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Using Water Footprints to Identify Alternatives for Conserving Local Water Resources in California

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Abstract: As a management tool for addressing water consumption issues, footprints have become increasingly utilized on scales ranging from global to personal. A question posed by this paper is whether water footprint data that are routinely compiled for particular regions may be used to assess the effectiveness of actions taken by local residents to conserve local water resources. The current California drought has affected an agriculturally productive region with large population centers that consume a portion of the locally produced food, and the state's arid climate demands a large volume of blue water as irrigation from its dwindling surface and ground water resources. Although California exports most of its food products, enough is consumed within the state so that residents shifting their food choices and/or habits could save as much or more local blue water as their reduction of household or office water use. One of those shifts is reducing the intake of animal-based products that require the most water of any food group on both a gravimetric and caloric basis. Another shift is reducing food waste, which represents a shared responsibility among consumers and retailers, however, consumer preferences ultimately drive much of this waste.

Keywords: water; footprint; food; waste; California

1. Introduction

The recent drought in California has prompted a flurry of articles advising that perhaps the most effective way to conserve the state's dwindling water resources is for its residents to adopt a diet that reduces animal-based foods (particularly red meat) and increases plant-based foods [1]. Animal-based foods include dairy products and eggs, as well as various meats. Traditionally, vegetarian diets have excluded the consumption of animal meat but supplemented plant-based foods with eggs and dairy products. By contrast, vegan diets include only plant-based foods. The recognition that altering a population's food choices could reduce water footprints is certainly not a new one. Pro-vegetarian and conservation groups have a history of touting meat-free diets as a way to preserve land, energy and water resources, as well as to reduce environmental pollution [2–4].

The relationship between water resources and dietary habits (especially the consumption of meat) has been evaluated from a number of perspectives during the last two decades. Mekonnen and Hoekstra [5] estimated the global water footprint of animal-based products and concluded that governments promoting a shift away from meat-rich diets will eventually become a component of environmental policies. From the perspective of nutritional water productivity, which describes the mass or energy of food produced per unit volume of water, changes in food habits may be required to provide the additional water needed to feed a larger population [6]. Food security will probably depend on people consuming a higher percentage of plant-based foods that can reduce the water necessary to grow crops [7]. Regional effects of climate change on crop yields and water availability could also influence the timing and extent of required changes in dietary habits [8].

Surprisingly, a national survey suggested that Americans rarely cite food habits as an effective means of conserving the quantity or quality of water resources and are largely uninformed about the water requirements of different foods [9]. According to a Nature Conservancy poll [10], more than three-quarters of Americans not using private wells were unable to identify the source of their household water. Given the lack of public knowledge about the requirements and sources of water for both food and direct use, it is not surprising that the connection between food habits and water savings has become a focus of educating people about sustainable strategies [11].

Where does the water used to produce food originate? From a global perspective, the origin of water dedicated to food production may be a moot point because the hydrologic cycle is planetary in scale and, whether water comes from an aquifer beneath one's feet or from a distant reservoir, conserving freshwater resources has worldwide implications. From a local perspective, exactly what water is being conserved by reducing food waste or by adopting a less water-consumptive diet is frequently of considerable importance. While many studies demonstrate the effectiveness of plant-based diets in reducing total or blue-green water footprints on a regional basis [12–14], the question arises as to where and in what form that water is conserved.

For example, do Californians contribute substantially to preserving local ground or surface water resources by wasting less food or altering their food choices? Reducing household water use clearly conserves local water resources, but the water used to produce food originates from many different locations—thus complicating a correlation between food habits and local water resources. The term "local" in this context refers to water resources allocated to users in the state, regardless of their actual proximity to the water source. Californians commonly receive water that is transported over long distances, requiring up to 7% of the state's total energy consumption [15].

2. Water Footprints

The concept underlying any footprint is that everything produced, consumed or utilized by humans requires inputs from the natural world (usually labeled as resources) that can be quantified as a means of assessing their inherent demands. Initially, ecological footprints were developed to estimate the area of biologically productive lands or waters required to produce and dispose of various products. As such, footprints serve to quantify the natural resources embedded in products or services that, when imported, exported or consumed locally, constitute a virtual transfer or translocation of those resources.

Water footprints track the volume of water that is consumed (i.e., no longer available for immediate reuse) to generate a product or service [16,17]. An internal footprint refers to the water required to generate products within a region that are also consumed or wasted within that region, whereas an external footprint refers to the water required to produce goods that are imported into and consumed within a region. Worldwide, about 90% of regional water footprints are devoted to food in the form of both crop and animal production [18]. By contrast, the contribution to domestic water supply and industrial products usually accounts for less than 10%.

Total water footprints include the sum of three types of water [18]. Green water is the rainfall directly consumed by agricultural crops or by grasses that feed grazing animals. The more familiar blue water includes lakes, rivers and aquifers that serve as recognizable sources for domestic, industrial and irrigated agriculture use. Finally, gray water represents the volume required to dilute contaminants, produced primarily by agriculture and industry, to concentrations that meet water quality standards for human health or the environment. A total water footprint includes all three types of water, but green water is often agriculture's largest component. Generally, blue water used for agriculture has greater environmental and resource impacts than green water [19].

The total water footprint of foods on a worldwide basis varies depending on how crops and animals are raised, processed and transported, as well as their generation of pollutants (Table 1). Among plant-based foods, sugar crops and vegetables (i.e., leaves and roots) require the least water per unit mass of food, followed by fruits, cereals and oils, and finally by nuts and pulses that require the most water [13]. Among the animal-based foods, beef has the largest water requirement, followed by sheep, pork, butter/cheese, poultry, and then eggs and milk [13,17]. Cereals and roots usually provide people with the most energy (based on calories), whereas fruits and vegetables provide the bulk of their food intake (based on mass). By contrast, animal products require the most water and often provide less than a quarter of the dietary calories or mass [20].

From the standpoint of blue water requirements on a gravimetric basis, plant-based foods (except nuts) demand less than animal-based foods (except milk). Total water volumes listed in Table 1 are worldwide averages, as are the ratios of blue-to-green and blue-to-gray water inherent in the total water footprint of foods [13]. Ratios of blue-to-green water can vary considerably based on the climate and agricultural practices of a region. Similar to the gravimetric comparison between plant-based and animal-based foods, the former require less water (except nuts) than the latter (except dairy) on a caloric basis. The calories provided by various foods are typically calculated on the basis of their relative composition (by mass) of fats, carbohydrates and proteins.

Table 1. Global averages for the volume of water required to produce a kilogram of food, the ratios of blue-to-green and blue-to-gray water for food production, and the volume of water required per Calorie (kilocalorie) of food consumed. Based on data presented by A.Y. Hoekstra [13].

Food Type	Water per kg (L)	Blue-to-Green Water Ratio	Blue-to-Gray Water Ratio	Water per Calorie (L)
Sugar Crops	200	0.40	3.5	0.69
Vegetables/Roots *	350	0.14	0.44	0.91
Fruits	960	0.20	1.7	2.1
Cereals (Grains)	1600	0.19	1.2	0.51
Oil Crops	2400	0.11	1.8	0.81
Pulses (Legumes)	4100	0.04	0.19	1.2
Nuts	9100	0.19	2.0	3.6
Milk	1000	0.10	1.2	1.8
Eggs	3300	0.09	0.57	9.7
Chicken (Poultry)	4300	0.09	0.67	28
Butter	5600	0.10	1.2	0.72
Pork	6000	0.09	0.74	2.2
Sheep/Goat	8800	0.06	8.6	4.3
Beef	15,000	0.04	1.2	10

Note: * Mean values for the two crop types are listed.

3. California Water

3.1. Use

A 2012 report by the Pacific Institute contained much of the data that were used in this paper to assess blue water footprints [16]. The report was based on information published from about 1995 to 2010 on a range of relevant topics and was comprehensive in its scope. Nonetheless, similar input information for assessing blue water footprints is available for at least some other nations and/or regions [7]. The Pacific Institute's 2012 report did not address aquaculture's water use, and it was not considered in this paper. California's aquaculture is conducted predominantly in marine environments and withdraws a minor portion of the state's surface and ground waters [21].

Figure 1 displays California's water footprint for the three types of water used to generate its products and services. About 23% of the footprint is green water, most of which is used to produce animal feed. Another 37% is gray water devoted to diluting industrial or agricultural pollutants, and the remaining 40% represents local blue water that is consumed within the state or exported virtually. Most of the state's blue water is used for irrigated agriculture, exceeding the contribution of green water to agriculture by about 55%. Comparing California's blue-to-green water ratio of 1.55 to global ratios for the crops listed in Table 1 (ranging from 0.04 to 0.40 with a median of 0.22) exemplifies the relative dependence of the state's agricultural production on blue water irrigation.

For purposes of assessing alternatives for conserving local water resources, blue water that is both produced and consumed in California is the major focus. Calculating this blue water footprint becomes a matter of subtracting the virtually exported blue water from the locally produced blue water. The Pacific Institute reported that about 29.7 billion cubic meters (BCM) of blue water is used annually in California to produce its various products and services [16]. Industrial/commercial and residential/business users rely solely on blue water, whereas agriculture utilizes both green and blue water. Even so, agriculture consumes almost nine-tenths of the state's locally produced blue water. Approximately 16.4 BCM of the blue water produced annually in the state is ultimately exported (predominantly as a virtual component of plant-based foods), leaving about 13.3 BCM per year as the volume of local blue water consumed in the state.

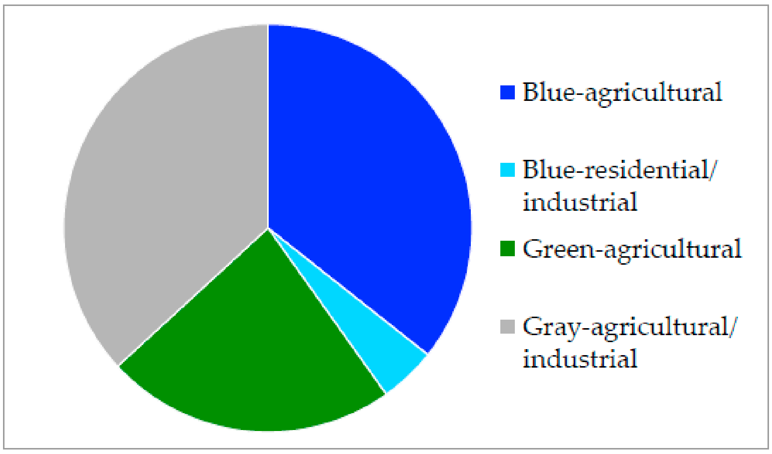

Figure 1. California's water footprint (calculated on a volumetric basis) for products and services produced within the state, whether consumed locally or exported. Based on data presented by the Pacific Institute [16].

It is interesting to note that California imports only about 10.6 BCM of virtual blue water per year [16]; hence, the state is a net exporter of the blue water that is a major focus of its current drought. Conversely, California is a net importer of green and gray water, mainly as virtual components of agricultural and industrial products, respectively [16]. California has a blue-to-gray water ratio of just over 2.4 for its agricultural products (assuming 40% of its internal gray footprint is related to agriculture [16]), which is greater than the global average of 1.7 calculated from Table 1. This is probably a result of the state's relatively small internal gray footprint (i.e., about one-quarter of its external gray footprint) and its large internal blue footprint dedicated primarily to irrigation.

The first column in Table 2 lists California's blue water (virtual or actual) that is produced, exported and consumed within the state. Blue water totals are divided into three categories of agricultural products, as well as a category each for commercial use or industrial goods and for direct use by residents. These categories are based on graphs presented in the Pacific Institute's 2012 report that provide estimates for the blue water used and virtually exported from the state [16]. Not shown in Table 2 is the local blue water required for energy production, which reportedly accounts for about 0.49 BCM per year in California [14]. Most of the virtual blue water associated with the state's energy demand is imported in the form of bioethanol (as a component of motor vehicle fuels), with only about 12% of this biofuel actually produced in the state [22]. Hence, the local blue water footprint for biofuels is less than 0.06 BCM annually.

Crops not specifically identified in the Pacific Institute's report as animal-based foods, animal feed, plant-based foods or non-edible products were assumed to represent plant-based foods. This applies to all the "other" foods that are both produced in and exported from California and that represent the lesser water-intensive crops [23]. The virtual water consumed for animal-based foods represents the water produced for feed crops minus the water exported in feed crops and in animal products (based on published conversion rates) [16]. Prepared foodstuffs exported from California were conservatively assumed to represent an equal mix of plant-based and animal-based products, although the former probably constitute a majority of these processed foods. Overestimating the exportation of prepared foodstuffs derived from animals reduces the projected amount of local blue water consumed by Californians who eat animal-based foods.

Table 2. Volume of local blue water (BCM per year) produced, exported and consumed by various California sectors. The volume of blue water devoted to each of these sectors for the three water use categories is shown in parentheses. Based on data presented by the Pacific Institute [16].

Water Use Categories	Local Blue Water (Total)	Animal-Based Foods and Feed Crops ^	Plant-Based Foods	Other Plant Products *	Resident's Direct Water Use	Commercial and Industrial Use/Products
Produced	29.7	11.5 (39%)	13.7 (46%)	1.2 (4%)	2.2 (7%)	1.1 (4%)
Exported	16.4	4.5 (27%)	10.6 (65%)	1.2 (7%)	0 (0%)	0.1 (<1%)
Consumed	13.3	7.0 (53%)	3.1 (23%)	0 (0%)	2.2 (16.5%)	1.0 (7.5%)

Notes: ^ Virtual water in feed crops and animal-based foods were estimated separately; * Includes non-food crops such as cotton.

Whereas most of the local blue water in the state is used to produce food, much of that food is not consumed within the state. A majority of the virtual blue water exported from California is a component of plant-based foods, rather than animal-based foods or feed crops. Considering that alfalfa, hay and other types of animal feed use the most irrigation water of any crops grown in California [16], residents consuming the bulk of locally-produced animal products limits the state's exportation (virtually) of an even larger proportion of its blue water. It also suggests that Californians reducing their consumption of animal-based food products should conserve more local blue water than if they were to reduce an equivalent percentage of their consumption of plant-based foods.

3.2. Waste

Absent detailed food waste statistics specific to California, losses from the state's food supply were estimated from 2008 data on consumers and retailers in the USA [24]. The consumer/retailer sector of the food chain controls post-production waste, which is normally greater in industrialized nations than the waste associated with pre-production activities such as growing, harvesting and storing crops. Retailers, and especially consumers in industrialized nations, waste most of the food as a result of their behaviors [25]. Besides possessing the largest water footprint associated with food waste, consumers also have the largest carbon footprint related to wasting food.

Figure 2 shows the relative waste of food by category. According to these data, meats are the most wasted and nuts are the least wasted food. When grouped by source, food losses average 31% and 27% for animal-based and plant-based products, respectively. These mean losses are consistent with published studies from the USA and other industrialized nations that estimate food losses in the consumer/retail sector at 25% to 33% [26–28]. Household food waste has been correlated with income level, and the major causes include overbuying food in stores, preparing too much food for meals and failing to consume perishable foods before their expiration dates [29].

Whereas consumer losses almost invariably exceed retail losses, the two were considered jointly because retail losses are partially a result of consumer preferences (e.g., avoiding slightly blemished fruits or vegetables) and because retailers can reduce the waste of food they purchase and distribute through practices similar to those of consumers (e.g., not overstocking shelves, not pulling food from shelves before the expiration dates, donating unspoiled food to people in need, or giving food scraps to animals) [30]. Restaurants also waste post-production food by serving large portion sizes, stocking for extensive menus, and offering limitless buffets at a fixed price.

Although water wasted by the residential/business and commercial/industrial sectors were not a focus of this paper, a California Efficiency Study [31] indicated that about 18% of residential water is lost to leaks alone. A more detailed analysis of water wasted by both the commercial/industrial and residential sectors in California estimated that reductions of almost 40% were feasible [32]. As a means of addressing the extended drought in California, the governor mandated a 25% reduction in water use by the state's residents and businesses as of April 2014 [33]. Some water districts within the state actually surpassed the mandated reduction, suggesting that cutbacks of direct water use by residents in excess of 25% are possible, if not probable, on a statewide basis.

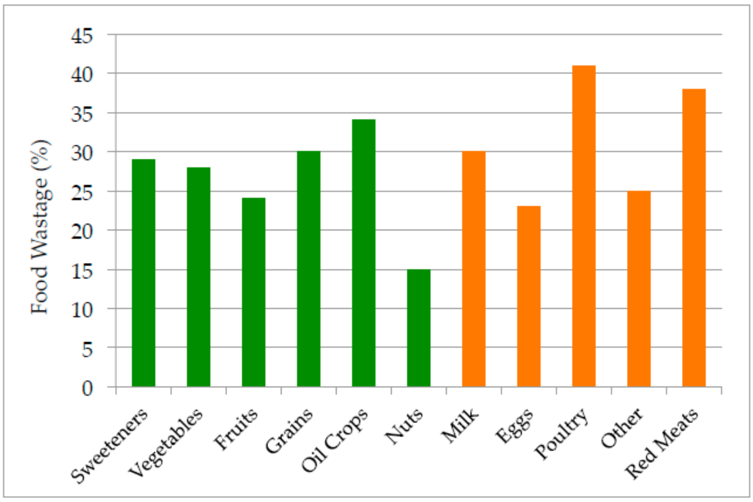

Figure 2. Estimates of wastage for various plant-based and animal-based foods are presented for the USA. Based on data provided by Buzby et al. [24].

3.3. Conservation Alternatives

In considering the alternatives to conserve local blue water, the demand side of the equation normally focuses on reducing direct water use by residences and businesses. Whereas tracking reductions in water use for this sector is the most practical, it is not necessarily where the greatest water savings can be achieved. The impact of various conservation alternatives for reducing the local blue water footprint is shown in Figure 3. Because the state has mandated reductions in direct water use of 25%, the same reduction was applied to food waste and to biofuel usage to generate the three bars on the lower portion of the graph. Because biofuels require such a small fraction of the state's local blue water, there is little reduction in the footprint from curtailing their use. By contrast, a 25% reduction in food waste has a greater impact on reducing the local blue water footprint than the same reduction in direct water use by residents and businesses.

Adopting a diet that includes one vegan day per week results in a decrease in the local blue water footprint that is slightly greater than that of a 25% reduction in food waste. A diet that includes just one vegan meal per day (assuming three meals total) achieves a decrease in the blue water footprint more than double that of reducing direct water use by 40% and more than 1.5 times greater than that of reducing food waste by 40%. These estimates suggest that although diets and food waste are extremely difficult to monitor, they possess a greater potential to reduce the internal blue water footprint in California than restricting residential water use. Vegetarian diets were not considered because the dataset did not distinguish between the feed destined for dairy cows and egg-laying chickens from that provided to animals butchered for their meat.

Decreases in direct water use and food waste were estimated by multiplying the volume consumed and the volume wasted, respectively, by the specified reduction factor and dividing by the total blue water consumed. Calculating the influence of a vegan diet on the blue water footprint involved decreasing the water volume for animal-based foods by 80%, multiplying by the fraction of total meals per week or per day that are vegan, and dividing by the local blue water consumed. An 80% reduction of the water associated with animal-based foods was based on the estimate that plant-based foods are a factor of 5 more water efficient than animal-based foods in providing the same number of calories [13]. Eliminating animal-based foods from a meal and replacing the lost calories with plant-based foods reduces the volume of virtual water consumed [5,12].

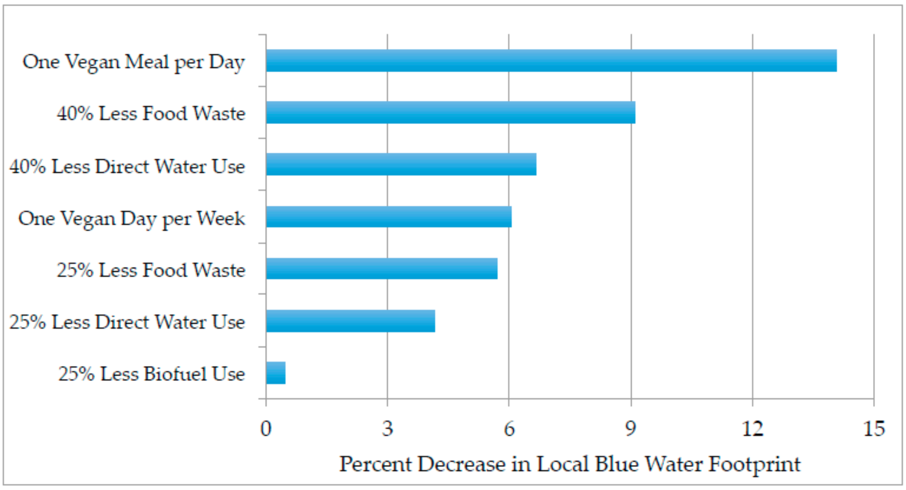

Figure 3. Percent decrease in California's local blue water footprint as a function of potential water-saving alternatives.

The reason for basing a tradeoff of animal- for plant-based foods on the basis of calories, rather than protein, is two-fold. First, the typical Western diet includes about twice the recommended protein intake of 0.8 g per kilogram of body weight or 50 g [34,35], which is attributable to a diet containing a high percentage of animal products. Although no consensus exists as to whether there are health effects associated with over-consuming protein, the excessive intake of animal-based products has been linked to an increased incidence and mortality of diseases such as stroke, cancer, diabetes and cardiovascular disease [36,37]. Second, plant-based proteins eaten in combination can provide a complete protein source (i.e., containing all essential amino acids) and offer nutritional benefits such as dietary fiber, antioxidants and phytochemicals [38].

Figure 3 indicates that the California population eating an average of one-third of their meals as vegans only reduces the local blue water footprint by about 14%. Other studies estimating the effect of populations switching from a typical Western diet to a vegetarian diet, including eggs and dairy products, report total water footprint reductions of 27% to 41% [12–14]. The difference is related principally to two factors. First, plant-based diets generally conserve more green than blue water because the former usually represents a larger portion of the total footprint devoted to food [17]. In particular, green water usually comprises a major portion of the footprint for animal-based foods [5,7]. Second, the vegan diets presented in Figure 3 assume that people eat plant-based foods for only one-third (33%) or one-seventh (14%) of their meals, rather than for every meal.

A 14% decrease in global blue water consumption was estimated for eliminating all animal products from the diet, but the authors noted that the relative importance of dietary shifts to water conservation is highly dependent on the available water resources within a specific country [7]. The largest water savings for both blue and green were observed in water scarce countries of the Middle East and North Africa. Jalava et al. [7] concluded that although limiting the consumption of animal products would decrease both blue and green water footprints globally, dietary shifts should be considered in combination with reducing food waste or loss on more localized scales.

The selection of the two dietary options shown in Figure 3 was based on existing programs of "Meatless Monday" and "Once A Week Vegan" that are designed to promote better health and raise environmental awareness about the consequences of dietary choices [39,40]. One vegan meal per day serves as a weight loss strategy that may be an easier transition to reducing animal-based foods in one's diet than an entire day of plant-based foods. As previously noted, the 25% reduction in food waste and biofuel use was selected to match the mandated reduction in direct water use, whereas the 40% reduction in food waste was selected to match a reportedly feasible reduction in direct water use [32,33].

4. Discussion

4.1. California Comparisons

Of the alternatives for conserving local water resources in California, reducing food waste and substituting plant-based foods for animal-based foods appear to be more effective than reducing an equivalent percentage of direct water use in residences and businesses. There are several attributes of this state that may account for food habits exerting such a marked influence on the internal blue water footprint. First, California is the major producer of plant-based foods in the USA and also possesses a large population capable of consuming a sizable percentage of its agricultural products. Typically, agricultural regions are rural and their limited populations consume a small fraction of the locally produced foods. Second, most of California has an arid climate that demands more blue water (as irrigation) than green water to produce its crops and animals. Third, the state exports a greater percentage of its plant-based than its animal-based foods, and the local blue water content of animal-based foods consumed in the state is more than double that of plant-based foods.

Whilst California is not unique in possessing both an arid climate and a large population, it is unusual inasmuch as it relies so heavily on blue water irrigation. For example, Spain is the most arid country in the EU with a population slightly greater than that of California. Nonetheless, more green than blue water is used in Spain to produce its agricultural products, and the green water contribution to animal-based products is considerably higher in Spain than in California [41,42]. While there are local exceptions to national or state trends (e.g., parts of Spain where blue water irrigation exceeds green water inputs and parts of California where green water contributes more to agriculture than blue water), this comparison focuses on larger populations and geopolitical regions for which sufficiently comprehensive data are available.

Populations living in arid nations of the Mediterranean tend to derive more of their calories from plant-based foods than populations in Northern Europe or North America [43]. Although Californians eat a higher percentage of plant-based foods than most Americans [44], their diet is more similar to people living in humid regions of the USA than to people living in very arid nations. Some nations located in North Africa and the Middle East (e.g., Egypt, Iraq) also depend more on blue water irrigation than on green water for generating agricultural products [42]. Nonetheless, the volume of blue water produced annually for crops and animals (on a per capita basis) in California is about twice that in Egypt, Iraq or Spain. Subsequent studies may identify other nations or states with a set of attributes similar to those of California, where people's dietary choices and food waste could play a role in conserving local water resources.

4.2. Policy Implications

Eating is as much a social and cultural activity as it is a nutritional activity. Traditions, images, beliefs and habits all play a role in determining one's willingness to change a behavior that many people consider to be an inherent personal right—not unlike water. Moreover, there are economic, religious and food access considerations that may prevent people from altering their predominantly animal-based diets or that result in them consuming only plant-based foods. The data presented in this paper do not account for regional or cultural differences within California, but rather assume a more homogenous population that consumes or wastes food according to state or national averages. Similarly, broad assumptions about residents' direct water use are made when statewide policies for water restriction are enacted. There was considerable resistance to the governor's April 2015 water restrictions, even though a tiered system was used to rank users [45]. Mandating dietary changes or reductions in food waste would likely meet even greater resistance and would be substantially more difficult to enact, monitor and designate exceptions.

The question of who might take responsibility for shifting diets or reducing food waste to support better public health or to conserve water resources is an interesting one. One perspective is that consumers are ultimately responsible because their food choices create a demand that retailers must fulfill and because consumers waste the most food. A challenge faced by the proponents of dietary shifts is motivating consumers to change their food-related behaviors by appealing to their sense of civic responsibility (e.g., conserving local water resources) [1,2,4] or their self-preservation (e.g., improving health and longevity) [35–37]. The long-term efficacy of either appeal is uncertain. According to a statewide survey [46], Californians identified health concerns as having the greatest influence over what they ate. Although they expressed a willingness to adopt new dietary strategies to improve their health, which included consuming more fruits and vegetables, only a fraction of the respondents actually did so.

Similarly, there is currently no widespread or discernable social momentum to reduce food waste in the USA [24]. Most consumers are not interested in waste because there is an abundant supply of inexpensive food and because financial incentives, such as tax credits to businesses that donate food, do not currently exist. Lifestyle changes prompted by the threat of consequences are dependent on whether people are just concerned or truly worried [47]. The latter will often lead to changes, whereas the former will not. If people truly believe that food habits will jeopardize their health or access to sufficient water, they may consume fewer water-intensive foods or reduce food waste. However, they are less likely to take these actions for reasons that they do not perceive to directly affect them (e.g., climate change, environmental degradation, treatment of animals).

Another perspective is that governments will eventually have to adopt policies that reduce the demand for animal products as a component of environmental management [5]. Governments have predictably refrained from regulating people's food habits, except to address specific public health issues [48]. Accordingly, California authorities are unlikely to target food habits as a means of conserving local water resources, although food waste is generally considered to be a more socially acceptable target than dietary choices. Besides the question of acceptance by residents, the meat industry will likely resist any policies intended to limit the consumption of its products [49].

There may be government policies that influence people's dietary choices and habits indirectly. Ralston [50] noted that policies affecting the supply, price, nutrition or safety of food can indirectly influence the dietary choices of consumers. These policies include farm assistance programs, food safety regulations, information regulations (labeling/advertising), and regulations addressing trade or the environment [50]. As an example, meat production has been implicated in issues that include greenhouse gas emissions, water pollution, global deforestation, infectious diseases among animals, steroid usage and, perhaps, antibiotic resistance [51–53].

The combination of water scarcity, safety concerns, environmental stresses, food costs and other economic factors may eventually be sufficient to propel large-scale dietary shifts by people without government regulations or public education campaigns. As for now, California hosts some of the nation's most popular alternative restaurants [54], however, only about 8% of the state's residents are vegetarians and fewer are vegans. Consumers who are genuinely interested in conserving local water resources via their food habits will probably need to do so on a voluntary basis.

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