Developing a Comprehensive Geodatabase for Dams: Statistics and Properties

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Abstract

Dams are barriers that are constructed to hold back water. However, other than for flood control, there are various other primary uses of dams, which include recreational use, which benefits the economy, and for fire protection. When a dam fails, the results can be catastrophic. People, important infrastructure (such as bridges), power plants, and the state's economy are put at a major risk. As a result, the objective of this project was to asses the features of dams in each state, such as height and storage, drainage area, maximum discharge, hazard potential, and primary purpose, to understand the capacity of which these dams are capable of harming people, infrastructure and the economy. This information was taken from the National Inventory of Dams (NID), and analyzed by ArcGIS/ArcMap and Microsoft Excel. From the images and graphs, it was concluded that dams from 16 states and Puerto Rico (PR) have an average discharge, the number of cubic feet per second which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation, of over 7000 ft^3/sec. Seven of these states and Puerto Rico, have dams that make up the 17 percent of all 90,580 dams in the United States that are high-hazard. In this project, features of dams were analyzed in order to understand how to prevent catastrophic events, due to dam failure, in the future.

Research Objectives

- *Understand the different aspects of Dams that can affect important infrastructure and life, including dam height, drainage area, storage, discharge, primary uses, and hazard potential.*
- *Utilize this information to prevent floods that can lead to ruination of bridges and power plants.*

CorpsMap National Inventory of Dams

Table 1. 10 largest reservoirs in the U.S..

Dam Name	State	Max. Reservoir Capacity (acre-ft.)
Hoover	NV	30,237,000
Glen Canyon	AZ	29,875,000
Garrison	ND	24,500,000
Oahe	SD	23,600,000
Fort Peck	MT	19,100,000
Grand Coulee	WA	9,562,000
Herbert Hoover Dike	FL	8,519,000
Kentucky	KY	7,535,400
Sam Rayburn	TX	6,520,000
Wright Patman	TX	6,505,000

Table 2. 10 tallest dams and their structural types and height.

Dam Name	River	Dam Type	NID Height (ft)
Oroville	Feather River	Earth	770
Hoover	Colorado River	Concrete	730
Dworshak	North Fork Clearwater River	Concrete	717
Glen Canyon	Colorado River	Concrete	710
New Bullards Bar	North Yuba River	Arch	645
New Melones	Stanislaus River	Earth	625
Mossyrock	Cowlitz River	Arch	606
Shasta	Sacramento River	Concrete	602
Don Pedro	Tuolumne River	Earth	585
Hungry Horse	South Fork Flathead River	Concrete	564

Table 3. Here, three of the four categories of hazard potential are defined. Downstream Hazard Potential is defined as potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities.

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

Statistical Computations

$$H_t = \frac{\sum_{i=1}^{n} h_i}{n}$$

where H indicates the average height (h) of *n* dams in the state of *t*.

$$Q_t = \frac{\sum_{i=1}^{n} q_i}{n}$$

where Q indicates the average discharge (q) of *n* dams in the state of *t*.

$$DA_t = \frac{\sum_{i=1}^{n} da_i}{n}$$

where DA indicates the average drainage area (da) of *n* dams in the state of *t*.

$$S_t = \frac{\sum_{i=1}^{n} s_i}{n}$$

where S indicates the average storage (s) of *n* dams in the state of *t*.

Results

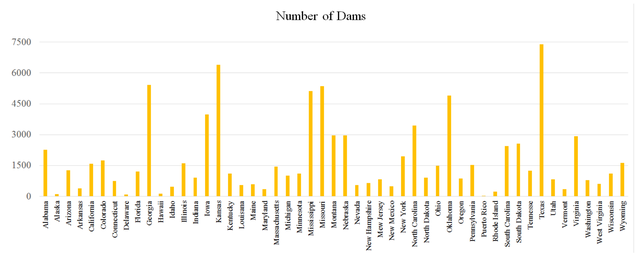

Fig 1. This histograms presents the number of dams in each state. As a result of many devastating floods in Texas' early history, Texas has over 7,500 dams, the greatest number of Dams in any U.S. state.

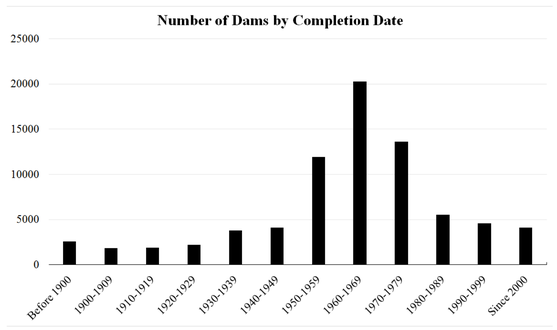

Fig 2. This figure shows the number of dams completed each decade. In the 1960s, there was a peak in the number of Dams created as a result of increasing legislation geared to protecting homes vulnerable to flooding.

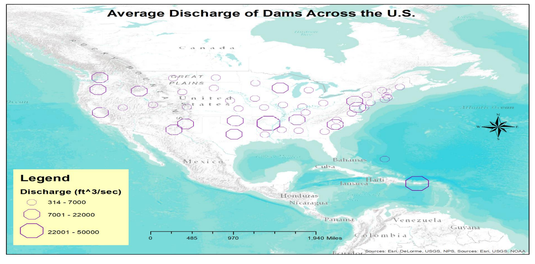

Fig 3. The dots represent the average NID height, defined as the maximum value of dam height, of all dams in each state (including PR).

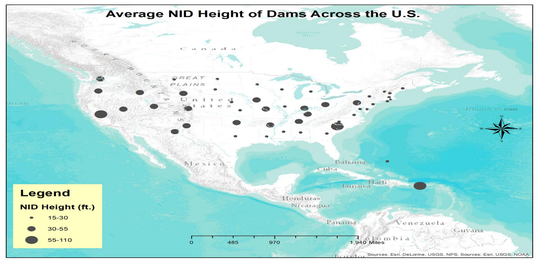

Fig 4. Discharge is defined as number of cubic feet per second which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation. The hexagons represent the average discharge of all dams in each state.

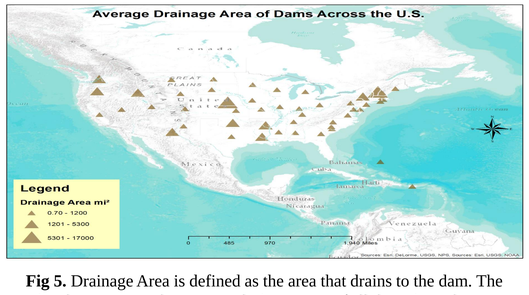

Fig 5. Drainage Area is defined as the area that drains to the dam. The triangles represent the average drainage area of all dams in each state.

More Results

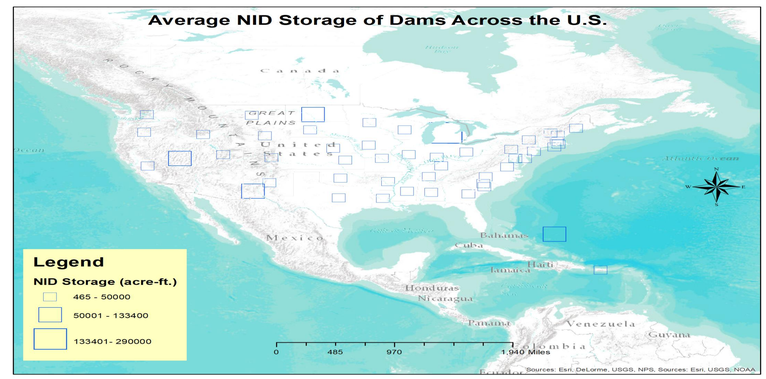

Fig 6. NID storage is defined as maximum value of normal storage and maximum storage The squares represent the average storage of all dams in each state.

Dams by Hazard Potential (counts)	
High	15498
Significant	11882
Low	60705
Undetermined	2495

Table 4. This table classifies all U.S. dams into four hazard potential categories.

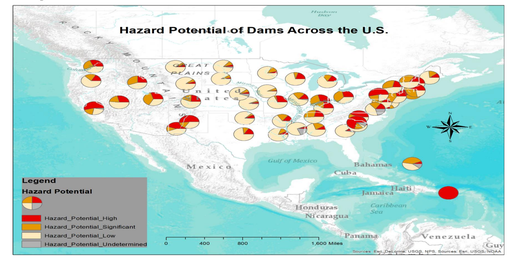

Fig 7. High hazard potential dams count for more than half of the dams in Puerto Rico, Hawaii, Delaware, West Virginia, Connecticut, Pennsylvania, California, and New Mexico. Pie charts demonstrate the number of dams per state in their respective hazard category.

Dams by Primary Purpose (counts)	
Debris Control	575
Fire Protection	10781
Fish and Wildlife	4930
Flood Control	16179
Grade Stabilization	906
Hydroelectric	2114
Irrigation	7706
Navigation	207
Other	8462
Recreation	25394
Tailings	1172
Water Supply	5628
Unknown	6526

Table 5. The 13 most common dam usages, and number of dams that are used for each purpose.

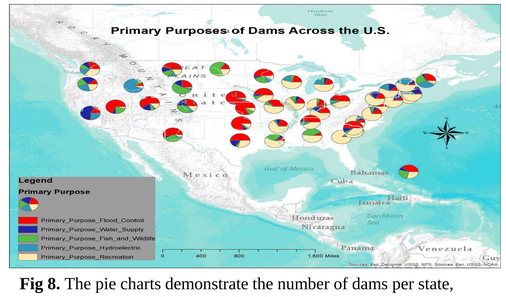

Fig 8. The pie charts demonstrate the number of dams per state, categorized by their primary purpose.

Summary

- There are 90,580 Dams in the United States, including in Puerto Rico.
- 21 States have average dam heights greater than 30 feet.
- 16 states and Puerto Rico have dams with high average discharge, of over 7000 ft^3/sec.
- 10 states have dams with average drainage area of 1200 mi^2.
- 15498 dams are considered high potential.
- Primary purposes of dams include, recreation, flood control, and fire protection.

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