Dam Development and Disasters in Nigeria

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ABSTRACT

Nigeria has abundant surface water bodies and good dam sites that could be utilized for dam construction to create reservoirs for various water uses including hydropower generation, flood control, water supply, irrigation, navigation, tourism, sanitation, fish and wild life development and ground water recharge. Dam development and disasters on people and the environment were examined. Various parts of our country are presently seriously ravaged by flooding. Moreover, impacts of dams and dam failures in the past were outlined. Various causes of dam failure were enumerated. Recommendations on how to avert future dam disasters in our country were also captured.

Keywords: dam, reservoir, disaster, impacts, flooding

1. Introduction

Water is a critical natural resource. Without it, life could not exist and people could not survive [1]. For more than 5000 years, dams have provided people with reliable sources of water for their survival. A dam is a barrier across flowing water that obstructs, directs or slows down the flow, often creating a reservoir, lake or impoundments [2]. Most dams have a section called a spillway or a weir over which, or through which, water flows either intermittently or continuously, and some have hydroelectric power generating systems installed. A dam- reservoir facility provides numerous benefits including generating electricity, direct water from rivers to canals, and irrigation and water supply systems, increase river depths for navigational purposes, to control water flow during times of flood and droughts, create artificial lakes for fisheries and recreational use, ground water recharge, etc. Many dams are multipurpose and fulfill several of these reasons.

Dam failures are comparatively rare, but can cause immense damage and loss of life when they occur. In 1975, the other dam failure in the failure of the Banqiao Reservoir Dam and other dams in Henan Province, China caused more casualties than any other dam failure in history. The disaster killed an estimated 170,000 people [3] and 11 million people lost their homes. Dam destruction is one of the greatest man-made disasters that can instantly generate casualties and will bring about disastrous consequences.

Dams and reservoirs in Nigeria are of particular importance in the north of the country, where rainfall is low. The construction of dams of appreciable heights and storage capacity became possible after the development of cement concrete and the mechanization of earth-moving and material handling equipment. The last century witnessed a dramatic increase in the construction of large dams. By 1994, about 5000 large dams had been built worldwide, three-quarter of them in industrialized countries. Today, over 45,000 large dam had been built in over 140 countries of the world [4]. The top five dam-building countries are China, United States, India, Spain and Japan and they account for nearly 80% of all large dams worldwide. China alone has built 22,000 large dams, the USA over 6390 large dams, India with over 4000 dams and Spain and Japan with between 1000 and 1200 dams each.

Nigeria has witnessed an upsurge in dam construction in the past three decades. Over 323 dams have been constructed in Nigeria and many more are under construction in different parts of the country. Between 1970 and 1995, 246 dams were constructed in Nigeria. The effect of the Sahelian drought of 1972-1975 aggravated the food shortage in the country prompting the various levels of government to embark on a rigorous policy to increase food production. To achieve this, impoundment of river basins was seen as inevitable to provide sufficient water for year-round irrigation which led to the construction of over 246 dams [5].

One thing is clear, that in the process of using surface waters for development, man has interfered so much with streams, rivers and lakes that now they can hardly be described as natural. It is also no doubt that dams have contributed to the economic growth of many nations. The numerous dams built round the world have played important role in helping communities and economies harness water resources for several uses. An estimated 30-40% of irrigated land worldwide now relies on dams and that dams generate 19% of world electricity [6]. However, these services are being provided not without a cost being paid for them.

2. Impacts of Dams

2.1 Ecological impact

The World Commission on Dams [6] reported that 60% of the World Rivers have been affected by dams and diversions. The impact of dams on the ecosystem include the physical, chemical and geomorphologic changes that occur when a river is blocked and altering the natural distribution and timing of stream flow. Dam construction also causes changes in primary biological productivity including effect on riverine riparian plant life and downstream habitat. The construction of storage dam and the subsequent inundation of the reservoir area effectively kill terrestrial plants and forest and displace animals [6]. Dam construction results in decrease in water quality and variable changes in the seasonal timing of water yield [7]. A dam also acts as a barrier between the upstream and downstream movement of migratory river animals, such as salmon and trout [8]. The depletion of groundwater aquifers, which is caused by the suppression of the seasonal flood cycle, is damaging the forests downstream of the dam [9].

2.2 Emission of Greenhouse Gases (GHG)

Reservoirs can also contribute to greenhouse gas emissions [10]. The emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflow from the catchments is a recently identified ecosystem impact of storage dams. Estimate suggests that the gross emissions from reservoirs may account for between 1% and 28% of the global warming potential of GHG emissions [6]. This challenges the conventional ideal that hydropower produces only positive atmospheric effects such as a reduction in emissions of carbon dioxide, nitrous oxides, sulphuric oxides and particulate when compared with other power generation sources that burn fossil fuels [11]. This implies that all reservoirs emit GHG.

2.3 Alteration of flow Regime

Storage dam alter the natural distribution and timing of stream flow. Flow regimes are the key driving variable for downstream aquatic ecosystem. Flood timing, duration and frequency are all critical for the survival of communities of plants and animals living downstream. Impoundments may result in a variety of downstream modifications that may be important to its physico-chemical conditions and the stream biota. The specific changes that

occur when a river is dammed depend on a complex series of interactions resulting from operation and construction of dams [12]. These changes compromise the dynamic aspects of rivers that are fundamental to maintaining the character of aquatic ecosystem.

2.4 Biodiversity Loss

Dams have led to the loss of aquatic biodiversity, loss of forest and wildlife habitat and species population. Dams disrupt the movement of species leading to changes in upstream and downstream species composition. Many river-dwelling species have several migratory patterns. For example, adult of anadromous fish such as salmon migrate upstream to spawn and the young descend. While for catadromous fish such as the eels, the adult migrate downstream and the young ascend upstream. Dams block these migrations. This is one of the most significant ecosystem impacts. Change in the physico-chemical properties of water bodies due to dam may lead directly to the death of aquatic biota [6].

2.5 Social Impact

The lives of many people and societies have been negatively affected by dams. An estimated 40-80 million people worldwide have been physically displaced by dam [6]. In China alone, 10.2 million people were displaced between 1950 and 1990 [13]. Though, independent source estimated that actual number is much higher than the official figure with 10 million people displaced in Yangtz Valley alone [14]. Among the project involving displacement funded by the World Bank, large dams account for 63% of displacement [15]. Indigenous people and ethnic minority suffer disproportionately as they lack citizenship, tenancy or land tenure papers.

The failure of dams has also led to displacement of many people, and even in many cases cause the death of some. In Nigeria, the Ojirami dam in Southern Nigeria, failed in 1980 and affected two communities, Enwan and Akuku. Many people in Enwan and Akuku communities lost their houses and other property worth millions of naira to the huge flood plunging the communities into serious housing problems. Those who once lived in their houses have been forced to relocate and now live in rented houses. It also led too the problem of overcrowding in many houses. Up to 30 persons living in houses meant for 10 persons [16].

2.6 Gender-Related Impacts

It has been extensively documented that there is gender inequalities in access and control of economic and natural resources. In Asia and Africa, women may not have the right to use land and forest but are rarely allowed to own or inherit the land they use [17]. For affected communities, dams have widened gender disparities either by imposing a disproportionate share of social cost on women or through an inequitable allocation of the benefits generated. For instance, when the Mahawell dam in Sri Lanka was built, the prevailing rule which allowed women the independent right to co-own and control land was undermined by a new arrangement that allow the household to nominate one heir usually a son [18].

2.7 Impact of Cultural Heritage

Dams have adversely affected the cultural heritage of many communities through loss of cultural resources (temple, shrines, and sacred elements of the landscape, artifacts and buildings). The submergence and degradation of archeological resources (plants and animals remains, burial sites and archeological elements are other significant cultural impacts of dams. Dams can also cause loss of or damage of cultural heritage through land reclamation and irrigation project. During the construction of the Inanda dam in South Africa, remains of human bodies buried under the reservoir site were exhumed and all buried in one hole profoundly disturbing local communities [19]. The risk of submerging ancestral graves is one of the reasons the Himba people in Namibia opposed the planned Epupa dam [6].

2.8 Health Related Impacts

Environmental change and social disruption resulting from the construction and operation of large dams and the associated infrastructure developments such as irrigation schemes can have significant adverse health outcomes for local populations and downstream communities. Among the resettled, access to drinking water, health services and ability to cope with new social and physical environment determines health conditions. Numerous vector-borne diseases are associated with reservoir development in tropical areas. Schistosomiasis (or Bilharzias), for instance, spread through snails breeding in still or slow moving waters was a significant public health problem that emerged from many water development projects.

Out of the 323 dams in Nigeria, 47 (15%) have been surveyed for the presence of local snail intermediate host species of schistosomiasis, while 11 were investigated for human infection. Findings shows that 20 (43%) of the 47 dams harbour the intermediate host of the disease. Human infection was recorded in 10 out of the 11 investigated for human infection [20]. Rift valley fever has also spread due to the presence of Aswan and Kariba dams and irrigation systems along the Blue Nile in Sudan [21]. Most reservoirs and irrigation projects undertaken in malaria endermic areas increase malaria transmission and disease. The increase was more pronounced for dams below 1900 meters of altitude and less pronounced above that altitude [22].

3. Dam Disasters In Nigeria

There have been several cases of dam-related disasters in Nigeria displacing thousands of people and plunging them into poverty and destroying properties.

3.1 Shiroro Dam

Over 26 villages in Kede, Lakpma and Shiroro Local Government in Niger State were flooded by the waters from Rivers Niger and Kaduna in 2003. The flood displaced about 10,000 persons in Ketsho in Kede Local Government who were said to have moved to Kwara state, while other 13,500 persons in Lakpam and Shiroro were rendered homeless. In the affected areas, houses, property, farm produce and animals were destroyed by the flood which struck in the early hours of Saturday 11th September, 2003. The flood resulted from a downpour and release of excess water from the Shiroro Hydro-Electric Dam by the National Electric Power Authority (NEPA). The affected villages include Galadima Kogo, Gofa, Kusasun, Pai, Lagodo, Nakapinda and Karai. The people suffered for the sacrifice they made by releasing their land for the construction of the Shiroro Dam for the good of the nation. [23].

Similarly in 1999 at least seven local government districts in the state were flooded when water from the Shiroro Dam was released. Thousands of houses and buildings in the state, including schools and hospitals were either destroyed or damaged in the disaster. Eight people were killed and 2,215 displaced in flooding in Kano State, in Northern Nigeria.

3.2 Obudu Dam

The Obudu Dam spillway was damaged by storm in July 2003 which resulted in fatal disaster that claimed over 200 houses, several farmlands, settlements and business concerns. The disaster was allegedly caused by the release of excess water from the Lagdo Dam in Cameroun, which overflowed Benue and Niger banks. Besides the release of excess water from Lagdo Dam, experts attributed the disaster to intensive and non-stop rainfall in Obudu on the fateful day for 16 hours. The rainfall recorded at the Obudu Dam meteorological station was 314.5mm, more than 15 years average rainfall for the peak months of July and September, which was not anticipated when the dam was constructed. The cumulative effect of these events led to the overflow of all water courses including the ones leading to Obudu Dam. The excessive flood discharge and load on spillway channel led to the failure of the dam.

Then, the estimated cost of rehabilitating the dam and completing the outstanding works on the irrigation area was valued at about N350m (approximately $2.8m). The dam was commissioned in 1999 to provide water for irrigation to indigenes of the area that are predominantly farmers as well as serves recreational and tourism purposes. It was also constructed to create employment to the youths through fishing. The people forwarded an appeal to the government to urgently come to their rescue. They expressed the fear that if the spillway was not rehabilitated before the next rainy season, the entire Obudu may be taken-over by flood [24].

3.3 Igabi Dam

Property worth about N500 million ($3.9m) were destroyed while thousands of people were rendered homeless in Kaduna State when River Kaduna overflowed its banks and submerges several streets and housing estates. The flood was caused by the collapse of Igabi Dam. Affected by the flood ar Mammam Kotangora Estate, Kirgo Road extension, Kabala area and parts of Malali Estate. At the Mamman Kotangora Estate, household items including rugs, television sets, fridges, chairs, tables and other expensive electronics were damaged when water from the river submerged most of the houses there. Several mechanic workshops, grocery store and pharmaceutical shops were also submerged.

At Kirgo area, apart from household items, maize and sugar cane farms were also destroyed. It was learnt that a manual irrigation system constructed by some farmers in the area made it possible for the river water to submerge places like Mamman Kotangora Estate and Kabala area. Apart from churches and mosques which were destroyed, the Nsukka town hall located at Kirgo Road extension was also affected.

Some Reported Recent Dam Disasters in Nigeria

August 30, 2012- Punch Newspapers reported "Five women have so far delivered babies successfully, while 57 pregnant women have so far been registered in Internally Displaced People Camps in Adamawa State". The camps were set up for persons displaced by the flooding caused by the release of water from Lagdo Dam in Cameroon Republic.

3.4 Eleyele Dam Disaster

This was reported by African Outlook thus: " Nigerian floods: Ibadan reflects on Eleyele dam tragedy". After six hours of torrential rain, the Eleyele dam, which provided drinking water to the Nigerian City of Ibadan could hold back the flow no longer.

3.5 Gusau Dam Disaster

Gusau dam collapsed on September 30, 2006 after heavy flooding. Forty persons were killed and approximately 500 homes were destroyed, displacing 1000 people.

3.6 Warawa Dam Disaster

- This took place on September 14, 20012. Numerous communities in Kano state were submerged following the collapse of the Warawa dam.

Main causes of dam failure

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Common causes of dam failure include:

- Sub-standard construction materials/techniques (Gleno Dam)
- Spillway design error (South Fork Dam, near failure of Glen Canyon Dam)

- Geological instability caused by changes to water levels during filling or poor surveying (Malpasset).
- Sliding of a mountain into the reservoir (Vaiont Dam – not exactly a dam failure, but caused nearly the entire volume of said reservoir to be displaced and overtop the dam)
- Poor maintenance, especially of outlet pipes (Lawn Lake Dam, Val di Stava Dam collapse)
- Extreme inflow (Shakidor Dam)
- Human, computer or design error (Buffalo Creek Flood, Dale Dike Reservoir, Taum Sauk pumped storage plant)
- Internal erosion, especially in earthen dams.
- Earthquake

Deliberate dam failure

A notable case of deliberate dam failure (prior to the Humanitarian Law rulings) was the British Royal Air Force Dambusters raid on Germany in World War II (codenamed *"Operation Chastise"*), in which three German dams were selected to be breached in order to impact on German infrastructure and manufacturing and power capabilities deriving from the Ruhr and Eder rivers. This raid later became the basis for several films.

List of major dam failures

Dam/incident	Year	Location	Details
Marib Dam	575	Sheba, Yemen	Unknown (possibly neglect)
Pantano de Puentes	1802	Lorca, Spain	608 deaths, 1800 houses and 40000 trees destroyed.
Dale Dike Reservoir	1864	South Yorkshire, England, United Kingdom	Defective construction, small leak in wall grew until dam failed.
South Fork Dam	1889	Johnstown, Pennsylvania, United States	Blamed locally on poor maintenance by owners; court deemed it an "Act of God". Followed exceptionally heavy rainfall. Caused Johnstown flood.
Walnut Grove Dam	1890	Wickenburg, Arizona Territory, United States	Heavy snow and rain following public calls by the dam's chief engineer to strengthen the earthen structure.

Dam/incident	Year	Location	Details
McDonald Dam	1900	Texas, United States	Extreme current caused failure.
Hauser Dam	1908	Helena, Montana, United States	Heavy flooding coupled with poor foundation quality
Austin Dam	1911	Austin, Pennsylvania, United States	Poor design, use of dynamite to remedy structural problems.
Desná Dam	1916	Desná, Austria-Hungary (now Czech Republic)	Construction flaws caused the dam failure
Lake Toxaway Dam	1916	Transylvania County, North Carolina	Heavy rains caused the dam to give way. Dam was later rebuilt in the 1960s
Sweetwater Dam	1916	San Diego County, California	Over-topped from flooding
Lower Otay Dam	1916	San Diego County, California	Over-topped from flooding; 40 deaths
Gleno Dam	1923	Province of Bergamo, Italy	Poor construction and design
Llyn Eigiau dam and the outflow also destroyed Coedty reservoir dam.	1925	Dolgarrog, North Wales, UK	Contractor blamed cost-cutting in construction but 25" of rain had fallen in preceding 5 days. This was the last dam failure to cause death in the UK to date (2010).
St. Francis Dam	1928	Valencia, California, Los Angeles County, United States	Geological instability of canyon wall that could not have been detected with available technology of the time, combined with human error that assessed developing cracks as "normal" for a dam of that type.
Nanty Gro	1942	Nanty Gro Valley,	Destroyed during preparation for Operation

Dam/incident	Year	Location	Details
Reservoir in Wales		Wales	Chastise in World War II.
Eder, Möhne Dams	1943	Eder Valley, Ruhr, Germany	Destroyed by bombing during Operation Chastise in World War II.
Vega de Tera	1959	Ribadelago, Spain	144 deaths.
Malpasset	1959	Côte d'Azur, France	Geological fault possibly enhanced by explosives work during construction; initial geo-study was not thorough. Over 400 deaths.
Baldwin Hills Reservoir	1963	Los Angeles, California, United States	Subsidence caused by over-exploitation of local oil field
Spaulding Pond Dam (Mohegan Park)	1963	Norwich, Connecticut, United States	6 deaths, more than $6 million estimated damages
Vaiont Dam	1963	Italy	Strictly not a dam failure, since the dam structure did not collapse and is still standing. Filling the reservoir caused geological failure in valley wall, leading to 110 km/h landslide into the lake; water escaped in a seiche over the top of dam. Valley had been incorrectly assessed stable.
Mina Plakalnitsa, (Vratsa)	1966	Vratsa, Bulgaria	A tailings dam at Plakalnitsa copper mine near the city of Vratsa failed. A total 450,000 cu m of mud and water inundated Vratsa and the nearby village of Zgorigrad, which suffered widespread damage. The official death toll is 107, but the unofficial estimate is around 500 killed.
Buffalo Creek Flood	1972	West Virginia, United States	Unstable loose constructed dam created by local coal mining company, collapsed in heavy rain

Dam/incident	Year	Location	Details
Canyon Lake Dam	1972	South Dakota, United States	Flooding, dam outlets flooded with debris.
Banqiao and Shimantan Dams	1975	China	Extreme rainfall beyond the planned design capability of the dam. Worst dam failure with more than 100,000 dead.
Teton Dam	1976	Idaho, United States	Water leakage through earthen wall, leading to dam failure.
Laurel Run Dam	1977	Johnstown, Pennsylvania, United States	Heavy rainfall and flooding that over-topped the dam.
Kelly Barnes Dam	1977	Georgia, United States	Unknown, possibly design error as dam was raised several times by owners to improve power generation.
Machchu-2 Dam	1979	Morbi, Gujarat, India	Heavy rain and flooding beyond spillway capacity. Between 1,800 and 15,000 dead.
Wadi Qattara Dam	1979	Benghazi, Libya	Flooding beyond discharge and storage capacity damaged the main dam and destroyed the secondary dam in the scheme.
Lawn Lake Dam	1982	Rocky Mountain National Park, United States	Outlet pipe erosion; dam under-maintained due to location
Tous Dam	1982	Valencia, Spain	
Val di Stava Dam collapse	1985	Italy	Poor maintenance and low margin for error in design; outlet pipes failed leading to pressure on dam.
Upriver Dam	1986	Washington state, United States	Lightning struck power system, turbines shut down. Water rose behind dam while trying to restart. Backup power systems failed, could not raise spillway gates in

Dam/incident	Year	Location	Details
			time. Dam overtopped (rebuilt).
Peruća Dam detonation	1993	Croatia	Not strictly a dam failure as there was a detonation of pre-positioned explosives by retreating Serb Forces.
Saguenay Flood	1996	Quebec, Canada	Problems started after two weeks of constant rain, which severely engorged soils, rivers and reservoirs. Post-flood enquiries discovered that the network of dikes and dams protecting the city was poorly maintained.
Meadow Pond Dam	1996	New Hampshire, United States	Design and construction deficiencies resulted in failure in heavy icing conditions
Opuha Dam	1997	New Zealand	Heavy rain during construction caused failure, dam was later completed
Vodní nádrž Soběnov	2002	Soběnov, Czech Republic	Extreme rainfall during the 2002 European floods
Zeyzoun Dam	2002	Zeyzoun, Syria	Failed 4 June 2002, killing 22 and affecting 10,000.
Ringdijk Groot-Mijdrecht	2003	Wilnis, Netherlands	Peat dam became lighter than water during droughts and floated away
Hope Mills Dam	2003	North Carolina, United States	Heavy rains caused earthen dam and bank to wash away
Big Bay Dam	2004	Mississippi, United States	A small hole in the dam grew and eventually led to failure.
Camará Dam	2004	Brasil	
Shakidor Dam	2005	Pakistan	Sudden and extreme flooding caused by abnormally severe rain, 70 deaths
Taum Sauk	2005	Lesterville,	Computer/operator error; gauges intended to

Dam/incident	Year	Location	Details
reservoir		Missouri, United States	mark dam full were not respected; dam continued to fill. Minor leakages had also weakened the wall through piping.
Campos Novos Dam	2006	Campos Novos, Brazil	Tunnel collapse
Gusau Dam	2006	Gusau, Nigeria	Heavy flooding
Ka Loko Dam	2006	Kauai, Hawaii	Heavy rain and flooding. Several possible specific factors to include poor maintenance, lack of inspection and illegal modifications.
Lake Delton	9 June 2008	Lake Delton, Wisconsin	Failure due to June 2008 Midwest floods.
Koshi Barrage	2008	Kusha[*disambiguation needed*], Nepal	Heavy rain
Algodões Dam	27 May 2009	Piau, Brazil	Heavy rain
Situ Gintung Dam	2009	Tangerang, Indonesia	Poor maintenance and heavy monsoon rain
Kyzyl-Agash Dam	2010	Kazakhstan	Heavy rain and snowmelt
Hope Mills Dam	2010	North Carolina, United States	Sinkhole caused dam failure
Delhi Dam	July 24, 2010	Iowa, United States	Heavy rain, flooding.
Niedow Dam	August 7, 2010	Lower Silesian Voivodeship, Poland	Heavy rain, over-topped from flooding
Ajka alumina plant accident	October 4, 2010	Hungary	Failure of concrete impound wall on alumina plant tailings dam.

Dam/incident	Year	Location	Details
Kenmare Resources tailings dam	October 8, 2010	Mozambique	Failure of tailings dam at titanium mine.
Fujinuma Dam	March 11, 2011	Japan	Failed after 2011 Tōhoku earthquake.
Dam in Campos de Goytacazes, Brazil	January 4, 2012	Rio de Janeiro State, Brazil	Failed after a period of flooding.
Ivanovo Dam	February 6, 2012	Biser, Bulgaria	Failed after a period of heavy snowmelt. A crack in the dam went un-repaired for years. Eight people killed and several communities flooded.
Köprü Dam	February 24, 2012	Adana Province, Turkey	A gate in the diversion tunnel broke after a period of heavy rain during the reservoir's first filing. The accident killed ten workers.

Source: [2].

4. Results and Discussion

This study shows that there are many dams existing in our country over the years. Moreover, many dam disasters including dam failures have occurred in the past. There is need to protect dams in our country. This country has witnessed many dam disasters including dam failures causing flooding that mostly led to loss of lives, properties and farmlands. Flooding is presently devastating most states of the country including Kogi, Bayelsa, Anambra, Benue, etc.

5. Conclusion

Dam development in this country started many decades ago. These dams store water for various purposes including hydro power development, irrigation, water supply, flood control, navigation, tourism, sanitation, etc.

Inadequate attention is being paid to the issue of flooding and other disasters arising from dam projects in our country.

6. Recommendations

- Communities within flood plains should be protected against flooding by constructing adequate water drainage facilities to hold the flood water from causing havoc.
- Adequate caution should be employed when passing water through spillways during flood. This is to ensure that flood water doesn't cause problems to communities downstream of dams.
- Adequate dam height should be provided to hold the flood water to prevent water from overtopping the dam to avert possible dam failure. This will increase the quantity of water in the reservoir for various water uses.
- Dam design and construction should be handled by experts in dam projects since its failure leads to catastrophe, including loss of lives, houses, properties and farmlands.
- Dam-Reservoir facilities should be optimized by making it a multi- purpose facility to enable employing the "great" reservoir water for different water uses.
- The Federal Government of Nigeria should vote more money under ecological funds for taking care of all forms of natural disasters. This money should be made available to remedy these disasters when they come.
- More dams should be built in this country to enable us reap the enormous gains of dam-reservoir facilities.

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