CLIMATE SURVIVAL SOLUTIONS

THE COMING MEGADROUGHT IN THE AMERICAN WEST

Fatema Dewan

Climate Survival Solutions

The Coming Megadrought in the American West

Abstract:

With time, humans have accelerated their anthropogenic activities to an extent which have degraded the ecosystem, with no point of return. These activities have pushed the world to a new era of the climate crisis, where almost all societal sectors are impacted. Any attempt to alter the 'Mother nature' has sure-shot repercussions. These repercussions involve extreme weather events, which are capable of large-scale destruction and social and economic losses. One such dire event - 'drought' -- marks the extreme scarcity of water in the region as well as imparts severe long-lasting effects on agriculture, ecosystem, energy generation, health and safety, fishing, recreation, and other societal sectors.

The United States's climate patterns have been inflicted with droughts from the beginning of the 21st century, following an earlier pattern of its two previous longest droughts in history, in the 1930s and 1950s. Droughts drastically reduce the amount of precipitation which is further tied to the reduction of soil moisture and groundwater. The drought has resulted in dangerously low levels of water in the most dependable reservoirs, Lake Mead and Lake Powell, which are only 36% and 38% currently full and are responsible for 90% of the water in Western U.S. Megadroughts are referred to as abnormally severe droughts for 20 years, and Western U.S. has witnessed four such megadroughts in past 1200 years.

A few drivers of such an impactful drought include variation in sea temperature, reduction in cloud formation, lower precipitation, reduction in the snowpack, dwindling soil moisture, and higher temperature. To put too much emphasis on any one driver as a creator of drought is not possible as drought is a conjugative effect of all drivers, which are independent and interconnected.

Nearly 60% of the western U.S. is currently facing exceptional droughts. Droughts have resulted in now multiple episodes of wildfire, death of native flora and fauna, destruction of human life and health, substantial reduction of agricultural produce, reduction in recreational activities, disruption of ranger's activities, etc, every year. Burn bans and water restrictions have been largely and strictly implemented as one means of addressing the crisis. The most-talked-about water cutback in January 2022 in Arizona is due to the lower levels of water in the reservoirs (Lake Mead and Lake Powell). Likewise, electricity cut-offs are recurrently experienced by the Americans due to the risk of Wildfires and disruption of hydropower stations due to the low water levels. The drought has now become an integral part of American society and the only option to survive this never-ending drought is in creatin and deployment of mitigation and adaptation plans.

The prime means of mitigating the impact of drought is the conservation of available water resources, and conservation of water begins at the individual level. The conservation in varied economic sectors such as agriculture, industries, tourism, etc., supports the creation of a drought-resilient society. The U.S. Bureau of Reclamation has formulated mitigation plans and strategies to alleviate the impact of drought in the region. It also funds several projects into different operational categories to support the drought contingency plans and planning. Several biotechnologies, utilizing the capabilities of biological entities for converting wastewater into a useful resource, are paving the way to lower the water crisis and climate change.

Keywords:

Western U.S., Megadrought, Water cutbacks 2022, Green energy, Mitigation, Climate Change, Contingency Plan, Water crisis.

1 Introduction:

Droughts are defined as the abnormally long period of acute shortage of water with below the normal levels of precipitation. They are one of the grave outcomes of global climate change. The reduction of precipitation either in the form of rainfall or snow drastically lowers the soil moisture or groundwater. They impact nearly all the horizons of society and result in massive economic losses.

Droughts are the culprits causing severe deterioration of the socio-economic framework of society. The economic losses are largely due to the reduction in agricultural cultivation owing to water scarcity and alteration in the soil characteristics. The flora and fauna of the drought-struck region face several dire consequences due to the extreme shortage of water, food, and shrinkage of their habitat. Likewise, the human population witnesses several dreadful impacts. Humans develop various health issues such as anxiety or depression, malnutrition, respiratory disorders, infectious foodborne diseases caused by *E. coli* and *Salmonella*. The drying of available water resources dwindles the size of water bodies and low water levels diminish the water flow causing stagnation of water. This increases the breeding ground for several types of mosquitoes. These mosquitoes rise the cases of vector-borne diseases. The high incidence of heat waves during the droughts marks several human deaths.

Droughts play an imperative role in the degradation of aquatic life due to the accumulation of high levels of pollutants, reduced water flow, higher water temperature, and reduction in the concentration of dissolved oxygen. Lower levels of water hinder recreational activities and increase the risk of injury during such activities. High temperatures, water scarcity, and dry climate trigger wildfires, consuming the native flora and fauna of the region. The water-demanding power stations face challenges to produce and maintain the supply of electricity.

Unlike other extreme weather events, such as hurricanes and tornados, the onset of drought is not sudden, which makes the identification of the start and endpoint of drought, very difficult. The initial impacts of droughts are difficult to identify, and it may take a few weeks or months to determine that drought has begun. Droughts may last for a few weeks to years. The longer period of drought implies more adverse impacts on society, the economy, and human health. Extreme water scarcity will result in the migration of more people in search of water, creating “water refugees”.

The threatful drought has burnt American West for nearly two decades. Several scientists refer to the drought as “Megadrought” and predict it to be the worst in the past 1200 years.

As with past megadroughts, the current event is driven largely by natural variations in climate. Megadroughts are defined as sporadic events of unusual severity for at least 20 years. The American West witnessed four major megadroughts in the last 1200 years, during the 800s, the mid-1100s, the 1200s, and the late 1500s. (Handwerk, 2020). Some scientists have predicted the occurrence of megadrought in the American West of 35 years or more by 2100 if global climate change occurs at a pace similar to the present time. The drought between 2000 and 2018 marks the second driest period of 19-years in the past 1200 years. Higher global temperature creates a more disastrous drought as compared to the drought that occurred in cooler temperatures. The biggest factor in intensifying the current drought into megadrought is the warming of the earth. Many climate models suggest the increase in the region’s

average temperature by 1.2°C due to several anthropogenic events. Warmer temperatures aggravate and intensify the droughts.

The two largest reservoirs of the U.S., Lake Powell, and Lake Mead are 2/3 empty and will hit the historical low of 1,065 feet by the end of 2021. Extreme and exceptional droughts are experienced in Montana, Idaho, Washington, Oregon, California, Nevada, Arizona, and New Mexico. 60% of Western U.S. is facing extreme and exceptional droughts. The ripple effect created by the dry condition can impact the entire nation as agriculture and other industries are interconnected. So, now it is quite evident that the drought in American West will stay for a very long time and the population should adapt to it by adopting several mitigation plans.

2 How did it happen?

The immediate cause of drought in the Western U.S. is the predominant sinking motion of air which consequently leads to compressional warming or high pressure inhibiting the cloud formation and resulting in lower relative humidity and decreased precipitation (Folger, 2017). The drought in the American West is also linked with the variations in sea surface temperature (SSTs). Cooler-than-average SSTs in the eastern tropical Pacific region (La Niña-like impact) illustrate a strong relationship with the everlasting drought conditions over the American West.

Climate experts predict a few other causes of the drought in the Western U.S. The main drivers of drought are thought to be natural factors such as snowpack, soil moisture, and temperatures (Jones , 2020).

The Western region mainly depends upon the snowpack for its water supplies. The snow-covered mountains in winter essentially melt during the spring season and subsequently reach the largest reservoirs of the nation, i.e., Lake Powell and Lake Mead. However, the water, obtained from the melted snow, gets absorbed by the soil during its course. The absorption rate of the soil is directly proportional to the dryness of the soil. The drier the soil, the more water it will absorb, causing the restricted flow into the reservoirs. For example, although Arizona had a substantial snowpack during 2020, the drier soil limited the flow of water into the reservoir. These conditions are aggravated by high temperatures. Higher temperatures melt the snow earlier and evaporation occurs rapidly, which causes the reduction in the water levels of the reservoirs.

Several current studies predict that the low-to-no snow winter will become a recurring phenomenon due to elevated greenhouse gas emissions, in the western U.S. between 35 and 60 years from now (Climate crisis report, 2021). The inability of snowpack to back up water shortages will necessitate the formulation and implementation of active water management.

The Sierra Nevada, Rockies, Cascades, and other mountain ranges facilitate the capturing, storing, and releasing of water for downstream utilities. Usually, snowmelt has a crucial delay time of delivering the water in spring and supplies the water in summer, when the level of precipitation is low and water stresses are high, majorly in the agriculture sector. However, the higher temperatures have depleted the formation of snowpack over the winter, causing extreme water scarcity during summers. Likewise, the warmer temperature will tend to bring more storms which will produce more rainfall and less snowfall. Studies reveal, the decrease in peak snowpack volume along with early occurrence of the timing of peak snowpack. For every 1° C of warming, the peak was estimated to occur approximately 8 days earlier in the year. Several regions such as Sierras already experienced very little snow in 2015 when the average

snowpack level was 5% of the normal, which was considered as an extreme event. “Low snow” is referred to as when the snowpack (or more precisely, the snow water equivalent, a measure of how much water will be released when the snowpack melts) is in the 30th percentile or lower of the historical peak.

As per this definition of “Low Snow”, California will witness sporadic low-to-no snow in the 2040s and persistent low-to-no snow in the 2060s. The western U.S. will face snow water equivalent deficits as compared to the historical levels.

Specifically, only 8 to 14% of years are categorized as low-to-no snow over 1950-2000, in contrast to 78% to 94% over 2050-2099. In all regions, a sudden transition will occur in the mid-to-late 21st century. The decrease in snow water is not only responsible for water crisis and droughts but may also cause an increase in the occurrence of the wildfire that will dramatically change the groundwater and surface water patterns and alter the vegetation type and density.

3 Impact of droughts on American West:

The impacts of drought are seen in most of the regions of the American West. The impacts are huge in terms of both intensity and severity.

Table 1., depicts some of the major impacts of drought on the different regions.

Sr. No.	Region	Impacts of Drought
1.	Washington	• Experienced 475 blazes so far on public land since the beginning of this year.
2.	Oregon	• High incidence of wildfires than usual. • Warm, dry spring and drought conditions. • Death of native fish having food and cultural importance.
3.	Northern Idaho	• Warm and extremely dry conditions.
4.	New Mexico	• Alteration on the flow pattern of the river. • Lower recharge of aquifers. • Loss of native vegetation and trees.
5.	California	• Risk of fires, crop damage, and interrupted electricity supply. • Loss of many acres of land due to blaze last year. • Lower production of winter wheat.
6.	Texas	• Loss of livestock and loss of cotton crop. • Dryland crops stunted. • Poor pasture conditions. • High incidence of Wildfires. • Burn bans implemented. • Dust and sand storms. • Dry soil with cracks.
7.	Arizona	• Limited forage, drying of the soil. • Plants stressed. • Drying of major water streams. • Scarcity of water and feed for livestock. • Snowpack reduction. • Skiing tourism reduction.

		• Rangers' activities disruption. • Increased incidences of forest-fires
8.	Colorado	• Reduced plant cultivation. • Mandatory water restriction implemented. • Increase in water temperature.

Table 1 Impacts of drought on Western U.S.

Source(s): NDMC, NOAA, USDA

4 Current Scenario of drought.

The effects of droughts in different regions of the U.S. change with the fluctuating temperatures. Many regions facing abnormally dry conditions can turn to severe droughts or exceptional droughts without any mitigation plans and solutions. Figure 1 below depicts recent drought conditions. The regions of Montana, Oregon, Nevada, and California experience exceptional droughts (D4). As per the latest statistics D1-D3 expanded in eastern New Mexico (U.S. drought Monitor).

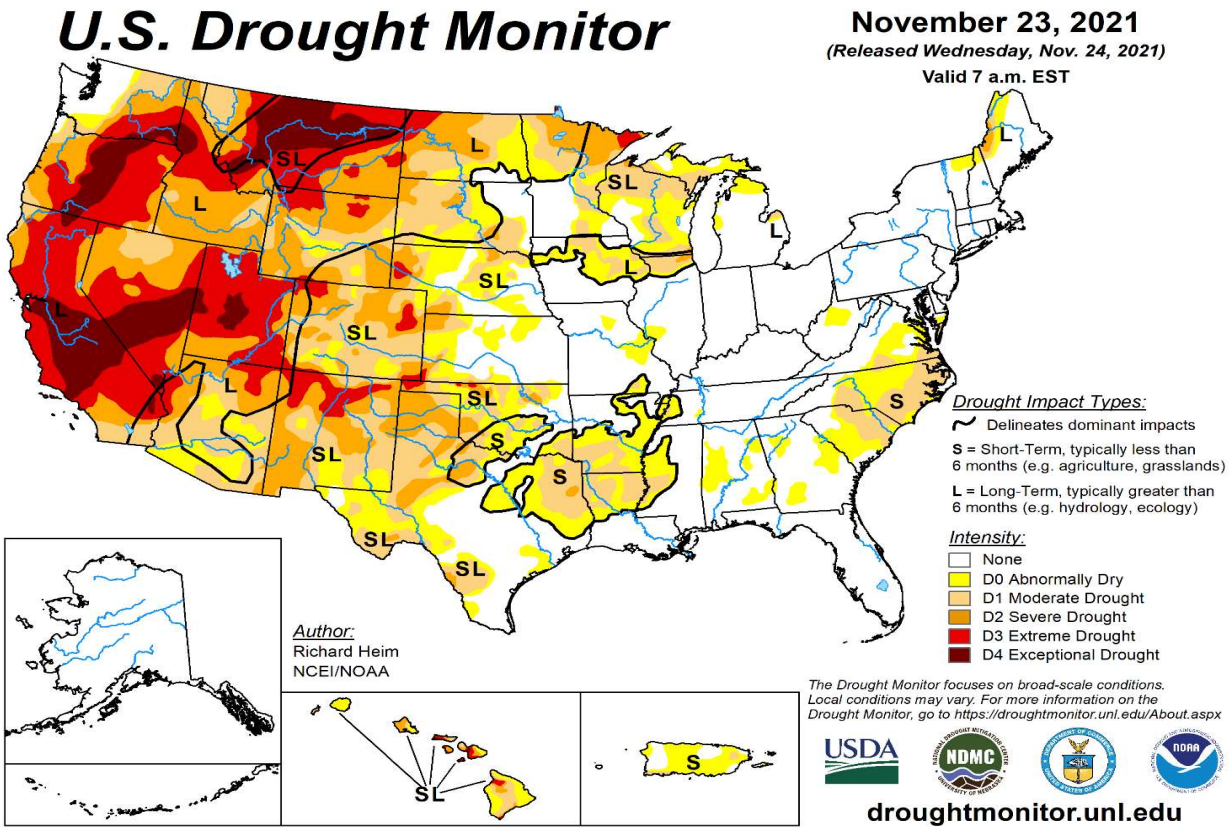

Figure 1 Drought Map

5 Water crisis in American West:

Water resources are increasingly low in the western U.S. due to the never-ending drought. The water crisis is largely attributed to:

a) Insufficient monsoon rains.

b) Shrining snowpack feeding rivers and lakes.

c) Depletion of groundwater (which was plentiful at the beginning of the 20th century).

Around 90% of the water comes from the Lake Mead reservoir on the Colorado River, which is only 36% - 38% presently full. Increasing populations have resulted in the deletion of water of the Colorado River by 23% since 2002. Many regions of the U.S. are predicted to face a reduction of 1/3 of their freshwater supply within next the 50 years. (Heggie, 2020). The river basins fed by rainwater and snow are estimated to be unable to meet the monthly water demands of the population by 2071. A serious water shortage will affect almost the whole of the U.S. Nearly, 96 out of 204 basins in western U.S. are under grave trouble. Likewise, a shortage in about 83 basins will likely occur by 2021 itself.

The extreme change in the pattern of precipitation due to climate change has caused, the wetter areas (majorly the northern U.S.) to be wetter drier regions to be drier. The regions with the projected increase in precipitation will have more intense concentrations of rainfall that are difficult to capture and use.

Several studies indicates higher temperatures (about 5.7°C warmer by 2050), which will result in higher evaporation from lakes, reservoirs, and rivers straining the water resources still further. This will undoubtedly impacts the supply of water.

Figure 2, given below depicts the water stress in the U.S. (where 0.1-0.2 shows low water supply stress index and 1.1-6.4 shows high water supply stress index. The water supply stress index refers to the ratio of water demand in all sectors to the total water supply from ground and surface water.

Figure 2 Water Stress in U.S.

Source: Averyt, K., Harriss, R., Newmark, R., Rose, S. K., Shevliakova, E., & Tidwell, V. (2014). Energy, Water, and Land Use. In J. M. Melillo, T. Richmond, & G. Yohe (Eds.), Climate Change Impacts in the United States: The Third National Climate Assessment. USGCRP GCIS. Retrieved from http://nca2014.globalchange.gov/report/sectors/energy-water-and-land

6 Government Directives

The U.S. has now officially declared a massive water shortage in the Lake Mead reservoir, which will trigger supply cuts in drought-stricken Southwest (Groom, 2021). The U.S. Bureau of Reclamation warned against the reduction in water distribution to Arizona, Nevada, and Mexico for the year beginning in October.

Arizona will face a loss of 18% of its yearly apportionment, Nevada will witness a cut of 7%, while Mexico will suffer from a cut of 5%. Lake Mead provides water to 25 million people in Arizona, Nevada, California, and Mexico, but its levels are dangerously low. Arizona and Nevada will face mandatory water cutbacks in January 2022. These water cuts will be triggered when the water levels fall below a threshold of 328 meters above sea level. Many hydrologists predict the drop of water in the reservoir by 325 meters by January. Similarly, A UN report warns the growing and intensification of drought with more warming of the planet. The water cut-off in California (Central Valley and Russian Watershed) began in October 2021.

These cuts will largely impact the farmers and the state will lose about 1/5 of the water they used to get earlier from the river (Morgan , 2021). These farmers are majorly involved in livestock rearing, dairy, alfalfa, wheat, and barley production. This would result in the need for more fallow land and more dependence on groundwater - the levels of which are already dwindled.

Hoover Dam, which forms the Lake Mead reservoir, generates 2000, megawatts of hydropower enough to supply electricity to about 8 million people. However, due to the reduction in water levels, the Hoover Dam could only generate electricity of 1500 megawatts, a nearly 25% drop. This decline would impact the region of California, Arizona, and Nevada. Recently, on thanksgiving occasion, power cuts for two days were declared for southern Californians due to the risk of wildfire. It affected nearly 200,000 customers. (Jacobo & Deliso, 2021)

Figure 3, given under depicts the water levels in reclamation reservoirs currently.

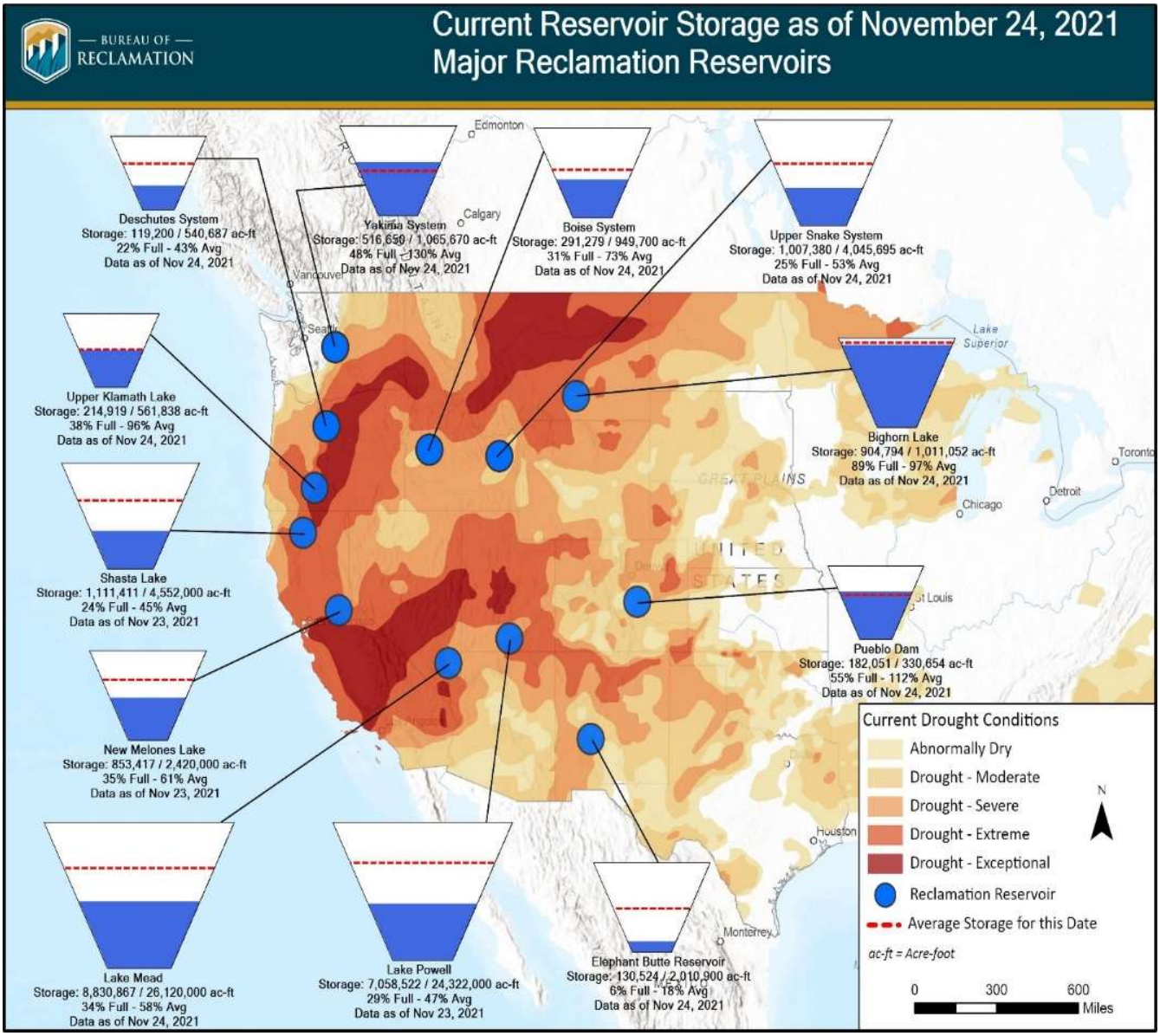

Figure 3 Water Levels of Reclamation Reservoirs

Source: Bureau of Reclamation, 2020

7 Adaptation and Mitigation

The first and foremost measure to combat the drought and intensive water crisis is "Conservation of Water" at individual levels as well as in different economic sectors. The conservation on individual levels involves

- Recycling of indoor water.
- Minimizing the wastage of water in bathrooms, kitchens, and laundry fixing any leaks.
- Setting stringent conservation goals (for example, utilization of only 40 gallons of water per person per day for indoor water uses.

- Utilization of drip irrigation system for landscaping.
- Harvesting the rainwater for landscaping.
- Employing adjustable nozzle or sprayer to regulate the water flow during washing of vehicles.

Agriculture has the maximum consumptive utilization of water of around 80 to 90% in the U.S. (Water footprint Calculator, 2020) with maximum losses. The conservation of water in the agricultural sector involves the following:

- Well-structuring of the soil to improve the water infiltration rate.
- Selection and cultivation of native drought-tolerant plants requiring less water to grow.
- Plantation of cover crops.
- Trapping of the surface water.
- Reducing evaporation and runoff.
- Recycling of the tailwater (i.e. water that drains to the lower sections of fields) back to fields.
- Utilization of the scientific approach of predicting the accurate timing and amount of water required by a particular crop to improve the yield and conserve water.
- Application of polyacrylamides (PAM) to the soil to improve the physical and hydraulic properties of soil and minimizes soil erosion.
- Laser levelling off the field to achieve uniform infiltration and decrease the runoff.
- Capturing rainwater and stormwater for irrigation and other purposes.

Likewise, conservation of water by recycling and reuse in several industries plays an imperative role in combating the water crisis.

Bureau of Reclamation, U.S. has developed and implemented many mitigation plans and projects to ease the impacts of drought. A Drought Response Program developed by the Bureau has a proactive approach against drought. It aids the water consumers for the drought contingency planning and acts to create a drought-resilient society. Bureau of Reclamation provides financial assistance to the ones, developing the drought contingency plans. It also funds several projects concerning drought resilience. Few of the Reclamation Projects (not limited to) undertaken to build a drought-resilient society is as listed under (Source: Bureau of Reclamation – Addressing Drought across West):

7.1 New water Supplies:

The projects concerning the new water supplies are intended to provide clean and sufficient water during times of drought. These projects aim to develop new storage techniques and infrastructure to lower the dependence on declining water sources. Currently, Reclamation has nearly 350 active construction sites to develop delivery systems and storage, dams, other major repairs and substitution works, and recreation rehabilitation events.

For example, Cle Elum Pool Raise Project aims to provide an additional water conservation approach for aquatic life, fish habitat, and fish migration. Similarly, Navajo Gallup Project has a goal of replacing the dwindling groundwater of north-eastern New Mexico with fresh water supplies, to provide water to parts of the Navajo region that earlier has no water system.

7.2 Reservoir operations:

These operations involve the reservoir managers who regulate and optimize the storage of water to address the needs of the population as well as maintain sufficient space in the reservoir to achieve

substantial flood management and control. Weather forecast plays a vital role in determining the flood control space in the reservoir. Likewise, the adjustment of timing and volume of the water release during the drought serves as a short-term mitigation plan while modification in the reservoir operations can largely respond to drought on a long-term basis.

For example, the Shasta Dam Temperature control device (TCD) acts as a reservoir operational tool during the drought. Shasta Dam is quite important for providing water to the central valley (California) for various purposes such as irrigation, industries, municipal, and other sanitary control. The TCD draws the water from different depths in the lake, allowing the use of warmer surface water earlier in the season and conserving the cold water for river temperature control later in the year.

7.3 Hydropower generation and stability:

Hydropower is critical in maintaining and stabilizing the electrical power supply throughout the West. On average, Reclamation provides 40 million megawatt-hours of electricity annually. To sustain the generation of hydropower during the drought, it is crucial to optimize the amount of power that can be produced from the water available.

For example, the Hydropower optimization system (HydroS) of Reclamation, improves the reclamation abilities by enhancing the power output along with conservation of water.

7.4 Water conservation:

Apart from several conservation measures (discussed above), Reclamation actively supports and enhances the water conservation operations. Various water conservation and efficiency projects help to maintain water supplies during droughts. These projects largely function on a wide range of water management activities such as lining or pipping of canals, installation of advanced measuring devices, automation in the irrigation system, installation of residential water meters, and practices that reduce urban water use.

For example, The Desert Water Agency in south California is involved in the installation of 8711 manual read residential meters, with encoder receiver transmitters that offer the consumers near real-time water usage data, including the leak detection in the system. The project aims to achieve the annual water savings of 1294 acre-feet, which will help the areas to cope with the ill impacts of drought, dwindling groundwater, and population growth.

7.5 Water Reuse:

Water recycling projects offer a local source of water that elevates flexibility during times of water scarcity. These projects are involved in the reclamation and reuse of wastewater, which is considered a drought-resistant supply of water, as the amount of wastewater continues to be available even during periods of water shortage. Bureau of Reclamation provides several grants for such projects.

For example, Reclamation provides grants through Water Reclamation and Reuse Program (XVI) that reclaims and reuse wastewater, spoiled groundwater, and surface water. Likewise, El Paso Water Utilities Public Service Board is involved in the construction of a first-large scale direct-potable-water reuse project that is expected to generate 13,000 acre-feet water annually, which will efficiently save the surface water and groundwater.

7.5.1 Biotechnologies:

Apart from various Reclamation projects for water reuse, several biological solutions must also be incorporated. These solutions are green, eco-friendly, low maintenance-requiring systems lowering the wastewater generation, and are very efficient. Few of such bio-solutions (not limited to) which converts the wastewater into a valuable resource are as listed under:

- **Microbial fuel Cell Technology (MFC) – generation of electricity from wastewater:**

  According to USEPA, an estimated average daily wastewater flows of approximately 50 to 70 gallons per person per day. In North America, approximately 85 cubic kilometers (A cubic kilometer is 1 trillion liters — about 220 billion US gallons) of wastewater generated each year out of which 61 cubic kilometers (75%) is treated. Yearly only 2.3 cubic kilometers or 3.8% of that treated wastewater is used. MFC can serve as an innovative technique to reuse the wastewater to generate electricity to offset the pressure on the energy grid and compensate for the loss of hydroelectricity due to droughts. This is a very promising technique but under a pilot-scale research phase.

  Principle of MFC:

  Utilization of catalytic mechanism of microbes for conversion of stored energy in chemical bonds of organic and inorganic compounds to electrical energy through redox reaction where electrons are transferred to a terminal electron acceptor to generate electricity. (Agrawal, N, Kumar, Chaturvedi, & Verma, 2019)

  Advantages of MFC:

  - Generation of energy from organic waste.
  - Direct conversion of substrate to electricity.
  - Reduced emission of GHGs.
  - Self-generation of microbes.
  - Resistance to environmental stress.
  - Low carbon footprint.

- **Indoor water recycling – Green Roof Technology:**

  The site for incorporation of this technology includes rooftops of individual houses, skyscrapers, empty places in the region. The prime purpose of this technology is to minimize indoor wastewater generation by converting it into something valuable and resourceful, thereby, creating innovative green infrastructure (GI). Innovative Green Infrastructure (GI) not only supports the recycling of the wastewater by also facilities pollination, water purification, increasing aesthetic beauty, and climate regulation.

  One such GI technology involves green roof technology.

  Principle of green roofing:

  A green roof can be defined as the system of roofing that utilizes plant life for covering the roof instead of the conventional covering compounds and can be developed using wastewater. The wastewater undergoes purification by biological (bacteriological) means.

  Creation of green roof technology:

  The green roof comprises several layers, including plants, growing media, cloth/filter membrane, drainage, and waterproof membrane. The layers house natural microbes which aid the purification of the water. The construction of the green roof and selection of the plants relies on

the type of house/building, type of roof, etc. Flat, as well as sloped roofs, are suitable for the creation of green roofs. It uses either a Horizontal subsurface flow system (SFS-H) or a Vertical subsurface flow system (SFS-V) wherein the water flows in horizontally and vertically fashion respectively within the green roof system. Both systems utilize a slightly varied medium in the terms of thickness.

The process:

The grey water (from the kitchen, bathroom, laundry (except toilet) after passing through the grease trap and sump tank, is pumped to the roof to water the plants on the roof. The treated water drained from the green roof can then be efficiently used in toilet flushing, laundry, landscaping, and garden irrigation. The system involves the installation of a photovoltaic system on the part of the roof.

Advantages of green roof technology:

- Provides excellent insulation to the house/building reducing heating and cooling costs by 50%,
- Act as an efficient natural filter for rainwater reducing the amount of rain drainage, extremely durable systems.
- Environmentally friendly.
- Requires no repairs - unlike many other roofing systems.
- Elevates absorption of air pollutants such as carbon dioxide by plants.
- Lowers the urban temperature and reducing the heat island effect.
- Attracts more honeybees, butterflies and birds otherwise difficult to see in concrete jungles.
- Improves the aesthetic beauty of the building.
- Recycles the water.
- Helps in water conservation.
- Alleviates the stress on the sewers.
- Reduces the wastage of water.

7.6 Diversify water Supply:

Expanding and developing alternative means of water supply improves the water supply dependability and creates resilience against drought. The projects under this category function to install pipes to provide water from alternative sources or help in the voluntary transfer of water during the drought.

For example, Reclamation is providing the grant to Arvin-Edison Water Storage District, (Kern County, in California) to construct intertie between the District and Kern Delta Water District to provide a supplementary annual water supply of nearly 1900 acre-feet. These projects lower the shortage of water locally and provide the water transfer possibility between the districts.

7.7 Planning and Science:

Reclamation is dynamically involved in the cooperative efforts to conduct the water supply planning and to develop science, technology, and tools to tackle drought. Reclamation supports the ones involved in drought contingency planning, basin-water supply and demand management, and the development of watershed strategies. It also aids the development of science and technology for water desalination, water purification, etc.

For example, Reclamation supports the approach to measure and monitor reservoir evaporation to address drought impacts.

8 Conclusion:

The droughts in the American West are here to stay for a longer period and it is not just a matter of a few years. The consistent climate changes will only aggravate the drought conditions, impacting the major population of the U.S. very soon. The freshwater resources, as evident are rapidly dwindling and are unable to replenish to meet the ever-increasing demands of the population. The entire hydrological cycle is disrupted by the highly fluctuating environmental conditions. The only way to safeguard the water, combat the drought conditions and utilize the water for various purposes is to either preserve the available water or recycle the water as much as possible.

The efficient indoor recycling of the water should be done more stringently and adequately coupled with a willingness and awareness of the resident. Likewise, the wastage of the water must be avoided by adopting several techniques at the individual house and community level. However, the wastewater should not be considered as waste but as a valuable resource for generating electricity to compensate for the loss of hydroelectricity due to drought conditions.

Several bans and fines will become more frequent to minimize the wastage of water along with the water cuts by the government to conserve and protect the potable water.

Out of several water management solutions, MFC and green roof technology can prove to be quite efficient in drought-prone regions. Although the climate crisis has pushed the world towards extreme weather events to the limit where there is no point of return, innovative and integrated water solutions can help to adapt to droughts in American West.

9 References

Jacobo , J., & Deliso, M. (2021). *More than 200,000 Californians could be without power on Thanksgiving.* abc news. Retrieved from https://abcnews.go.com/US/200000-calfornians-power-thanksgiving/story?id=81376371

Agrawal, K., N, B., Kumar, B., Chaturvedi, V., & Verma, P. (2019). Microbial Fuel Cell: A Boon in Bioremediation of wastes. In M. w. treatment, M. P. Shah, & S. Rodriguez-Couto (Eds.), *Microbial biodegrdation and Remediation.* Elsevier Inc.

Climate crisis report. (2021). *Climate Survival Scenarios: Adapting to the Shrinking Mountain Snowpacks of the Future.* Trillions Intelligence Network. Retrieved from https://www.trillions.biz/news/171658-Climate-Survival-Scenarios--Adapting-to-the-Shrinking-Mountain-Snowpacks-of-the-Future.html

Folger, P. (2017). *Drought in the United States: Causes and Current Understanding.* Congressional Research Service.

Groom, N. (2021). *U.S. declares first Western reservoir water shortage, triggering cuts.* Reuters. Retrieved from https://www.reuters.com/world/us/us-declares-first-ever-shortage-western-reservoir-triggering-water-cuts-2021-08-16/

Handwerk, B. (2020). *The American West May Be Entering a 'Megadrought' Worse Than Any in Historical Record.* Smithsonian Magazine. Retrieved from https://www.smithsonianmag.com/science-nature/american-west-may-be-entering-megadrought-worse-any-historical-record-180974688/

Heggie, J. (2020). *Why is America running out of water?* National Geographic. Retrieved from https://www.nationalgeographic.com/science/article/partner-content-americas-looming-water-crisis

Jones , C. (2020). *What's causing the drought in the West — and why it's so bad.* PBS news hour. Retrieved from https://www.pbs.org/newshour/science/whats-causing-the-drought-in-the-west-and-why-its-so-bad

Morgan , M.-J. (2021). *Water cuts are coming to Arizona and Nevada after the US declared the first-ever Colorado River water shortage.* Business Insider. Retrieved from https://www.businessinsider.in/science/news/water-cuts-are-coming-to-arizona-and-nevada-after-the-us-declared-the-first-ever-colorado-river-water-shortage/articleshow/85389560.cms

Water footprint Calculator. (2020). *Food's Big Water Footprint.* Water footprint calculator.