in short periods of time, the soil will not have the capacity to absorb all of it.

[19] The study was conducted in Central Valley and used a sample size of 700.

After prolonged periods of drought, the soils in California and Punjab are not porous enough to let water infiltrate. On top of not providing the ground the water it needs, high intensity rains will also cause severe runoff that could potentially lead to landslides and flooding. The water table in Punjab is falling by roughly 25-30 cm per year. (Pandey and Bharwaj). California's groundwater on the other hand, is dropping as much as 3 feet in some years (Mount et al., 2018).

Although it is not mentioned as often in Punjabi news outlets as it is in California, both states are subject to wildfires. Between August 2nd, 2021 and July 18th, 2022, 4,971 fires were reported in Punjab, which is much higher than just a decade earlier (Global Forest Watch, 2022).

To limit the adverse effects of climate change on water resources, residents of California are paying for much of the new water infrastructure. Mount et al. (2018) explain how "local revenue—from water and sewer bills and local taxes—accounts for roughly 85 percent of the more than $30 billion spent annually on water management". And while the state's heavy reliance on local revenue to fund water projects seems grave, it is a step up from Punjab, where many towns must fend for themselves to upkeep the water grid. Not all towns in the state have sewage systems, and those that do are only partially covered (Government of Punjab, 2021). Some towns are not provided with any water supply systems, requiring that people use untreated water sources for their domestic and agricultural needs.

Public action, Government Reaction and Recommended Policy

Punjab

Public Action

India has a long history of protests relating to the current climate crisis. The sourcing of energy through coal mining and hydro dams are two massive issues that have led to the displacement of

millions of people (EJ Atlas, 2015). But in September of 2020, the largest ever protest in history took place. It centred around three new farm laws that would severely affect the ability of small landholders to survive.

The first and second laws deal with contracts that determine the quantity, price and crop sold between farmers and contractors. Even though the bill is called the Farmers Agreement on Price Assurance and Farm Services Act*',* it makes marginal farm owners vulnerable as it does not provide any regulatory clauses. It also forbids legal discussion between farmers and contractors making it impossible for farmers to go to court if a contract were to fall through (Singh N., 2021). The third law eliminates the government's control over prices and stocking limits, making it easier for farmers to stockpile. And while this may seem like a positive thing, stockpiling is actually not beneficial for small and medium sized farms because they rarely have adequate storage systems. To keep the grain from being eaten by insects, rats and other pests, large metal grain bins are necessary. This storage protects the grain from being spoiled but also allows farmers to sell their produce to at the time that they please, not just government regulated markets which collect after the main harvest (Sethi, 2021). This can lead to artificially determined prices if farmers wait until there is a shortage of grain to sell their product. This is beneficial for agribusiness firms, who do not actually own land, but control inputs, storage and technology and for large-scale farmers (Singh N., 2021). At the same time, Parliament passed three labour codes that reduce unions' authority. In Punjab there are 32 unions, some are large holding more than 150,000 members and others that represent smaller regions have only a few hundred. Farmers rely on these unions to protect their rights and working conditions (Singh N., 2021). Together, the laws and labour codes proposed in 2020 increase the possibility of corporate farming and large agribusiness companies.

These laws were passed quickly with little discussion, but once farmers in Punjab caught on, they immediately began the march to Delhi to protest. Punjab, a state in which households get an average of 90% of their income from agriculture, made up the bulk of the protest (Pandey & Bhardwaj, 2021). Punjab's population relies more heavily on their agricultural income than any other state, so if small farms were to be pushed out of the market by these new laws, they would likely be forced to sell their land and become contract laborers. On November 6th, 2020 the convoy of trucks and tractors arrived at the Nation's capital. The protestors, largely made up of the unionized workers mentioned above, received lots of positive feedback from locals. They were gifted water, food, health support and blankets from nearby businesses and communities. This allowed over two hundred thousand protestors to set up long-term campgrounds that they sectioned off into 'villages' (Sethi, 2021). Three weeks after the protests began, two newspapers written by protestors in the campground were being printed. The first wrote of the farmers demands and the second, led by a group of women, "focused on women farmers and landless laborers" (Sing N., 2021). Many ceremonies took place (Women's day, Guru Ravidas Memoriam, folk singing, International Human Rights Day) that attempted to close the divide between gender, class and caste (Sing N., 2021). In fear that the government would allow yet another sector to be controlled by large corporations, workers from various sectors were on strike in support of the farmers (Sewell, 2021). The protest was also strongly backed by Dalit[20] women who have consistently been written out of the policy discourse. For decades they have been involved in movements that seek justice for the ongoing farmer's suicides[21], sexual violence and land acquisitions (Sing N., 2021). Their presence expanded the initial demands of the protest (the

[20] Dalit: people belonging to the lowest stratum castes in India/ Currently, only 3.5 percent of Punjab private farmland belongs to Dalits who make up 32 percent of the population (Sing N., 2021).

[21] India has had an exceptionally high rate of farmer suicides since the 1970s. This is primarily due to farmer's inability to repay their loans. In the last five years in Punjab the number of suicides has increased twelvefold (Sewell, 2021)

abolishment of the three farm laws) towards guaranteed minimum wages, equal wages for women, prevention of land evictions and intolerance towards sexual violence. Later added to the farmer's charter was the mandatory universal public distribution of food, and end to farmer's exploitation through big corporations (Sing N., 2021).

The government was not supportive; with the intention of wearing out the protestors, they cut off necessities like water and heating (Singh N., 2021). Support from well-known sport, military and artistic figures came into the picture. This helped to raise funds and spread information, putting pressure on those in power (Sewell, 2021). Farming and workers' unions from Western countries also poured into help by spreading the message so that their struggles would reach media worldwide (Sethi, 2021). Much of this was made possible by the digital distribution of information. The use of photographs, interviews and raw footage shared through networks like Instagram, twitter and Facebook meant that more people could view and empathize with the protestors (Sethi, 2021). Videos and other media could be distributed without the heavy editing that often takes places on national broadcasts. Endorsement from California's Punjabi farmers illustrates the international support. In solidarity with those in Delhi, thousands of Californian vehicles made their way to the Indian consulate to raise awareness with the aim of sparking political change. By early February, the U.S. embassy, which has maintained close relations with New Delhi, urged their government to resume discussion with farmers (Sewell, 2021).

Up until late January, the protest had been entirely peaceful. Government and farmer representatives halted discussions when some protestors broke the barricades leading to the centre of the city (Sewell, 2021). The police retaliated with batons and teargas in attempt to disperse the farmers. Stronger barricades and fences were also installed which affected water and food supply (Sewell, 2021). In the months ahead, non-violence, a strategy of mass political

action that has a long history in India, was practised (Sethi, 2021). However, the protestors still faced difficulties obtaining internet and continuing discussion with the government.

More recently, in spring of 2022, farmers also protested the wheat ban. Farmers demanded 6.24 USD per 100 kg of product as compensation for their reduced harvests due to the unexpected heat in March. Sehgal (2022) reveals that this wheat ban is part of a larger scheme to benefit the corporate farms, allowing them to control the prices. Their access to adequate storage facilities enables them to stock the wheat in huge quantities. They are preparing to export their product despite the country's current issues of food insecurity (Sehgal, 2022). So far there have been few negotiations between the already struggling farmers and the Punjab government.

Government Reaction and Recommended Policy

Over the past 15 years, Punjab has achieved a number of water management initiatives. For instance, access to safe drinking water has greatly improved and more and more rivers are being monitored for their quality (Neelima et al, 2014). But as long as harmful land practises are encouraged, land and water resources will degrade in quantity and quality. Public action has provided some relief for farmers, but it does not fully resolve the root issue.

On November 19th 2021, all three farm laws were repealed. Protestors remained on the outskirts of Delhi until December 9th but warned that they would return if the laws were ever re-enacted (Singh N., 2021). The MSP and input subsidies remain in place to help small-scale farmers, but their effects continue to cause harm to the environment. Additionally, the fight against agricultural exploitation in the state remains an issue, particularly for landless labourers who are payed significantly lower wages than their landholding neighbours.

In response to complaints regarding the recent ban on wheat exports, the federal government has retaliated with statements explaining that the ban is in place to protect the national food supply.

Along with local farmers, the international market has suffered from this recent ban, expressing that it is worsening food supply and food prices due to the Russia-Ukraine war[1] (Sehgal, 2022). Even though the current wheat supply is in crisis, Piyush Goyal, India's commerce minister, reassures the export ban will not affect global markets since its grain mostly remains within the country (Sehgal, 2022).

There are many measures the government of Punjab could take to limit water consumption and reduce the effects of climate change. Some examples1 include the use of sensors for more efficient water use, investment in wastewater treatment and drainage technology for waterlogged areas and better-defined property rights (Dhiman, 2015). These adaptations require substantial funding and research but would greatly improve farm's survival rate in the long run. Given the amount of money that is currently being offered to farmers as subsidies, the transition towards more sustainable agriculture would be possible. The input subsidies that farmers rely on to stay afloat are what caused the agricultural stress in Punjab in the first place (Pandey and Bharwaj, 2021). The government's current subsidies on water, energy and chemicals should instead be replaced by direct benefit transfers that can be used by farmers for more long-term investments.

The 2014 State action plan on Climate change (SAPCC) details a comprehensive list of the country's pressing social and environmental issues (Neelima et al., 2014). This indicates that the government is aware of the ongoing issues in rural and urban life, but because the job of identifying climate concerns and preparing financeable and actionable mitigation strategies is left to separate states, there is lots of room for project plans to fall through. Assessments tend to be vague and overlook many local issues. Additionally, the broad goals described in the SAPCCs are seldom actionable as they do not lay out the small steps that need to be taken. As a whole, the SAPCCs do not shed light on future climate concerns and do not involve communities in

stakeholder consultations (Kumar, 2018). This highlights how proposed government policy does not match the events actually taking place on the ground.

Ukraine is one of the world's top wheat exporters. Due to the Russia-Ukraine war, it has been unable to ship much of its grain to neighbouring countries[22].

California

Public Action

Public action to protect farmers in California has been a much more covert affair. While there have been some protests that shed light on the water crisis, most efforts take place in the form of court hearings.

In the past, when farmers have been unsatisfied with water apportionment plans, they have placed lawsuits against the district (Canon, 2022). But because water access involves so many players, the lawsuit is often too substantial to be dealt with in the county and needs to be addressed by a California appeals court[23]. A recent example of this is the Fresno city and Friant districts' lawsuit against the federal government. Farmers in this region were cut short of water in 2014 due to an agreement made in the 1930s that allowed a group of nearby farmers to take water from the San Joaquin in the event of a water shortage (Bittle, 2022). This group of farmers are known as the "exchange contractors". During the 2014 drought, they received much of the water that Friant farmers were relying on, forcing many to fallow their land (Bittle, 2022). In response, some of the Fresno-Friant farmers filed a class action lawsuit against the exchange contractors and the federal government. This has caused a massive divide between farming

[22]Another proposed adaptation strategy is to switch some of the rice and wheat production to vegetables (Kumar, 2018). The fertile soil and extensive irrigation cover provide Punjab the opportunity to diversify into horticulture (Kumar, 2018). But these crops require refrigerated storage and must be sold within 24-48 hours after being harvested. A transition like this would be extremely costly and would not greatly improve the state of the water table since most vegetables are water intensive.

[23] Luckily, the Central Valley mainly relies on water resources that lie entirely within the state, preventing inter-state water conflicts from arising

communities, who once stood more or less united (Bittle, 2022). In Figure 6, the beneficiaries of the irrigation contract to the West have green fields, while the Fresno-Friant district to the East is in a critical state.

California is known to have large disparities in drinking water availability among different ethnicities in the San Joaquin Valley (Balazs et al., 2011). Many renting Latino populations receive drinking water that is highly contaminated with nitrate and other impurities. Because the concentrations are much higher in impoverished, non-white rural communities. Balazs et al. (2011) label this as a serious environmental inequity. A similar situation is ongoing in Tulare country, just South of the San Joaquin valley. The poverty rates in this county are the highest in the state, and unsurprisingly, health care coverage is low (EJ Atlas, 2015). Furthermore, these contaminated waters have been found to cause permanent health issues across a number of studies.

EJ Atlas (2015) has marked this on their map of worldwide movements. Local communities organized to protest the unequal access to safe drinking water. This story gained media attention back in the early 2010s and is now being protested again, almost a decade later. Despite the declaration by the state of California that clean water is a human right, many still do not have access, which has pushed Central Valley residents to travel to Sacramento to protest (Quintanilla, 2022). They are calling for the implementation of two bills; Senate Bill 222 and Assembly bill 2201. This first would help provide affordable water to low-income residents and the second would prohibit new permits to pump groundwater (Quintanilla, 2022). Groundwater is mainly contaminated by nitrates and pesticides caused by intensive agricultural production, but much of the mobilized group includes farmers who also struggle to obtain access to clean drinking water.

There is also a strong environmentalist point of view in California that is backed by thousands of activists who want to protect nature for nature's sake. For them, waterway conservation is a necessary measure in protecting the species that are not able to adapt as quickly as the anthropogenic changes require that they do. Many environmental activists want the government to allocate more water to aquatic ecosystems that have been exposed to chronic drought in recent years (Börk et al., 2022). This has been detrimental to endangered fish species like the Chinook salmon and delta smelt (Börk et al., 2022). This would cause further strain on farmers that rely on appropriative water rights in the Sacramento San Joaquin delta.

Public action in the farming and environmental sectors are competing for the government's say on how to allot water from year to year.

Government Reaction and Recommended Policy

After 7 years of back and forth, the lawsuit against the federal government and exchange contractors did not go in the Fresno-Friant farmers' favour. Judge Armando Bonilla explained in his ruling that while the zero-water allocation was harsh, the federal government did not breach its 90-year-old contract when it allowed the exchange contractors to take from the San Joaquin water supply (City of Fresno v. United States, 2022). Their water rights, given in the early 1900s, outweigh the Friant farmers' claims to water. Farmers in Fresno worry for future years, as drought is likely to become more and more severe.

The exchange contractors have no incentive to give up this contract (Bittle, 2022). Unless the U.S. Bureau of Reclamation pushes to renegotiate the contract towards a fairer distribution, the rewriting of the water rights may never happen. As the drought worsens and water access continues to be regulated by the "first in time, first in right" premise, there is no other option but for some farms to win and others to lose.

The U.S Environmental Protection Agency (EPA) responded to the water quality protests by giving small grants to local communities. But this issue really needs to be resolved from the root cause rather than just giving a one-time payment to households to buy safe water (Mount et al., 2018). Because affected communities typically have few means to purchase treatment systems or alternative water sources, reliable government support is necessary for the vast improvement of existing infrastructure (Balazs et al., 2011). Communities stay in the poverty cycle in part because they are forced to continue to pay high drinking water rates.

There is a strong belief amongst many experts that the state water board should have greater power over water usage. This would enable the state to override the seniority and riparian water rights that allow farmers to take as much water as needed from the state's rivers and streams to grow their crops (Beam, 2022). To do this, the state has talked about using $1.5 billion of taxpayer money to buy senior water rights says (Beam, 2022). One and a half billion is not enough to cover the costs needed to acquire all of the water, but it is a relatively quick action that can be made to protect some parts of the ecosystem. The decision must be made carefully, as it will likely burden the livelihoods of farmers, prompting even more lawsuits (Beam, 2022). Some experts, like those writing for the California water blog, are in favour of this move, claiming that it may be the solution to protecting endangered species (Börk, 2022). There are parts of the legislation that environmental activists recognize need reworking, such as the use of taxpayer money to buy the rights (Börk, 2022). Instead, methods like reverse auctioning[24] can be used to avoid public disputes and ensure wealthy water holders do not receive giveaways.

In search of a transition towards more suitable crops, some studies have analyzed the effect of growing almonds, to understand whether the heavy ecological footprint is worth the high value.

[24] Holders of water rights propose a price at which they are willing to sell their rights. Bids land close to their opportunity costs, revealing holders' true willingness to accept the adoption of conservation practises (Valcu-Lisman, 2017).

They find that while almonds are high in nutrients, they could be replaced by other economical options like spinach, or berries which don't require as many resources (Fulton et al., 2019). These crops do however require cold storage which would greatly increase farmers expenses and risk of crop loss. Transitioning fruit and vegetable production from California to another state is a possibility but would mean the relocation of many farming communities. It would also require immense investment into new infrastructure and transportation routes.

In order to improve California's water systems so that it can adapt to the changing climate, funding for projects need to come from a broader, more reliable mix of state and local funding sources (Mount et al., 2018). While there have been improvements to water management in the past 10 years, much of the progress is limited by old water rights and lack of community funding. The demands coming from the protestors and lawsuits will not be admitted unless these two fundamental changes are made.

Discussion

The populations of Punjab and California have two distinct approaches when it comes to defending their agricultural rights and access to water. Both states have (mostly) taken non-violent approaches. This allows for movements to gain support from allies.

In Punjab, farmers and local supporters stopped everything to spend months on end in informal settlements to protest at the nation's capital. In doing so, the protestors took time and potential income out of their own lives. In California, there have been some protests, but they tend to be held by smaller groups of people for a shorter duration of time. This has been beneficial for bringing attention to the issue at stake but does not generally compel change. Additionally, the conflicting demands of urban, rural environmentalist populations creates added tension in government's decision making.

Most of the successful public action begins with farms grouping up with those struggling with the same water issues and bring it up in court with the affiliated water board. This route, however, takes years to have any payoff, and typically only benefits the parties directly involved. This contrasts the protests in Punjab, where people came together from varied social classes, and many were not even part of the agriculture industry. This comparison illustrates how demands coming from groups of people that hold united goals have a better chance of settlement than those with opposing positions.

In Punjab, there was vast coverage on newscasts, prints and social media. Not only did this help people directly affected by the strike better understand the issue, but it also drew in lots of attention from across the globe. Even people who do not actively follow international news had the opportunity to learn about mass protest once famous icons like Greta Thunberg and Rihanna spoke up about it (Sewell, 2021). Punjabi American farmers gathered to protest on behalf of those in India and the U.S. embassy recognized the urgency of the issue and pushed for New Delhi to repeal the three farm laws. This exemplifies how media coverage that draws attention towards outside influences can help put pressure on the government to make decisions.

Conclusion

As this paper has demonstrated, the physical conditions that Punjab and California share have resulted in similar realities for the farming communities in either states. Despite their different histories, they are now experiencing severe water crises. This is due to the adoption of destructive farming practises as well as atmospheric conditions that have been intensified by climate change. Higher temperatures, shrinking snowpack, and shorter, more intense wet seasons are just some of the changes that are negatively affecting the availability of water. Because the

water table is not given the chance to recover from year to year, sources are being depleted at record speeds.

Public efforts to gain access to the declining water resources were compared. This was used to better understand what actionable methods people can do to make a change. Media coverage, unified demands and longevity of the protests are found to make public efforts worthwhile. Water rights and subsidies that have been in existence for decades contribute to unfair advantages and adverse environmental effects.

In both states, farmers' wins do not actually improve the longevity of the water resources but rather help them gain access to what remains. But if power were left to environmental groups that wish to protect the natural ecosystem, there would certainly be repercussions on the agricultural economy. Moving towards sustainable crop growth will require reliable funding and forward planning using advanced climate models. It needs to be done at a slow enough pace for people to safely transition away from harmful land practises while ensuring economic stability. The goals laid out by governments that supposedly put their word into action need to be measurable. This allows decision makers to assess their current situation when planning for future risks. Policies should also be legally binding, so that failed objectives have repercussions.

Appendix

Tables

Table 1: http://moef.gov.in/wp-content/uploads/2017/09/Punjab.pdf

PUNJAB CHEMICAL INPUT USAGE ESTIMATE
(in metric tonnes)

Chemical input	Kharif (paddy season)	Rabi (wheat season)
Insecticide	1,744	434
Weedicide	1,795	1,026
Fungicide	299	245

Data source: A 2020 report by Punjab Agricultural University

Figures

Figure 1: : https://abhipedia.abhimanu.com/Article/State/OTgyODQEEQQVV/Geography-of-Punjab-Punjab-State-Civils-

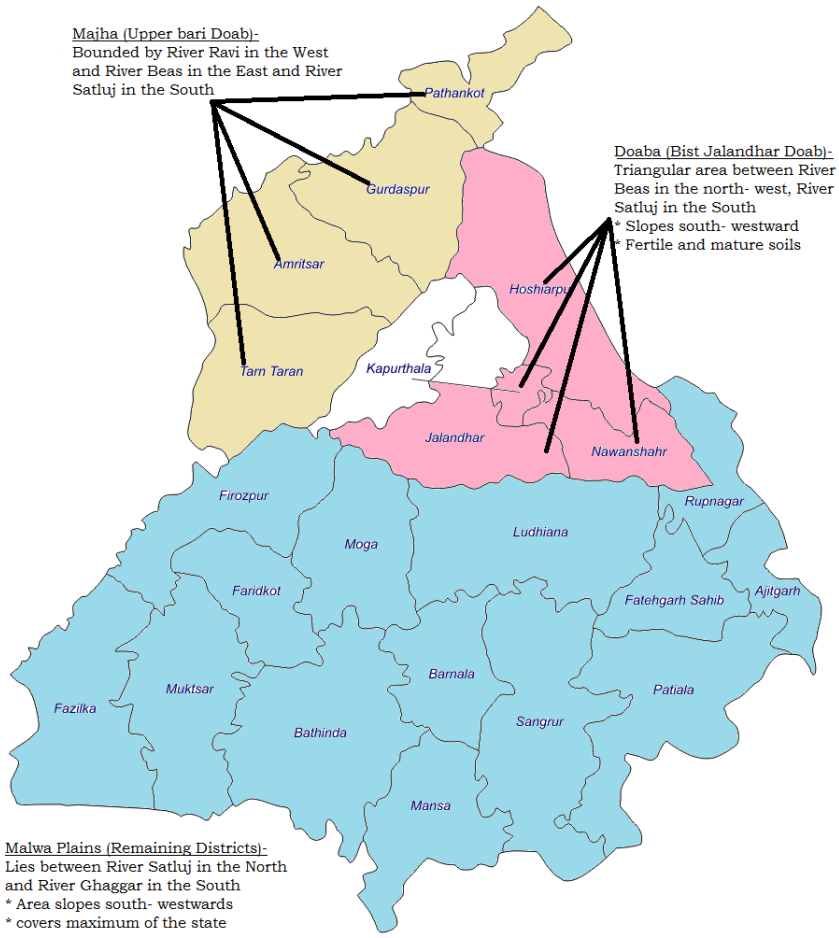

Figure 2: https://oag.ca.gov/gambling/game/central_valley

Figure 3: https://s.giannini.ucop.edu/uploads/giannini_public/19/41/194166a6-cfde-4013-ae55-3e8df86d44d0/a_history_of_california_agriculture.pdf

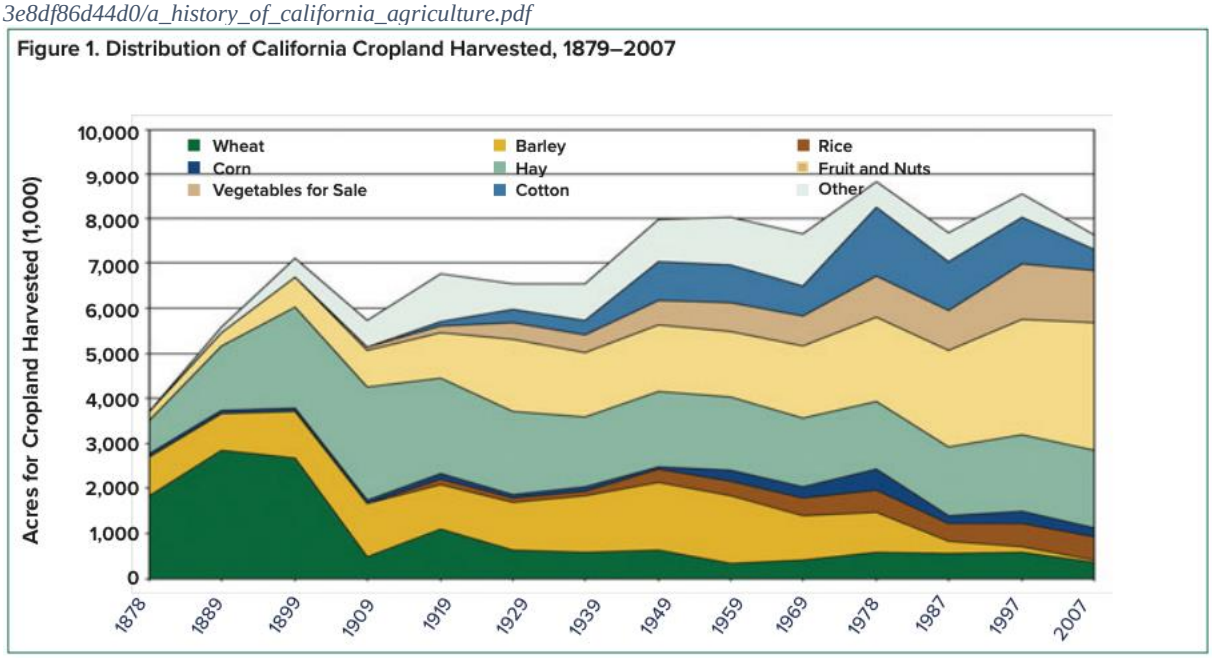

Figure 4: Kumar et al. 2018

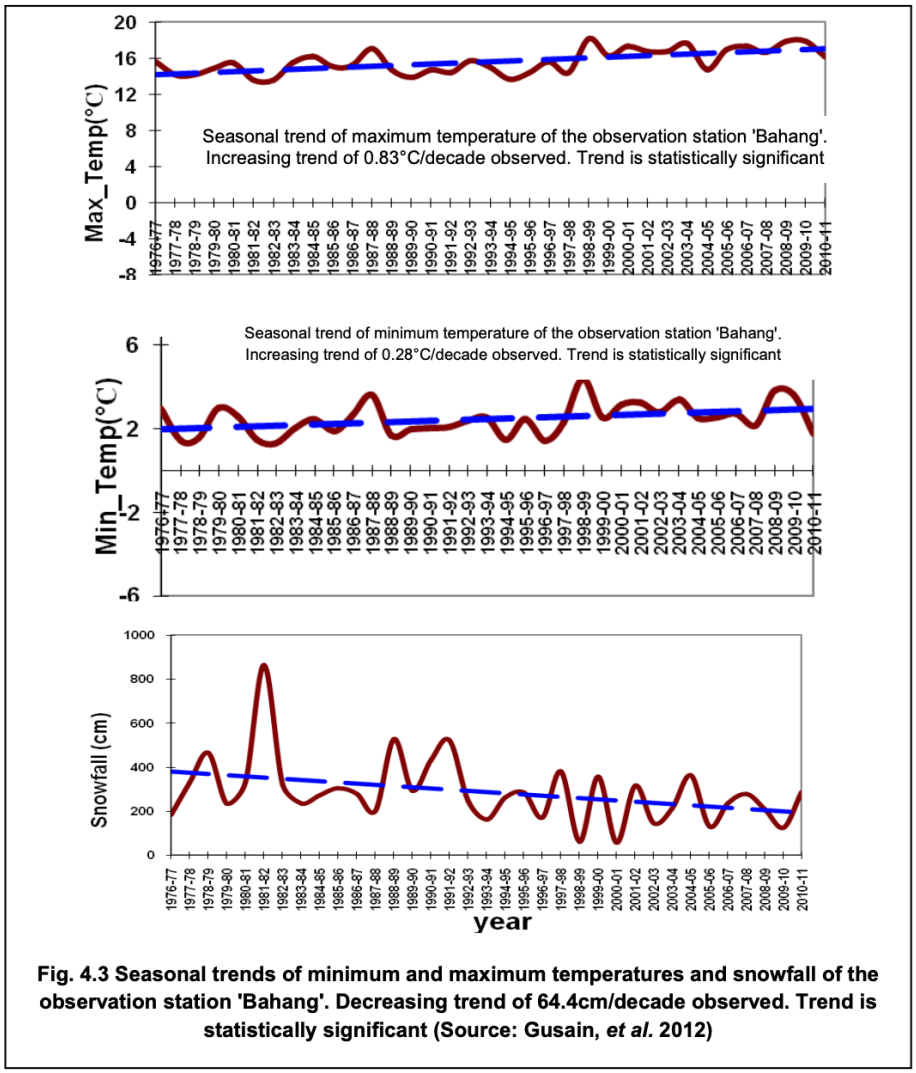

Fig. 4.3 Seasonal trends of minimum and maximum temperatures and snowfall of the observation station 'Bahang'. Decreasing trend of 64.4cm/decade observed. Trend is statistically significant (Source: Gusain, *et al.* 2012)

Figure 5: https://abhipedia.abhimanu.com/Article/State/OTgyODQEEQQVV/Geography-of-Punjab-Punjab-State-Civils-

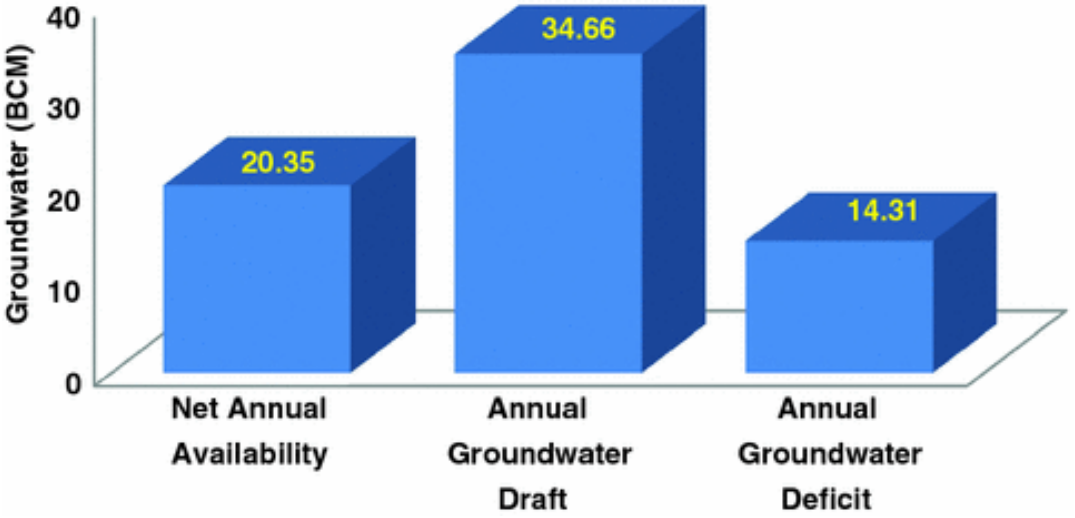

Figure 6: https://grist.org/agriculture/central-valley-drought-exchange-contract/

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