FREIGHT MOBILITY RESEARCH INSTITUTE
College of Engineering & Computer Science
Florida Atlantic University

Project ID: Y6R3-22

DATA ANALYTICS AND SUPPORT TOOLS FOR INLAND WATERWAYS

FINAL REPORT

by

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June, 2024

ACKNOWLEDGEMENTS

This project was funded by the Freight Mobility Research Institute (FMRI), one of the twenty TIER University Transportation Centers that were selected in this nationwide competition, by the Office of the Assistant Secretary for Research and Technology (OST-R), U.S. Department of Transportation (US DOT). This research was also cost shared through the State Planning and Research (SPR) Program by the Tennessee Department of Transportation and the Federal Highway Administration under **RES 2023-07:** More Effective Use of Tennessee Waterways to Account for Competing Uses and Address Freight Congestion.

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EXECUTIVE SUMMARY

The United States (U.S.) inland waterways system (also known as the backbone of the transportation logistic system) directly connects 28 states and plays a crucial role in our nation's competitiveness and economic growth supporting efficient, safe, and sustainable transport for multiple commodities including agriculture, chemicals, and building materials. The cost to transport commodities on the inland waterways is roughly half the cost to ship by rail. Estimated transportation cost savings, according to the United States Army Corps of Engineers (USACE) and the U.S. Chamber of Commerce range from $7 billion (bn) to $9 bn annually. By 2045, it is expected that the U.S. Inland Waterways System (IWS) will contribute (in)directly $121 bn in economic output, 450 thousand jobs, and $62.3 bn in GDP. Furthermore, inland waterway transportation provides effective means of expanding capacity with less environmental and funding issues compared to other modes of transportation. Unfortunately, lagging infrastructure maintenance and improvement have resulted in frequent delays, with the percentage of delayed vessels increasing from 35% in 2010 to 53% in 2017. The State of Tennessee (TN) is one of the 12 states with the largest movements of freight via the inland waterways. Tennessee boasts a robust transportation network, comprising over 92 intermodal facilities, with 57 dedicated to port operations along its three main rivers. Additionally, the state is serviced by 33 common carrier railroads, including six Class 1 and 23 short line railroads, collectively managing 3,048 miles of rail tracks. Annually, Tennessee sees over 220 million tons of freight traversing its railways, including significant quantities of motor vehicles, food products, chemicals, and locally produced goods. Trucking also plays a substantial role, with 10,000 trucking companies navigating the state's extensive network of 95,523 miles of public roads. Intermodal options are abundant, offering shippers, manufacturers, and agricultural entities varied transportation services and seamless connectivity.

Competing on a national scale for business development, Tennessee's transportation infrastructure remains pivotal. The state hosts 7,137 manufacturers and sustains an average of 334,000 manufacturing jobs annually, generating considerable economic output. Transportation remains integral to these industries, as well as to agriculture and the general populace. Internationally, Tennessee handles around 12% of the nation's cargo, predominantly domestic. With a thriving transportation and logistics sector, the state boasts over 13,000 establishments employing over 218,000 individuals, contributing significantly to its economy.

Water transport, particularly via Tennessee's rivers and the Tenn-Tom Waterway, plays a crucial role in transporting raw materials for manufacturing. Barge traffic, with its substantial capacity and environmental benefits, is prioritized in the state's transportation planning, reducing greenhouse gas emissions, and ensuring safety in cargo transport operations. Considering the economic impact (81,000 jobs, $3.9 bn in personal income, 6.3 bn in Gross State Product, $517 million in state and local taxes in 2018) and other benefits (e.g., safety, reduced environmental externalities and truck traffic) to our state and local communities a closer look at our current IWS conditions, connectivity, operations, and redundancies is warranted. As a state we need the tools and data to identify opportunities for federal funding and areas to invest (capital and operational)

to take full advantage of the available capacity, increase efficiency, safety, and resiliency, and reduce externalities from freight movements in TN.

The goal of this project was to develop a set of recommended strategic objectives for the Tennessee Department of Transportation (TDOT) that support safe, reliable, and resilient use of TNs IWS and, at the same time, maximize economic impact, support investment decisions, and foster workforce preservation and development. To achieve this goal, this research developed a knowledge bank on best practices on inland waterway programs, web-based and desktop Data Analytics and Decision Support (DADS) tools that analyze and synthesize the available data on TNs IWS and its assets (e.g., ports, terminals, locks, etc.) into a set of performance stressors, metrics, and indices. The tools, data sources, and recommendations developed as part of this projects will support : 1) In-house analysis of TNs IWS commodity flows through its ports, terminals, and other intermodal facilities, 2) Stressor identification of TNs IWS and its assets, 3) Identification and prioritization of possible investments to accommodate current and projected growth of critical commodities favorable for waterway transport and modal shift (from truck to rail), 4) Support the development of a waterway program in TN and leverage federal funding opportunities, and 5) Identify and foster partnership opportunities.

Key Findings

- Inland Waterway (IW) transportation in TN contributed revenues of $938.6 million on 2022 with an annual growth rate 5% from 2017 to 2022 and is expected to grow at an annualized rate of 3.1% from 2023 to 2027.
- During the same period IW establishments in TN decreased by an annualized -1.8%.
- IW employment in TN has increased an annualized 0.7% to 2,722 workers, while industry wages have increased an annualized 6.1% to $233.9 million.
- Over the five years to 2027, the revenue of IW in TN is expected to grow an annualized 3.1% to $1.1 billion, while the national industry is expected to grow 0.9%.
- Industry establishments are forecasted to grow by 1.3%
- IW industry employment is expected to increase by an annualized 1.1% to 2,879 workers, while industry wages are forecast to increase by 3% to $271.0 million.

Key Recommendations

- Create by State legislation, a Tennessee Ports Council chaired by the Lieutenant Governor and including the Commissioner of DOT and the Commissioner of Environment and Conservation and representatives of each major community or county where there is commercial port activities present. The Council should also have an Executive Director and at least two full-time staff, one of whom should be dedicated to logistics research and the other to grant writing.
- The new Tennessee Ports Council should employ a full-time Database Administrator who shall work with other State agencies to create and maintain an accurate database of cargo movements and volumes, business interests dependent on transportation, and budgets dedicated to transportation system improvements related to river facilities and associated infrastructure.
- As part of developing the proposed Port Council, a full-time grant writer should be employed to undertake grant applications on behalf of the State and identify match

requirements from the State and private sector. Where appropriate, also administer funds as directed by the Ports Council for public and private port improvement. This would also involve the GSA requirements for tracking grant processes.

- The Port Council when established should employ a full time Business Development Director who would coordinate efforts with port and terminal, as well as rail and road interests, to support sales and marketing staffs to grow general business activities Statewide.
- The Port Council should review all proposed Federal projects, set State priorities and work with key agencies through Council staff to ensure attention is paid to key issues that impact the State.
- TN DOT should create a senior position within the department focused on port and waterway planning in conjunction with and support of the Port Council.
- The proposed DOT Port position should also work closely with rail personnel in DOT to ensure that the transportation network is properly protected and funded as appropriate. A strong emphasis on the services provided by the State's short line railroads should continue. The State needs to carefully consider, and as appropriate protect, rail right of ways for current and future freight and passenger traffic.
- TN DOT should establish a program, supported by Federal and State grant funding, for purchase of new cargo handling equipment for port and terminal facilities.
- The State should establish under DOT a dredging advocate and program to address the dredging of public and private facilities as well as river infrastructure as appropriate.
- A reporting system coordinated with the State regarding waterway conditions and safety issues should be established under the TDOT Port position.
- Overall, the Tennessee Department of Transportation needs to integrate a further expansion of port and maritime issues into their DNA.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1 Introduction

One of the fundamental elements of the nation's transportation system is the Inland Waterway System (IWS) (**Figure 1-1**). The IWS serves 38 states with 193 lock sites with 239 chambers and 12,000 miles of navigable waterways (i.e., commercially active inland and intercostal waterway systems) [1] [2]. The Mississippi River, Tennessee River, Ohio River, Illinois River, Arkansas River, Columbia River and the Gulf Intracoastal Waterway are the primary inland waterways system and move about 14% of the nation's intercity freight totaling 514.9 million tons and valued at $134.1 billion USD in 2019 [3] with the major commodities of crude petroleum, coal, farm products, industrial and chemical products [4]. The U.S. IWS is also known as the backbone of the transportation logistic system since it directly connects 28 states. Consequently, it plays a crucial role in the nation's competitiveness and economic growth supporting, efficient, safe, and sustainable transport for multiple commodities including agriculture, chemicals, and building materials.

Key Deep Water Ports

1 Port of South Louisiana
2 Port of Houston
3 Port of New York/New Jersey
4 Port of Long Beach
5 Port of New Orleans
6 Port of Beaumont
7 Port of Virginia
8 Port Corpus Christi
9 Port of Los Angeles
10 Port of Baton Rouge
11 Port of Texas City
12 Port of Mobile
13 Port of Lake Charles
14 Port of Plaquemines
15 Port of Baltimore
16 Port of Pascagoula
17 Port of Savannah
18 Port of Tampa
19 Port of Philadelphia
20 Port Arthur
21 Port of Valdez
22 Port of Seattle
23 Port of Portland (OR)
24 Port of Richmond
25 Port of Tacoma
26 Port of Freeport
27 Port Everglades
28 Port of Marcus Hook
29 Port of Oakland
30 Port of Boston
31 Port of Charleston
32 Port of Paulsboro
33 Port of Jacksonville
34 Port of Galveston
35 Port of Portland (ME)
36 Port of Honolulu
37 Port of Kalama
38 Port of Anacortes
39 Port of Miami

Key Inland Ports

1 Port of Huntington-Tristate
2 Port of Metropolitan St. Louis
3 Port of Duluth - Superior
4 Port of Pittsburgh
5 Port of Chicago
6 Port of Two Harbors
7 Port of Detroit
8 Port of Memphis
9 Port of Indiana Harbor
10 Port of Greater Cincinnati
11 Port of Cleveland
12 Port of Toledo

Key Inland and Intracoastal Waterways

1 Atlantic Intracoastal Waterway
2 Apalachicola-Chattahoochee River
3 Gulf Intracoastal Waterway
4 Lower Mississippi River
5 Tennessee–Tombigbee Waterway
6 Tennessee River
7 Arkansas River
8 Missouri River
9 Ohio River
10 Monongahela River
11 Upper Mississippi River
12 St. Clair River
13 St. Lawrence Seaway
14 St. Mary's River
15 Columbia-Snake River

Figure 1-1 USA Marine Transportation System

SOURCE: HTTPS://WWW.USCHAMBER.COM/SITES/DEFAULT/FILES/LEGACY/USCHAMB_WATERWAY_MAINFACTSHEET_090613A.PDF

The cost to transport commodities on the inland waterways is significantly lower than the cost to ship by rail. The estimated transportation cost savings, according to the United States Army Corps of Engineers (USACE) and the U.S. Chamber of Commerce range from $7 to $9 billion annually (i.e., the transportation cost by inland waterways is almost half by rail with barge costs roughly $0.01 per ton-mile and rail costs of $0.02) [5]. These numbers refer to cumulative impacts through 2020. By 2045, it is expected that the U.S. IWS will contribute in total $121 billion USD in economic output, 450 thousand jobs, and $62.3 billion in Gross Domestic Product (GDP) [6]. Furthermore, inland waterways transportation provides effective means of expanding capacity with fewer environmental and funding issues as compared to other modes of transportation. Based on the literature, the most highlighted challenges for federal government includes delays/maintenance/upgrade at/of the locks, dredging of the channels, gate reliability, and integration with the other modes [7]. Unfortunately, lagging infrastructure maintenance and improvement have resulted in frequent delays, with the percentage of delayed vessels increasing from 35 percent in 2010 to 53 percent in 2017. A meticulous assessment of IWS and its assets, would assist to recognize critical conditions and components. This process could lead to the identification and prioritization of capital and operational investments, and in support of applications for federal funding.

The State of Tennessee (TN) based on the National Waterways Foundation (NWF), is ranked in the 11th position in the U.S. by the inland waterway's movement freight with 950 miles of navigable inland waterways. Considering the economic impact (i.e., 81,000 jobs, $3.9 billion in personal income, 6.3 billion in Gross State Product, $517 million in state and local taxes in 2018) and other benefits (e.g., safety, reduced environmental externalities, and truck traffic) [8] , the state needs a closer look at the current IWS conditions, connectivity, operations, and redundancies. Tennessee, among other states that could reap substantial benefits from IWS, require data and key performance indicators (KPIs) to identify opportunities for federal funding and areas to invest (capital and operational) to take full advantage of the available capacity, increase efficiency, safety, resiliency, and reduction of externalities from freight movements. Cumberland river, Memphis Harbor, Tennessee and Mississippi river with Memphis, Nashville and Chattanooga ports constitutes the major valuable assets (e.g., in terms of tonnage movements) of TN's IWS [9]. Figure 1-1Error! Reference source not found. shows the navigable rivers of TN. In 2022, a report[1] published by the American Society of Civil Engineers gives Tennessee's Inland Waterways an overall grade of D+ (for 2021). Among other, recommendations include the increase the USACE budget to maintain and operate locks and dams, completion of the Chickamauga replacement locks, completion of the additional extended lock at Kentucky lock and repair of the Melton Hill Lock, Nickajack Lock, Pickwick Lock, and Watts Barr Lock.

[1] https://infrastructurereportcard.org/state-item/tennessee/

Figure 1-2 Map with navigable rivers of Tennessee

The scope of this deliverable is to present a review of best practices, performance, and funding opportunities on IWS. The contribution of this review could serve as a significant tool for the Tennessee Department of Transportation (DOT) and for federal practitioners and stakeholders to take full advantage of the available capacity, increase efficiency, safety, resiliency, and reduction of externalities from IWS. More specifically, this report focuses on a) examining the available inland waterways programs and practices on the state level, b) reviewing methodologies used in evaluating and prioritizing infrastructure assets, c) identifying and categorizing key performance indicators (KPIs) of inland waterways assets, d) reviewing methodologies used to quantify economic benefits that the inland waterways and ports bring to the nearby communities and the state, e) reviewing opportunities for federal and non-federal funding and areas to invest (capital and operational), f) identifying and categorizing the available data from deferent agencies that could provide beneficial information on IWS.

Chapter 2 Inland Waterways Challenges

IWS are facing various challenges due to closures, infrastructural aging, delays, dredging issues, and other [10] [11] [12]. These challenges can be categorized into six classes: i) technical, ii) regulatory, iii) environmental, iv) geopolitical, v) financial, and vi) integrated project development (**Table 2-1**).

Table 2-1. Summary of IWS stressor types and challenges

Stressor type	Challenge
Technical	Lack of waterway and/or berth depth
	Lack of dredging
	Lack of air draft
	Lack of vessels (tugs)
	Lack of terminals
	Lack of night navigation facility
	Lack of maintenance
	Lack of modernization
	Undersized lock
	Lack of trained labor
Regulatory	Model integration/ infrastructures development
	Operation/maintenance
	Policy party
	Restructuring
Environmental	Air pollution
	Waste pollution
	Water pollution
	Wildlife
	Navigable water due to changing depth
Geopolitical	Cross structures
	Inter linking of rivers
Financial	Lack of investments in private sector
	Lack of investments in public sector
Integrated project development	Lack of long-term commodity commitments
	Promoting the modal shift
	Providing fund from normal budget

Technical challenges are related to the lack of adequate navigation infrastructure and may include the lack of depth, dredging, air draft, numbers of IWS vessels (tugs and barges), terminals, night navigation facility, maintenance, modernization, and undersized locks. Sufficient depth is necessary for navigating larger vessels and making the IWS a viable commercial solution for improving economy and sustainability [12]. The lack of regular dredging is critical to increasing/ maintaining the water depth in a navigational channel as well as flood and erosion control [13]. The adequate vertical clearance of bridges is also crucial since it can hinder the passage of large

IWS vessels. Sufficient IWS vessel numbers are another concern that can be addressed by the private sector. Unfortunately, building vessels is highly dependent on capital investment, and private sectors are not willing to invest in barges unless user industries have a long-term commodity commitment. The lack of terminals also affects productivity and the interface between cargo and transit. In addition, the lack of night navigation capabilities (e.g., Differential GPS (DGPS) and River Information Service (RIS)) causes major obstruction in the successful night operation. The aged infrastructure of the IWS, requires significant maintenance but due to budgetary constraints (and lack of visibility in the eyes of the public), it cannot be performed routinely which causes more scheduled and unscheduled downtime at the locks [14]. Various IWS facilities (i.e., terminals, dams, and locks) were built in the 1930s and do not have enough space to accommodate more than 15 barges. This proves the necessity of modernization. As an example, the facility along the Ohio River was modernized by the replacement of a 600--foot chamber with the new facility which allows the passage of a 15-barge tow in one lockage. The undersized locks cause significant delays and consequently increase pollution and transportation costs [15].

Regulatory challenges are mostly related to model integration/infrastructure development, operation/maintenance, governmental policy, and regulatory restructuring (e.g., safety and environmental standards; access to petroleum and other fuel supplies). The lack of possible multimodal corridors connecting industrial clusters, disconnect of international maritime traffic and hinterland coastal, and the lack of adequate maintenance policy, can and will cause significant delays and costs [11] [16]. In addition, coordination and collaboration between states that share the IWS is another challenge that needs to be addressed [17].

Environmental impact is another recognized challenge that includes pollution of air, water, and wildlife habitats [18][19]. The Geopolitical challenges are mostly related to cross structures and inter linking of rivers [16]. Sometimes increasing the depth of navigational channels is not practical due to economic challenges in constructing the locks/dams. To ensure the use of waterways for navigation, river inter-linking projects are necessary which are sometimes neglected due to the *geographic position* of the region. While considerable attention has been paid to the development of road and rail, the IWS has been neglected. Adding to the challenges is the *lack of investments* by governments and private sectors as well as the lack of trained labor [15]. In other words, the systematic inadequate financing for development and maintenance lead to a situation that is on the edge of technological disaster [20]. Furthermore, there is a need to *integrate the development* of the IWS projects by considering the shortage of long-term commodity commitments for sustainable operations/economic stability as well as providing the funds from the normal budget to develop proper infrastructure. Finally, promoting the modal shift is another concern for the transport sector which needs to be considered to improve the environment as well as the economy [11].

Chapter 3 State Programs

In this chapter we present information on inland waterways programs already in place in the U.S. by other states. We briefly discuss each program for each state and include a hyperlink to each program's webpage. For states that do not have a program in place we provide general information with respect to funding sources used to date for capital (infrastructure) and operational improvement projects.

3.1 Alabama

Alabama DOT established the Alabama Infrastructure Bank program to provide government units with an alternative financing source for funding needs related to the construction and improvement of highway and transportation facilities. The Alabama Coastal Management Program (ACAMP) promotes wise management of the cultural and natural resources of the state's coastal areas and fosters efforts to ensure the long-term ecological and economic productivity of coastal Alabama.

(SOURCE: HTTPS://WWW.DOT.STATE.AL.US/PROGRAMS/ATIB.HTML; HTTPS://ADEM.ALABAMA.GOV/PROGRAMS/COASTAL/DEFAULT.CNT)

3.2 Arkansas

The Arkansas DOT does not have a program in place to support inland waterways infrastructures and investments. The Arkansas Waterway Commission, a sole state agency responsible for developing, promoting, and protecting waterborne transportation in Arkansas, maintains the Arkansas Port, Intermodal, and Waterway Development Grant Program. The program reinvests (e.g., capital improvements, port development projects, including landside infrastructure, real estate purchase for port expansion, and much-needed dredging projects) the ad valorem tax paid by industries on the value of the barges utilizing Arkansas' navigable waterways. Arkansas Port, Intermodal, and Waterway Development Grant Program calendar year 2022 available funding is $1,952,102**.** (SOURCE: HTTPS://WWW.WATERWAYS.ARKANSAS.GOV/GRANT-PROGRAM/)

3.3 Illinois

In the Spring of 2019, the Rebuild Illinois Capital Bill appropriated $150 million to the Illinois Department of Transportation (IDOT) for the Illinois Port Capital Investment Grant Program with $40 million going directly to the Alexander-Cairo Port District. It is anticipated that funds will be programmed over the state's fiscal years 2022 – 2025 and be based on the year in which funds are requested by applicants. (SOURCE: HTTPS://IDOT.ILLINOIS.GOV/TRANSPORTATION-SYSTEM/TRANSPORTATION-MANAGEMENT/PLANNING/ILLINOIS-PORT-FACILITIES-CAPITAL-GRANT-PROGRAM**)**

3.4 Iowa

Iowa DOT does not directly invest in the IWS, although the department does have an advisory role with the U.S. Army Corps of Engineers and representation on the Upper Mississippi River Basin Association and the Missouri River Association of States and Tribes. Nevertheless, IDOT conducted studies in order to assist with the modernization [21] and alternative financing evaluation [22] of inland waterways assets.

(SOURCE: HTTPS://IOWADOT.GOV/SYSTEMS_PLANNING/PLANNING/WATERWAY)

3.5 Kentucky

The Kentucky Transportation Cabinet prepared an economic development plan to leverage the Ohio River corridor as well as other freight and rail assets to promote growth and retention of businesses throughout the commonwealth. The main funding program is the Kentucky Riverport Improvement (KRI) Program which was established to provide grants for public Riverport authorities to fund dredging or maintenance of access. Funds are transferred from the General Fund to the Kentucky Transportation Cabinet (KYTC) operating budget to support the KRI program. The FY 2023-2024 budget designates $500,000.00 from the General Fund in each Fiscal Year (FY) to improve public riverports within Kentucky.

SOURCES: HTTPS://TRANSPORTATION.KY.GOV/MULTIMODALFREIGHT/PAGES/KY-RIVERPORT-GRANT-PROGRAM.ASPX; HTTPS://TRANSPORTATION.KY.GOV/MULTIMODALFREIGHT/PAGES/KENTUCKY-RIVERPORTS,-HIGHWAY-AND-RAIL-FREIGHT-STUDY.ASPX

3.6 Louisiana

The Water Resources and Development Acts (WRDA, formerly Rivers and Harbors Acts) assisted by the Civil Works branch of USACE are the main sources of infrastructure development. Currently there are four studies underway: the Mississippi River Ship Channel Deepening, which is in the process of moving towards construction, and three Section 203 Studies, Baptiste Collette Bayou Deepening, Houma Navigation Canal Deepening, and the Acadiana to the Gulf of Mexico Access Channel Deepening. There is also the LaDOTD's Port Priority Program which ensures that adequate landside facilities are available to meet a definite market need by providing guidance and public funds to build landside infrastructure.

SOURCES: HTTP://WWWSP.DOTD.LA.GOV/INSIDE_LADOTD/DIVISIONS/MULTIMODAL/PORT_PRIORITY/PAGES/WATERWAYS.ASPX; HTTP://WWW.DOTD.LA.GOV/INSIDE_LADOTD/DIVISIONS/MULTIMODAL/PORT_PRIORITY/PAGES/PORTS.ASPX

3.7 Maryland

Maryland DOT operates the Port of Baltimore, one of the nation's top ports for total cargo tonnage and overall dollar value of cargo. However, there is not any available program to provide funding for the IWS of the state. The Maryland Department of the Environment's Wetlands and Waterways Protection Program protects Maryland wetlands and waterways from loss and degradation. Examples of activities which require permits from the Wetlands and Waterways Protection Program include building a new pier, adding a platform or boat lift to an existing pier, dredging a boat slip, putting in a bulkhead, etc.

SOURCES: HTTPS://WWW.MDOT.MARYLAND.GOV/OPCP/MD_FREIGHT_PLAN_DRAFT_EXECUTIVESUMMARY_WEB.PDF; HTTPS://MDE.MARYLAND.GOV/PROGRAMS/WATER/WETLANDSANDWATERWAYS/PAGES/INDEX.ASPX

3.8 Mississippi

The Mississippi Department of Transportation (MDOT) is the lead sponsoring agency in representing the M-10 Marine Highway Corridor. The state has also put in place the Ports Multimodal Transportation Improvement Program (MTIP) with the main goal to maximize the impact of the available Multimodal Funds by supporting projects that will improve the service, operations, and competitive position of water ports within Mississippi. The MDOT also commissioned a study to assess the economic role of ports and waterways [23].

SOURCE: HTTPS://MDOT.MS.GOV/PORTAL/INTERMODAL_PLANNING/#C1290

3.9 Missouri

The Missouri Department of Transportation (MoDOT) conducted an economic impact study for its public ports. This study assessed the economic role of public ports and waterways in supporting and enhancing the state and local economy [24].

SOURCE: HTTPS://WWW.MODOT.ORG/WATERWAYS-GENERAL-INFORMATION

3.10 Ohio

The Ohio Department of Transportation (ODOT) maintains the Ohio Maritime Assistance Program (MAP) where public water port authorities are eligible to apply for infrastructure grants. The ODOT, estimated the economic impacts generated by marine cargo activity at the commercial docks within the state along the Ohio River. The study also quantified the economic benefits of capital investment in the maritime cargo terminals as well as the transportation cost savings to Ohio shippers and consignees due to the availability of low-cost water transportation of the Ohio River [25].

SOURCE:HTTPS://WWW.TRANSPORTATION.OHIO.GOV/PROGRAMS/MARITIME-FREIGHT/RESOURCES/MARITIME-ASSISTANCE-PROGRAM

3.11 Oklahoma

The Oklahoma DOT does not provide any program for inland waterways. However, Arkansas Waterways Commission, Oklahoma Department of Transportation, and the University of Arkansas at Lile Rock, conducted an analytical regional economic impact study for the McClellan-Kerr Arkansas River Navigation System (MKARNS) . The findings of this study can inform future MKARNS investment, decisions resulting in sustainable growth in the regional and national economies.

SOURCE: HTTPS://OKLAHOMA.GOV/ODOT/PROGRAMS-AND-PROJECTS/WATERWAYS/REGIONAL-ECONOMIC-IMPACT-STUDY.HTML

3.12 Pennsylvania

PennDOT has launched the Ports Incentive Program which is part of the Pennsylvania Intermodal Cargo Growth Incentive Program (PICGIP) to entice shippers to increase their shipping volume through the state's ports.

SOURCE: HTTPS://WWW.PENNDOT.PA.GOV/DOING-BUSINESS/RAILFREIGHTANDPORTS/PAGES/DEFAULT.ASPX

3.13 Texas

Currently, the State of Texas does not provide direct funding for port capital improvements. However, the Texas portion of the Gulf Intracoastal Waterway (GIWW), which is dually designated, makes it eligible for federal grant funding for both M-69 specific projects as well as M-10 projects. The Infrastructure Investment and Jobs Act appropriated $25 million in funding for the marine highway grant program, and the Consolidated Appropriations Act, 2022, added another $14.8 million. The grants target previously designated Marine Highway projects, providing funds for port and landside infrastructure as well as vessels. As part of a USACE initiative, a webpage has been developed to query awarded and pre-awarded projects in the Galveston District (https://www.swg.usace.army.mil/Missions/Navigation/Navigation-Projects-Contracts/).

SOURCES:HTTPS://WWW.TXDOT.GOV/PROJECTS/PLANNING/GULF-INTRACOASTAL-WATERWAY.HTML;
HTTPS://FTP.TXDOT.GOV/PUB/TXDOT-INFO/MRT/GIWW-2022-FINAL-JULY-25-DIGITAL.PDF

3.14 Washington State

The Washington State DOT operates the largest ferry system in the United States. Most of the investment and programs emphasize to preserve and improve the ferry system. The available programs and projects from Washington State Ferries (WSF) division under the 2023-25 Capital Improvement and Preservation program focus terminal construction, vessel construction, emergency repair, preservation, improvements, new vessels, and administrative and project support.

SOURCE: HTTPS://WSDOT.WA.GOV/PUBLICATIONS/FULLTEXT/BUDGET/WSDOTBUDGET-CIPPBOOK-23-25.PDF

3.15 West Virginia

The West Virginia DOT does not have a program in place related to IWS.

Chapter 4 Key Performance Indicators

Key Performance Indicators (KPIs) for IWS in not a new concept, especially for the maritime industry. In the US, and at the federal level, the Committee on the Marine Transportation System (CMTS) is responsible to evaluate the promotion and adequacy of the Maritime Transportation System (MTS) with other modes. In 2010, they collaborated with the Transportation Research Board and the Bureau of Transportation Statistics to identify major KPIs including safety and security; capacity; resilience and reliability; environmental stewardship; and finance and economics; infrastructure; data access; MTS operations; MTS and its surroundings; and freight flow [20, 21]. Following CMTS, the USACE performed a comprehensive research and identified seventeen KPIs for the MTS infrastructure [27]. To improve the productivity of marine container terminals, the US Maritime Administration (MARAD) identified the most useful KPIs based on the usage of the asset in the terminal operations and categorized them into three groups including containers cranes and yards; terminal facilities; berths and vessels [28]. In addition, the National Cooperative Freight Research Program (NCFRP) proposed a set of KPIs and a framework to evaluate the performance of any freight transportation system. It introduced a "Freight System Report Card" which contained six main groups namely efficiency; demand; system condition; safety; environmental impacts; and system investment. New KPIs were also developed by other agencies. For example, the Freight Performance Measure Primer was introduced by the Federal Highway Administration (FHWA) to develop consistent, effective, and meaningful performance measurement practices for freight operations at state levels. This primer also provided a list of KPIs by modes and classified them into five classes including maintenance and preservation; safety; congestion, mobility, and reliability; connectivity and accessibility; and environmental stewardship [29]. In Europe, thirty-five KPIs were identified by the Permanent International Association of Navigational Congresses (PAINC) and classified into eight classes including infrastructure; environment; ports; fleet and vehicles; economic development; information and communication technology; safety; and security. In another research, the Southeast Europe Transnational Cooperation Program of the European Union identified nine KPIs for IWS on the Danube River and classified them into three major groups including infrastructure, maintenance, and navigable waterways information [26].

While the federal government has a key role in maintaining, constructing, and operating the IWS facilities (e.g., locks, dams, and channels), it is recommended that State DOTs develop reports on the condition, performance, and use of the marine transportation system [30]. State governments can provide technical and financial support for the IWS facilities. For example, they can provide and rehabilitate the connecting road/rail access to IWS facilities [7]. In this study, several states with IWS were reviewed based on the inclusion of IWS and the availability of the statewide freight plans (i.e., Washington, Minnesota, and North Carolina). Based on the literature, most states use at least one KPI, although some of them have more than five KPIs. It should be noted that the number of used KPIs does not have any correlation with the waterborne freight traffic flows. For example, the State of Louisiana with high traffic has only one KPI, while the State of Maryland with low domestic waterborne traffic has seven KPIs [7]. All states support their IWS by funding some portion of the modal connectivity (e.g., primarily in truck corridors, highway

access, and freight rail) and funding the industrial land development, through state and regional economic development agencies. Currently, multiple states have ongoing studies on channel expansion, restoration and increase of barge fleet capacity, new rail access and storage, repair of damaged facilities, modernization of port handling equipment, wharf, and dock area expansion (e.g., Missouri).

As mentioned, many different agencies developed different KPI's to assess IWS. Consequently, the consolidation of KPI's constitutes another challenge which is one of the main goals of this research. Taking into consideration the related research on IWS performance measurements, we propose a seven group categorization of IWS KPIs: 1. safety and security; 2. economy and logistic cost; 3. availability and connectivity; 4. maintenance, service, and preservation; 5. accessibility, congestion, and reliability; 6. throughput and capacity; and 7. environmental stewardship. In the following subsections, we analyze every specific performance indicator of each group, and actions taken by different states for them. The proposed categorization could be considered as an expansion of performance measurement classification by Farazi et.al [7]. **Table 4-1** encapsulates the proposed categorization of the eight KPI groups and provides an overview of the available data source for every group. Next, we provide a brief discussion for each group of KPIs.

Table 4-1. KPI for Inland Waterways

Group	KPIs	Available Data	Examples of State Action
Safety & Security	Crashes in channels/lock/dams	BTS USCG	Kentucky, Louisiana
	Theft when passing lock, dam, intermodal facility		Illinois, Texas
	Consistency of port administration with MTSA 2002		Maryland
Economic & Logistic Cost	General commodity tonnage handled in ports	AIS BEA BLS BTS USACE	Florida, Maryland, Minnesota, North Carolina, , Washington,
	Track commodity tonnage handled		Minnesota, North Carolina,
	Percentage of export versus import of commodities by value and weight		North Carolina
	Change of tonnage movements by miles and values		Kentucky
	Annual waterborne commodity		Arkansas, Rhode Island
	Modal share by value/tonnage Analysis of commodity and industry		Minnesota, Ohio
	Create more permanent job Build warehouse and rest facility		Missouri
Availability & Connectivity	Enhancing modal connectivity	BLS LPMS	Illinois
	Dredging maintenance		Kentucky, Maryland
	Availability of cubic yards of dredged sediment in navigation channels Availability of land for the installation/expansion of locks/dams		Texas
	Lock availability/Build Intracoastal Waterway		Iowa

	Boulevard Connector		Alabama
Maintenance, Service, & Preservation	Rate of dredging Lock/dam's condition Repair damaged facilities Modernize the port's handling equipment Upgrade site conditions	LPMS	Kentucky, Missouri
	Average maintenance cost for lock/dam		Texas
	Capacity of dredging material placement and remaining space for bay and harbor sections		Maryland
	Support port improvements		Indiana
	Extend the length of the harbor's wharf Create additional working space to improve the cargo dock operations		Illinois
	Channel deepening		Louisiana, Mississippi
	Upgrade port facility/system/ infrastructure		Minnesota
Accessibility, Congestion, & Reliability	Modal shift	BTS LPMS USCG	Illinois
	Improve the road/rail access		Mississippi, Missouri
	Average truck turn time at ports and the accessibility of rails to port		Florida, Maryland
	Delays at locks/ Unscheduled lock closure		Iowa
	Port access		Florida, Texas
	Improve the marine routes		California, Oregon, Washington
	Initiate a container-on-barge service		Missouri
Throughput & Capacity	Throughput (i.e., annual inbound /outbound loaded and annual domestic/foreign/import/export TEU)	BTS LPMS	Arkansas, Oregon, Rhode Island, Texas
	Type/number of container crane; Berth length; Container terminal size; Port utilization		Florida, Texas, Washington
	Warehousing facility		Illinois
	Dock-wall facility; Total volume; Service life of facility; Dock length		-
	Port capacity		Washington
	Value of handled TEU		Florida
	Intermodal connections to rail siding/yards		Mississippi
	Expand and restore the barge fleeting capacity		Arkansas
	Expand the facility and capacity		Minnesota
Environmental Stewardship	Air pollution (CO2, NOx, VOC, SOx); Pollution incidents in locks and dams	BTS USCS	Texas
	Noise emission		-

	Probability of natural disaster (i.e., cyclones, hurricanes, flood, drought) at port		-
	Ecological comprehensiveness and adjustability		Maryland, Mississippi, Texas
AIS: Association for Information Systems, BEA: U.S. Bureau of Economic Analysis, BLS: Bureau of Labor Statistics, BTS: Bureau of Transportation Statistics, LPMS: Lock Performance Monitoring System, USACE: U.S. Army Corps of Engineers, USCG: U.S. Coast Guard			

4.1 Safety and Security

The KPIs in this category includes the number of accidents/incidents/allisions/collisions as well as the number of thefts/vandalism [31] with the channels/lock/dams and intermodal facilities. Consistency of port administration with the Federal Maritime Transportation Security Act 2002 (MTSA) is another safety KPI. Due to the high importance of IWS safety, some states received state funds to improve it. For example, the state of Illinois has been authorized $110 million to public agencies for planning and developing the facilities within the public port districts to improve the safety/security besides enhancing the modal connectivity, promoting economic competitiveness, increasing economic opportunities, reducing the congestion using modal shift, and advancing the environmental sustainability [32]. Some other states such as Kentucky [33], Maryland [34], and Louisiana [35] concentrated on the number of crashes in a channel and locks/dams. They also focused on the port administration's consistency with the MTSA to improve safety. Reducing the number of thefts during passing from lock/dam and intermodal transfer is also another KPI for a navigation channel [7].

4.2 Economic and logistic cost

To support the decision-making process of IWS performance, it is essential to develop performance measures that consider the economic aspects and logistic costs, along with other criteria. The most frequent KPIs used by states under this category are: i) "port throughput of the general commodity in tons", and ii) "Tonnage handled by waterborne modes in the state". In addition, other economic and logistic cost related KPIs that can be used to evaluate the performance of IWS include inland transportation costs, product handling charges, port tariffs, terminal handling cost, port calling cost, concession costs, delays etc. [36] [37]. Usually, the KPIs in each state concentrate on a specific aspect of the IWS. For example, two KPIs in North Carolina and four KPIs in Minnesota concentrated only on the commodity tonnage handled [37][38]. The States of Maryland, Florida, and Washington also concentrated on general commodity tonnage handled at ports [34][39][40]. More specifically, the foreign commodity tonnage handled through ports was evaluated by the State of Maryland [34]. In the State of North Carolina [37], the percentage of export versus import of commodities by value and weight was considered as the KPI. The State of Kentucky focused on the change of tonnage movements by miles and values to evaluate the port performance [33]. The State of Arkansas and Rhode Island concentrated on the annual waterborne commodity tonnage [41][42]. The State of Minnesota evaluated the port performance using the modal share by value/tonnage [38]. They also provided a framework to integrate waterways freight problems into the long-term Minnesota Department of Transportation programs and improved the economic competitiveness of their ports. The state of Illinois also used funding to promote economic competitiveness and increased economic opportunities [32]. The State of Minneapolis provided a framework to integrate waterways into

the long-term transportation planning program and improve the economic competitiveness of their ports [7]. The State of Ohio funded a multi-year project in 2015 to identify the best strategies and plans to leverage Ohio's MTS as well as create a persistent analysis of commodities and industries [43]. Moreover, the port of New Madrid in the State of Missouri used $2.58 million of state and federal investment to attract private investment of $70 million in 2009. They used their funding to build a warehouse, construct the storage facility, strengthen a road, and created more permanent jobs. As a result, tonnage through the port doubled.

4.3 Availability and Connectivity

This category of KPIs quantifies the performance of IWS in supporting the freight movement through the supply chain networks. This measure could be the availability of equipment (e.g., mobile and crawler cranes), resilience (e.g., in the form or redundant capacity), numbers of the workforce [44], port congestion, lock availability, and dredging maintenance [36]. In terms of connectivity, the KPIs are land distance to major shippers, inland intermodal connection, proximity to the region with economic growth, proximity to logistics clusters and industrial areas, proximity to export/import regions, proximity to major suppliers, proximity to intermodal connection, and port weather condition [45]. As an example, the State of Texas used the availability of cubic yards of dredged sediment in navigation channels as the KPI. They also used the availability of land for the expansion of locks and dams for measuring the IWS performance [46]. While the State of Alabama focused on improving the connectivity by conducting the Intracoastal Waterway Boulevard Connector project [47], the State of Illinois focused on enhancing the modal connectivity [32] and the State of Iowa used the lock availability as the KPIs [7].

4.4 Maintenance, Service, and Preservation

Served states by inland waterways have developed a variety of funding mechanisms and structures to support their MTS for improving efficiency. Using the average maintenance cost for lock/dam or the capacity for dredged material in navigation channel as well as the rate of dredging, lock/dam's condition, repair damaged facilities, modernizing the port's handling equipment, and upgrading site conditions are some of the examples of this category of KPIs. For example, the State of Indiana received $5 million to support improvements. While the State of Kentucky focused on the rate of dredging and lock/dam's condition [33]. The State of Maryland concentrated on the capacity of dredging material placement and remaining space for bay and harbor sections [34]. In addition, the State of Minnesota got the local governments and private sources funds to upgrade the facility, system, and infrastructure. The State of Indiana with four ports on the Great Lakes and two significant commercial ports on the Ohio River got $5 million in capital funding to support improvements to three major ports in the great lake and the Ohio river between years the 2015 and 2017. Four different studies are underway in the State of Louisiana, that improve on the types of KPIs discussed in this subsection, that include the Mississippi River Ship Channel Deepening; Houma Navigation Canal Deepening, Baptiste Collette Bayou Deepening; and Acadiana to the Gulf of Mexico Access Channel Deepening. These efforts are ongoing through congressional approval (Water Resources Development Act) and assisted by USACE [48]. Paducah in the State of Kentucky funds ($3,320,000) several infrastructure improvements to repair damaged facilities, modernize the port's handling equipment, and upgrade site conditions. Granite City Harbor in the State of Illinois also received $4,140,000 in

funding to extend the length of the harbor's wharf and create additional working space to improve the cargo dock operations [48].

4.5 Accessibility, Congestion, and Reliability

The KPIs in this category measure port reliability; port accessibility, port flexibility; pickup and delivery; barge service network; fast transit time; response rate; average dwell time for liquid tanker/ container and roll-on/roll-off; and frequency of barge services [45][36][49]. As an example, the Aberdeen Port in the State of Mississippi funded ($4,000,000) to build 12,200 linear feet of new rail which create direct access between the Kansas City Southern Railroad and the port along the Tennessee-Tombigbee Waterway. The port of New Madrid in the State of Missouri used state/federal funding to improve the road/rail access and create permanent jobs and received an American Maritime Highway Program (AMHP) designation from the MARAD to initiate a container-on-barge service between Memphis, TN and Herculaneum, Missouri [50]. In the states of Maryland [34] and Florida [40] the KPIs were mostly concentrated on the average truck turn time at ports and the accessibility of rails to ports. Iowa state with four KPIs focus on locks and dams, the delays at locks, and unscheduled lock closure (*5*). In the State of Texas, the number of port access was addressed as the KPIs [46]. Alabama state concentrates on reducing congestion by conducting the Intracoastal Waterway Boulevard Connector project. Their purpose was to reduce traffic congestion and providing an emergency evacuation route on SR-59 [47]. Illinois state also used their funding to reduce the congestion using modal shifts [32]. In addition, some of the states focus on marine routes such as the states of Washington, Oregon, and California. They concentrate on a project in M-5 coastal connector (between San Diego, Bellingham, and Southern Oregon) to support a service carrying the commodities on barges, reduce the truck traffic along the Interstate 5 and provide regional cargo interests with modal options. The State of Missouri also has a project that will expand the options for good movements on inland waterways to improve accessibility to the international market and increase competitiveness. This program includes the agricultural commodities in containers from the central Missouri port and terminal along routes M-29, M-55, and M-70 to ocean ports along the Gulf on route M-10 [51].

4.6 Throughput and Capacity

The KPIs in this category measure the number of diversified commodities, top commodities; long-distance distribution, throughput (i.e., annual inbound/outbound (un)loaded and annual domestic/foreign/import/export), channel depth, air draft restriction, type and number of container crane, berth length, container terminal size, port utilization, warehousing facility, dock-wall facility, the volume of total commodity, the service life of the facility, dredging capability, and dock length [45][36][49]. Note, that some of the KPIs under this category can also be included in the economic/logistic costs category. As an example, the State of Mississippi focused mainly on the channel depth for IWS [52] while the states of Washington, Florida, and Texas are port specific [7]. Port capacity and the value of handled TEU were the KPIs in the State of Washington [39] and Florida [40], respectively. The State of Minnesota and Missouri used their funding to improve and expand the facilities and capacity [38]. Bay St. Louis in Mississippi is an example of how they used their funding to construct the rail storage yards to improve the operations at the port facility. Their aim was to add a new rail siding, two sets of storage tracks, and 130 additional storage spaces which increase the storage capacity by 20 percent. In the State of Arkansas, the Little Rock

District of the Corps of Engineers focused on a study that has been authorized by Congress to determine the possible impacts of expanding the Arkansas River channel from 9 to 12 feet [53]. They also have a funded project ($3,079,845) to expand and restore the current barge's fleeting capacity. Finally, the Bureau of Transportation Statistics (BTS) provides the port performance program to evaluate the port's throughput and capacity at the Nation's top ports using five different criteria including data availability; national consistency; timeline; relevance and clarity; accuracy and transparency [54]. These can also be used for IWS ports.

4.7 Environmental Stewardship

As the literature suggested the IWS provides a more environmentally friendly mode of transport when it either replaces or compliments the other two major (by tonnage) modes (road and rail). Nevertheless, inland waterway transport can have a significant impact on water quality, the ecological value of the water body, and air quality which should be evaluated using some measures. In terms of environmental stewardship, the KPIs could be air pollution (CO_2, NO_x, SO_x), noise emission, water pollution, and the probability of natural disasters (i.e., cyclones, hurricanes, floods, and drought) at port and the wildlife habitat [36]. An additional KPI could be considered by the ecological comprehensiveness of environment (e.g., wildlife habitat and wetlands) by the IWS. The State of Maryland provides a characteristic example of IWS adjustability towards sustainable development. The Mid-Atlantic dray track replaced as well as created acres of wildlife habitat and wetland [34]. The State of Texas used the discharge of ballast and waste in water (in navigation channels) as well as pollution incidents (in locks and dams) as the KPIs [56]. Environmental sustainability is also enhanced by the State of Illinois [32]. Moreover, the amount of dredging material for beneficial use in the navigation channels, as well as the air/noise pollution produced by vessels while waiting for loading/unloading in locks and dams, are considered the KPIs in several studies [11][16][56].

Chapter 5 IWS Data Sources

In this chapter of the report, we list and provide a brief description of the available data sources that can be used to estimate the various KPIs of IWS. The U.S. Coast Guard (USCG) and the Army Core of Engineering (USACE) are the main source for publicly available IWS data. Most of the data available is a by-product of the AIS (Automatic Identification System) data, collected by the USCG through onboard navigation safety devices that transmit and monitor the location and characteristics of vessels in the US and international waters in real time. The AIS data includes the information related to the vessel type, vessel size, vessel positioning, and operation (i.e., latitude, longitude, course over ground, speed, rate of turn, heading, navigation status) and it is available on the MARAD website [57]. This information can be used to identify the inland waterway freight flows. However, the AIS data has some limitations in providing information about the commodity type carried by vessels. This limitation was resolved by combing the data with a lock performance monitoring system (LPMS). This dataset is operated and maintained by the USACE and includes data related to navigable channel dredging, water levels, lock/dam's performance, channel depth, travel time reliability, and waterborne commerce statistics [7]. This publicly available data summarizes the monthly and annual tonnage of 36 commodities transported by vessels in each direction in 200 locks/dams along IWS of the US. The combination of AIS data with USACE locks data brings a comprehensive source for planning purposes. Also, the historical lockage data for the period of 1993 to 2017 is published by USACE (2018). However, the details about some commodities/ companies are not included in the public version due to confidentiality issues [57]. The USCG also provides data on accidents, death, and injuries as well as marine discharge/pollution and travel time reliability for IWS. The major sources of statistics on employment over IWS are the Department of Commerce (track import/export) and the Bureau of Labor Statistics [44]. In addition, the financial information on the Harbor Maintenance Trust funds and fuel usage can be obtained from the Department of Treasury and Department of Energy, respectively [7]. BTS also provides annual data on freight movement, system reliability, safety, transportation and economy, energy use, and environmental impacts [59]. We refer to the project website (https://sites.google.com/view/iws-v1-1?usp=sharing) for all the available tools that analyze these data.

Chapter 6 Infrastructure Asset Prioritization

Prioritizing transportation projects requires a programmatic approach since each mode of transport has independent prioritization processes, based on quantitative and qualitative measures unique to the specific mode/program. Quantitative measures include Benefit-Cost measures, and qualitative measures include measures based on criteria defined by the evaluator. The evaluation methods should be able to meaningfully compare projects across different modes in a uniform, consistent and reasonable manner, leading to a better allocation of resources and a better understanding of project trade-offs. The Project 08-36, Task 112 NCHRP report details the cross-mode prioritization of projects by various departments of transportation in the United States [59]. California Department of Transportation (Caltrans) developed a Life-Cycle Benefit-Cost model (20-year project life cycle) to evaluate the highway and transit projects. Life-cycle costs and benefits, net present value, benefit/cost ratio, rate of return on investment, and project payback period are evaluated. Minnesota Department of Transportation grouped its evaluation criteria into three broad categories, the Benefit-Cost Analysis (BCA), which is 60% of the project's total score; qualitative factors, which account for 30% of the final score; and financial plan/match make up the remaining 10%. The metrics included in the BCA include economic impacts such as travel time savings and environmental impacts like changes in emissions and social impacts, including safety (e.g., injuries and fatalities). The qualitative factors evaluated are local economic impact, context sensitivity, system considerations, community health and access, and multimodal impacts. The financial plan was evaluated based on the level of matched funds from other sources; projects must have at least a 10% match, with higher matches receiving better scores. North Carolina Department of Transportation implemented a strategic prioritization process, a silo-based approach.

In the scholarly literature, the evaluation of transport infrastructure for the prioritization of future investments is broadly categorized as monetary and non-monetary evaluation techniques for valuation; and one or multicriteria according to the number of criteria employed [60]. The financial evaluation of a project is to check if the project is financially self-sustainable, whereas the economic evaluation is to see if the project generates net benefits to society. Traditionally, decisions on transportation investment use the Cost Benefit Analysis to achieve the goal of profit maximization or cost minimization. However, CBA does not comply with the environmental and social impacts, indicating a move towards multicriteria approaches [61]. Multicriteria methodologies have emerged as a discipline of Operational Research (OR), aiming to support decision-making in complex situations. One of the tools for making decisions in complex situations is linear programming; however, it can be limited when applied to complex problems involving several variables. The subjective aspects of decision-making gained greater attention in recent years when the need to quantify social and environmental factors has increased.

A wide range of evaluation methods is available in the literature to prioritize transport infrastructure projects (see [62];[63];[64];[60]). Most of them are based on multicriteria analysis

(MCA), which in most cases, combines cost-benefit analysis. In general, the methodological framework comprises three steps: (i) identifying the factors influencing infrastructure investment decisions, (ii) quantifying identified factors, and (iii) ranking the infrastructure projects. MCA is a tool for evaluating different alternatives when several points of view and priorities are considered to produce a typical output. The biggest challenge in prioritizing infrastructure projects is valuing or weighing various factors influencing investment decisions. In the decision science literature, several non-economic theories/techniques exist to weigh these factors. The popular non-economic methods are multi-attribute and multicriteria decision theory, the Delphi approach, and the analytical hierarchy process (AHP) [64].

Multi-attribute utility theory (MAUT) and multicriteria decision-making (MCDM) approaches have been used largely to support decision-making processes [65]. The objective of MAUT is to attain a conjoint measure of the attractiveness (utility) of each outcome of a set of alternatives. The method is employed when prospective alternatives are evaluated to prioritize them. In its most basic form, MCDM assumes that a decision-maker is to choose among a set of alternatives whose objective function values or attributes are known with certainty. A commonly used MCDM is the Delphi method. The application of the Delphi method can be found in several existing studies, such as [66] and [67]. The analytical hierarchy process is a process of ranking objects based on psychology and mathematical techniques. This method derives priority scales using a measurement technique through pairwise comparisons based on expert judgements. The scales measure intangibles in relative terms. The comparisons are made using a scale of absolute judgements that represents how much more one element dominates another with respect to a given attribute. The method has been widely used in infrastructure investments' prioritization (e.g., [68] ;[69]).

In transportation, many researchers use the multicriteria approach for various purposes. Zubaryeva et al., (2012) used a multicriteria decision support method to assess the potential lead markets for electrified vehicles in Europe. They combined several economic, social, environmental, and transport-related factors [70]. Taefi et al., (2016) applied multicriteria analysis to recommend various policy measures to support battery electric freight vehicles in Germany based on the rating by two stakeholder groups [71]. Barbosa et al., (2017) developed a multicriteria model to assess urban public transport considering user perceptions. They identified the objective and subjective aspects of the users' opinions of the integrated public transport system implemented in Brazilian cities [72]. Mishra et al., (2016) developed a bi-level optimisation approach for allocating scarce resources for capacity expansion and transportation network improvements [73]. Haque et al., (2021) developed a multi-period discrete network design problem and a Multi-Period Econometric Network Investment Model for multi-period network investment decisions [73]. Thus, the multi-criteria approaches can be used to evaluate and prioritize specific transport infrastructure assets, considering various quantitative and qualitative aspects.
Common methodologies to estimate the direct, indirect, and induced impacts of investment in the inland waterways system output to the economy are input-output analysis, econometric models, computable general equilibrium models, cost-benefit analysis, and hybrid models. A variety of sources (public and proprietary) are needed with the latter usually being very expensive to obtain. Direct impacts reflect the economic activity that occurs in the industries in which

investments are made or changes occur. Indirect impacts are additional economic impacts that occur to industries upstream to the industry that was directly impacted as it purchases inputs and services to produce or provide its own product or service. Induced impacts are those impacts created by changes in the spending of labor income and profits generated by the direct and indirect impacts. At the state level, potential economic benefits can be estimated by projecting possible changes in flow of goods, mode choice changes (which can lead in reduction of road congestion and increase in road safety with fewer trucks on the road), increase in services, employment, and income of the local, state and even regional economy. Iowa, Missouri, Ohio, and Mississippi have completed studies on the economic impact of IWS to their region and can be used as templates. More information about these studies was provided in Chapter 3.

6.1 Port evaluation

Port performance is critical for the effective and efficient management of organizations. Measuring effectiveness and efficiency helps decision makers to control the process and plan for further development. Hossain et. al., (2019) determined the inland port performance using six different criteria including port availability, port facility, port service, port connectivity, port economics, and port environment. They used a Bayesian Network approach to focus on both qualitative and quantitative factors to rank a port. In addition, they utilized a belief propagation and sensitivity analysis to evaluate the inland waterways port performance [36]. Shetty and Dwarakish (2016) utilized statistical analysis to evaluate the relationship between the observed performance parameters and rate of un/loading, vessel waiting time, and quality of inland transport. As a result, they determined the optimum port infrastructure and capacity [74]. Turner et. al., (2004) implemented the Tobit regression and Data Economic Analysis (DEA) to measure the container port efficiency in North America between 1984 and 1997. They also explored the relationships between industrial structures and port efficiency and found out a well-established relationship between rail industry and seaport remains a significant determinant of port infrastructure productivity [75]. Barros (2006) measured the Italian seaport efficiency using DEA. He combined the financial and operational factors to evaluate the role of containerization, labor, and size in port efficiency [76]. Oliveira and Cariou (2015) used datasets from 200 container ports between 2007 to 2010 and implemented the DEA approach to evaluate the seaport efficiency and found that this value decreases with competition intensity [77]. The performance of China's port was measured by Sun et. al., (2017) using a non-radial Data Envelopment Analysis. The regression results showed that berth quantity, port assets, and geographical location notably impact the environmental performance of China's port [78]. Baros et. al., (2005) used a stochastic cost frontier method to investigate the extent of technical efficiency and technical changes in Portuguese seaport costs [79]. Chang and Tovar (2014) measured the technical efficiency of port terminals and evaluated the effects of certain factors (i.e., structural reform) on the inefficiency of terminal ports using the Stochastic Distance Function [80] [81]. Kutin et. al., (2017) analyzed the relative efficiency of container ports and terminals in the Association of Southeast Asian Nations (ASEAN) using DEA and found that there is a significant difference between the performance of seaport and inland seaports [82]. Coto-Millan et. al., (2000) estimated the port efficiency of Spanish ports using stochastic frontier cost and the results showed the larger ports were more inefficient [83]. Panayides et. al., (2009) reviewed the application of DEA for evaluating the economic efficiency of seaports and improved its methodology by considering the variation that was not applied before to the port section [84]. Wiegmans et. al., (2015) evaluated the Dutch

inland port performance in terms of transshipment growth and level using various statistical analyses [86]. Hosseini et. al., (2016) proposed a methodology to measure resilience as a function of adaptive, absorptive, and restorative capacities using Bayesian networks [86]. Moreover, Baroud and Barker (2018) developed a Bayesian kernel approach to evaluate the importance of locks and dams along the Mississippi rivers and identify the more critical locks and dams that influence the IWS resilience [87]. Finally, the World Bank Group and IHS Markit developed a Container Port Performance Index (CPPI) but only considers total port time (port to berth and berth time) [88]. The following table (Table 6-1) categorizes and provides a summary of the aforementioned literature.

Table 6-1 Inland and seaport evaluation literature

Measure	Authors	Year	Approach	Port
Productivity/Efficiency	Hossain et. al.,	2019	Bayesian approach	Inland port
	Shetty and Dwarakish	2016	Statistical analysis	Inland port
	Turner et. al.,	2004	DEA and Tobit regression	Seaport
	Barros	2006	DEA	Seaport
	Oliveira and Cariou	2015	DEA	Seaport
	Sun et. al.,	2017	DEA	Seaport
Technical efficiency	Baros	2005	Stochastic Cost Frontier (SCF)	Seaport
	Chang and Tovar	2014	Stochastic Distance Function (SDF)	Port Terminals
Relative efficiencies	Kutin et. al.,	2017	Data Envelopment Analysis (DEA)	Seaport/inland seaport
Economic efficiency	Coto-Millan et. al.,	2000	Stochastic Cost Frontier (SCF)	Seaport
	Panayides et. al.,	2009	DEA	Seaport
	Wiegmans et. al.,	2015	Statistical analysis (regression)	Inland Port
Resilience	Hosseini and Barker	2016	Bayesian approach	Inland port
	Baroud and Barker	2018	Bayesian kernel approach	Lock/dam

Chapter 7 Funding Opportunities

The World Economic Forum (WEF) identified factors of productivity and economic wealth for 141 counties. The second among twelve factors was infrastructure. The global competitive report [89] ranked the U.S. as the second overall in competitiveness in 2018-2019. This ranking contradicts with the 12th position of the U.S. regarding the transportation infrastructures. The American Society of Civil Engineers (ASCE) validate the WEF report by conducting a nation assessment of major transportation infrastructure types. The overall score for 2021 report card for America's infrastructure was C-, with the inland waterways infrastructure earned a D+ [90]. A recent report by the CMTS [91] reveals concerns of a substantial decrease in real infrastructure investments the last 21 years. **Figure 7-1** depicts the average annual percentage growth of GDP and public infrastructure expenditures over four-year intervals. Overall, the US ranks 9th with respect to the annual inland infrastructure investment as a percentage of GDP. Compared to China, who ranks first, the US invests 100 times less (**Figure 7-2**). Additionally, the Federal infrastructure spending in the US has consistently declined since 1965 and is currently at its lowest levels since 1960 (**Figure 7-3**). These numbers do not reflect the effect of the new "Infrastructure Investment and Jobs Act (IIJA) bill passed by the current administration 2021.

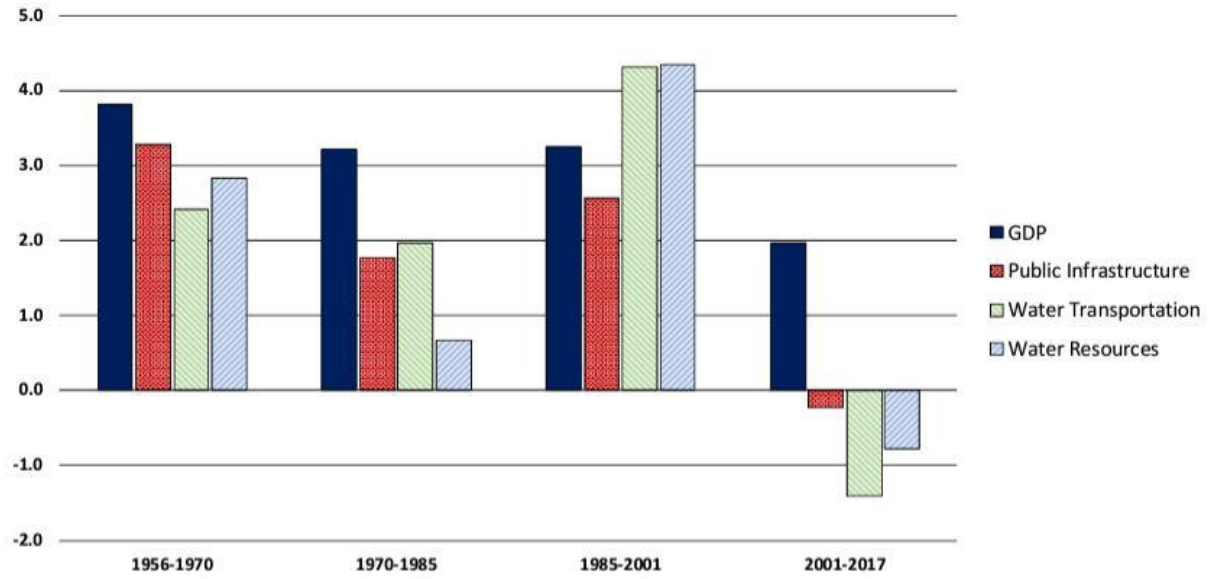

Figure 7-1 Public Infrastructure Spending (1956-2017)-Average Annual Percentage Growth Rates

SOURCE: HTTPS://WWW.CMTS.GOV/ASSETS/UPLOADS/DOCUMENTS/CMTS_ECONOMIC_ANALYSIS_OF_SPENDING_ON_MTS_INFRASTRUCTURE.PDF

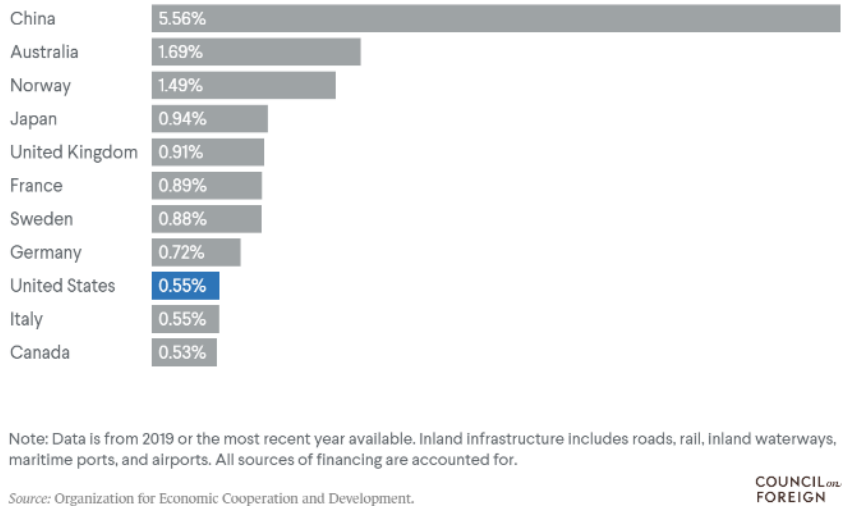

Figure 7-2 Annual inland infrastructure investment as a percentage of GDP

SOURCE: HTTPS://WWW.CFR.ORG/BACKGROUNDER/STATE-US-INFRASTRUCTURE

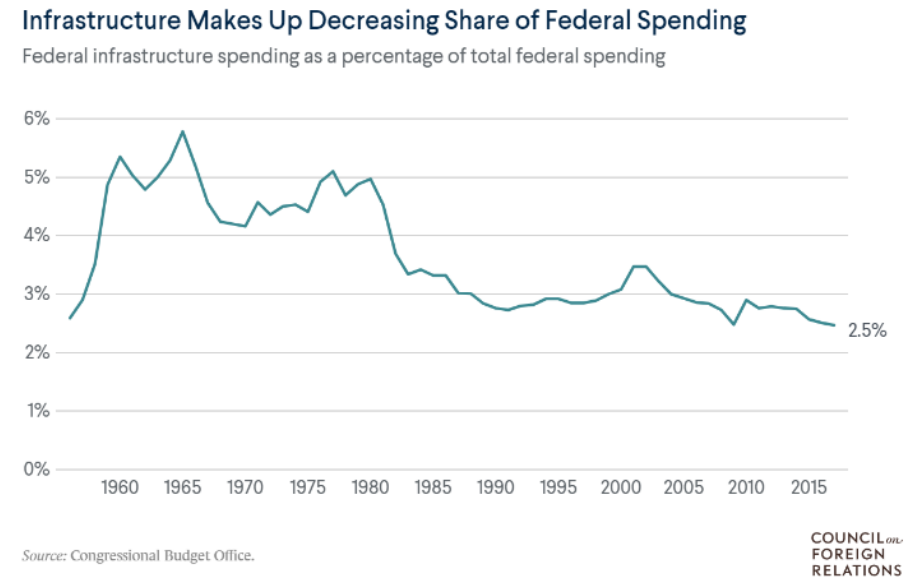

Figure 7-3 Federal infrastructure spending as a percentage of total federal spending

SOURCE: HTTPS://WWW.CFR.ORG/BACKGROUNDER/STATE-US-INFRASTRUCTURE

The role of IWS has changed significantly since the system was built to promote the early needs and economic development of the nation. The combination of climate change with the advanced age of IWS infrastructures raises critical limitations to navigation services. The challenges of IWS, as highlighted at the previous section, constitute a unique set of circumstances for IWS enhancement with a potential economic impact of increased average commerce costs associated with underinvestment of 22% (from 2019 to 2039) [92]. The increased supply chain costs will make U.S. products and services more expensive and less competitive or affordable. Consequently, both domestic and international trade will be affected by the increased costs associated with sub-optimal performance of the waterways systems. Delays in domestic

shipments due to inland waterway capacity limitations will primarily affect the energy and bulk commodity markets, business income will decrease, and employment will drop, and the aggregate wages and salaries earned by the U.S. workforce will decline [92]. The American Society of Civil Engineers (ASCE) estimated that the cumulative investment gap between 2020 and 2029 based on current trends for inland waterways and marine ports is $25 billion and for dams is $81 billion [90].

To meet this infrastructure investment demand there are various federal assistance-funding programs (summarized in **Table 7-2**). However, in recognition of the aforementioned potential economic impact by underinvestment in the US infrastructure, the Bipartisan Infrastructure Law-Infrastructure Investment and Jobs Act (IIJA)[93] provides a significant investment to strengthen the nation's infrastructure, competitiveness, and prosperity. More specifically the act authorizes $17 billion in port infrastructure and waterways, to not only address the existing issues (repair and maintenance) but also to reduce congestion and emissions (by investing on low-carbon technologies). The USACE received $2.5 billion through the IIJA, which was allocated for inland waterway building and rehabilitation projects as well as an increase in annual operations and maintenance funding [94] . The USACE submitted an updated plan in March 2022 for allocating the vast majority of the $2.5 billion from the IIJA [95]. The program fully covers new lock programs that take care of some of the USACE's most urgent building and rehabilitation needs. **Table 7-1** summarizes the new IWS construction projects scheduled for 2022. These projects are in addition to the four ongoing major inland waterways projects USACE is currently undertaking: Olmsted Locks and Dam on the Ohio River; Locks and Dams 2, 3 and 4 on the Monongahela River; Kentucky Lock and Dam on the Tennessee River; and Chickamauga Lock on the Tennessee River.

Table 7-1 USACE Construction projects 2022 under IIJA

State	Project	Funding (Millions)
Arkansas	Arkansas River Three Rivers Improvement Project	$109.1
Arkansas, Oklahoma	McClellan-Kerr Arkansans River Deepening	$92.6
Illinois	T.J. O'Brien Lock & Dam, Illinois Waterway	$52.5
Illinois, Missouri	Lock and Dam 25 - Upper Mississippi River	$732.0
Kentucky	Kentucky Lock and Dam, Tennessee River (additional funding to ongoing project)	$465.5
Pennsylvania	Montgomery Lock and Dam, Upper Ohio River	$857.7
Pennsylvania	Emsworth Lock and Dam, Upper Ohio River	$77.0
Total		**$2,386.5**

Source: [94]

On October 2022 the U.S. Department of Transportation Secretary Pete Buttigieg announced that the department's Transportation's Build America Bureau will offer low-cost and flexible financing for transit and Transit-oriented Development projects (INFRA/Mega/Rural Grant programs) at the maximum level authorized under the law [96]. The expanding funding opportunities are categorized by the Federal Funding Handbook for the Marine Transportation System in seven

main categories: infrastructure; economic development; energy; resilience; safety and security; environment and sustainability; research and development [97]. Following is a list of the current financing, and technical assistance programs for IWS (**Table 7-2**). We refer to the project website (https://sites.google.com/view/iws-v1-1?usp=sharing) for a discussion for each one of these available funding programs. The authors would like to note that these funding opportunities are either discretionary or grant based and are highly competitive and not consistent across the board (amounts, annual appropriations, award criteria, etc.).

Table 7-2 Funding Opportunities-Programs*

Program	Keywords	Website
Advanced Transportation and Congestion Management Technologies Deployment Program	Ports, Transportation, Safety, Efficiency, Infrastructure	https://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm https://www.grants.gov/web/grants/search-grants.html?keywords=693JJ322NF00010
Rebuilding American Infrastructure with Sustainability and Equity (RAISE)	Transportation, Ports, Maritime, Roads, Rail	https://www.transportation.gov/RAISEgrants
Capital Construction Fund (CCF) Program	Fishing, Marine, Vessels, Maritime, Economic Development	https://www.fisheries.noaa.gov/national/funding-and-financial-services/capital-construction-fund-program
Construction Reserve Fund (CRF)	Transportation, Vessel, Maritime	https://www.maritime.dot.gov/grants/construction-reserve-fund
Infrastructure for Rebuilding America (INFRA) Grants	Ports, Transportation, Infrastructure, Maritime, Roads, Rail	https://www.transportation.gov/grants/infra-grants-program
Mega Grant Program	Public ports, railway, highway	https://www.transportation.gov/grants/mega-grant-program
Marine Highway Grants	Security, Infrastructure, Ports, Maritime, Resilience	https://www.maritime.dot.gov/grants/marine-highways/marine-highway https://www.maritime.dot.gov/grants-finances/marine-highways/grants
Port Infrastructure Development Program (PIDP)	Infrastructure, Ports, Maritime, Resilience, Environment	https://www.maritime.dot.gov/PIDPgrants
The Army Civil Works program (Ports & Waterways Construction)	Infrastructure, Ports, Construction, Navigation	https://www.usace.army.mil/Media/News/NewsSearch/Article/3042747/us-army-corps-of-engineers-releases-work-plan-for-fiscal-2022-civil-works-appro/
Private Activity Bonds (PABs)	Transportation, Infrastructure, Roads, Rails, Port Development	https://www.fhwa.dot.gov/ipd/finance/tools_programs/federal_debt_financing/private_activity_bonds/#:~:text=Private%20Activity%20Bonds%20(PABs)%20are,of%20tax%2Dexempt%20municipal%20bonds.

Section 129 Loans	Transportation	https://www.fhwa.dot.gov/ipd/finance/tools_programs/federal_credit_assistance/section_129/default.aspx
Small Shipyard Grants Program	Transportation, Vessel, Maritime	https://www.maritime.dot.gov/grants-finances/small-shipyard-grants
State Infrastructure Banks (SIBs)	Transportation, Public-Private-Partnerships, Roads, Rail	https://www.transportation.gov/buildamerica/sibs https://www.transit.dot.gov/funding/funding-finance-resources/state-infrastructure-banks/state-infrastructure-banks-sibs
Transportation Infrastructure Finance & Innovation Act (TIFIA)	Transportation, Public-Private-Partnerships, Roads, Rail, Intermodal Facilities, Ports	https://www.transportation.gov/buildamerica/financing/tifia/tifia-credit-program-overview https://www.fhwa.dot.gov/ipd/finance/tools_programs/federal_credit_assistance/tifia/
USACE Planning Assistance to States	Infrastructure, Community, Environment, Conservation	https://www.nae.usace.army.mil/missions/public-services/planning-assistance-to-states/ https://www.usace.army.mil/Missions/Civil-Works/Project-Partnership-Agreements/templates_pas/
Economic Development Assistance Programs	Economic Development, Job Creation	https://eda.gov/programs/eda-programs/ https://www.grants.gov/web/grants/view-opportunity.html?oppId=290874
Planning Program & Local Technical Assistance Program	Economic Development, Resilience	https://www.grants.gov/web/grants/view-opportunity.html?oppId=280447 https://www.eda.gov/funding-opportunities/
Civil Infrastructure Systems (CIS)	Infrastructure, Resilience	https://www.federalgrants.com/Civil-Infrastructure-Systems-48716.html https://beta.nsf.gov/funding/opportunities/civil-infrastructure-systems-cis
Continuing Authorities Program	Infrastructure, Community, Erosion, Storm Damage, Resilience, Flood Control, Navigation	https://www.nae.usace.army.mil/Missions/Public-Services/Continuing-Authorities-Program/
Humans, Disasters, and the Built Environment (HDBE)	Resilience, Infrastructure	https://beta.nsf.gov/funding/opportunities/humans-disasters-and-built-environment-hdbe
Pre-Disaster Mitigation Grant Program	Resilience	https://www.fema.gov/grants/mitigation/pre-disaster
USACE Flood Risk Management Services (FRMS)	Infrastructure, Community, Flood Management, Resilience	https://www.iwr.usace.army.mil/Missions/Flood-Risk-Management/Flood-Risk-Management-Program/About-the-Program/
Port Security Grant Program (PSGP)	Security, Infrastructure, Ports, Training, Maritime, Resilience	https://www.fema.gov/grants/preparedness/port-security https://www.homelandsecuritygrants.info/GrantDetails.aspx?gid=17040

Clean Vessel Act Grant (CVA)	Environment, Resilience, Ports	https://www.federalregister.gov/documents/2015/09/14/2015-22723/clean-vessel-act-grant-program
Congestion Mitigation & Air Quality Improvement (CMAQ) Program	Air Quality, Congestion, Transportation, Environment	https://www.transportation.gov/sustainability/climate/federal-programs-directory-congestion-mitigation-and-air-quality-cmaq#:~:text=The%20Congestion%20Mitigation%20and%20Air,attain%20national%20air%20quality%20standards.
Cooperative Endangered Species Conservation Fund/ Section 6 Grants (CESCF)	Resilience, Environment, Endangered, Wildlife, Habitat	https://lwcfcoalition.org/section-6
National Coastal Wetlands Conservation Grant Program	Environment, Coast, Wetland, Conservation, Ecosystem	https://www.fws.gov/service/national-coastal-wetlands-conservation-grants
Endangered Species Conservation - Recovery Implementation Funds	Resilience, Endangered, Environment	https://www.federalgrantswire.com/endangered-species-conservation---recovery-implementation-funds.html#.YyPO89eZNXh
Marine Debris Removal Grant	Environment, Natural Resources,	https://www.fisheries.noaa.gov/grant/fy19-marine-debris-removal https://www.grants.gov/web/grants/view-opportunity.html?oppId=308384
Source Reduction Assistance Grant Program (SRA)	Environment, Pollution	https://www.grants.gov/web/grants/view-opportunity.html?oppId=340576 https://www.epa.gov/p2/fy-2020-and-fy-2021-source-reduction-assistance-grant-program-request-applications
ERDC Broad Agency Announcement (BAA)	Infrastructure, Ports, Maritime, Wetlands, Dredging	https://www.grants.gov/web/grants/view-opportunity.html?oppId=338472 https://govtribe.com/opportunity/federal-contract-opportunity/2021-erdc-broad-agency-announcement-baa-w912hz21baa01
Operations Engineering (OE) Program	Research, Science, Modeling, Data, Environment	https://beta.nsf.gov/funding/opportunities/operations-engineering-oe

*Note: Funding programs relating to passenger ferries were not included in this study

Chapter 8 Strengths, Weaknesses, Opportunities and Threats (SWOT)

This chapter provides the components used for the SWOT analysis, performed as part of this project, for each IWS facility in TN. A complementary webpage was developed (https://sites.google.com/view/iws-v1-1/home) to streamline dissemination and use of the results from the SWOT analysis. A SWOT analysis is a strategic planning tool used to identify and evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a business or project. It is a comprehensive framework that helps organizations understand their internal and external factors, enabling them to make informed decisions and develop effective strategies. Next, we briefly present a short breakdown of possible components of each item in a SWOT analysis.

1. Strengths:

- Internal factors that give the organization a competitive advantage.
- Positive attributes, resources, or capabilities that contribute to success.
- Examples may include a strong brand reputation, skilled workforce, innovative products, efficient processes, or a robust financial position.

2. Weaknesses:

- Internal factors that place the organization at a disadvantage.
- Areas that need improvement or vulnerabilities that can hinder success.
- Examples may include outdated technology, lack of skilled personnel, poor financial management, or internal processes that are not streamlined.

3. Opportunities:

- External factors that the organization could exploit for its benefit.
- Emerging trends, market changes, technological advancements, or gaps in the competition that present positive prospects.
- Examples may include untapped markets, new partnerships, advancements in technology, or changing consumer preferences.

4. Threats:

- External factors that could pose challenges or risks to the organization.
- Elements outside of the organization's control that may negatively impact its performance.
- Examples may include economic downturns, regulatory changes, intense competition, technological disruptions, or shifts in consumer behavior.

Process of Conducting a SWOT Analysis:

1. Define the Objective:

- Clearly state the purpose of the analysis, whether it's for a specific project, product, or the overall business.

2. Gather Information:

- Collect relevant data and input from various sources, including internal stakeholders, market research, and industry reports.

3. Identify Strengths:

- List all internal factors that contribute to the organization's success. This could include unique skills, valuable assets, or a strong market position.

4. Identify Weaknesses:

- Highlight internal factors that hinder the organization's performance. This may involve examining areas of inefficiency, resource limitations, or internal conflicts.

5. Identify Opportunities:

- Look for external factors that the organization can capitalize on. This could involve market trends, technological advancements, or changes in customer behavior.

6. Identify Threats:

- Identify external factors that could potentially harm the organization. This may include changes in the competitive landscape, economic challenges, or regulatory issues.

7. Prioritize and Evaluate:

- Assess the significance of each identified factor and prioritize them based on their impact on the organization.

8. Develop Strategies:

- Use the SWOT analysis to develop strategies that leverage strengths, address weaknesses, capitalize on opportunities, and mitigate threats.

9. Implementation and Monitoring:

- Implement the strategies and regularly monitor the environment for changes that may require adjustments to the organization's strategy.

Chapter 9 Economic Benefits

This chapter provides an analysis on the national, regional, state, and local benefits stemming from TNs IWS, its ports and terminals, and other assets. The main goal of this section is to provide quantitative performance indicators of the current and potential economic contribution of TNs IWS to support the state in attracting federal funding. The majority of the data and conclusions presented herein are based on two reports from IBISWorld [4, 5] and analysis of data using the analytics tools developed as part of this study (https://sites.google.com/view/iws-v1-1/home).

In 2019, the U. S. Department of Agriculture released a major study [1] on the strategic value of inland waterways to U.S. agriculture and the U.S. economy. In 2019, the US IWS moved more than half a billion tons which translated to nearly 7-9 billion dollars in transportation savings to the nation over the cost of shipping by other modes (e.g., truck or rail). The U.S. economy depends on farmers using the inland waterways system to maintain a competitive position in the global export marketplace, with agricultural exports providing a significant positive contribution to the U.S. balance of trade [1].

The inland water transportation industry (IWTI) has experienced varied conditions over the last few years. The COVID-19 pandemic, stagnant freight volumes led to supply chain disruptions, natural disasters (e.g. winter storm Uri which resulted in the shutdowns of many petrochemical plants for an extended period), and vast commodity price fluctuations all restrained industry growth. The lower Mississippi River experienced the longest flood on record, lasting 226 days between December 2018 and August 2019. This flood resulted in the reduction of cargo transported during the same period. In addition, high competition from railroad and truck companies put downward pressure on industry freight rates, limiting revenue growth. To reach more customers and minimize operating expenses, large companies[2] have continued to consolidate. The majority of IWTI is represented by small companies. These small companies have limited operational capacities that have made them more vulnerable to external and large internal competitors, limiting profit growth. Industry revenue (from 2018 to 2023) has decreased at a Compound Annual Growth Rate (**CAGR**) of 1.1% to $7.9 billion over the past five years (2018-2023), including an increase of 0.2% in 2023 alone when profit is expected to reach 19.6%. The number of people employed in the industry is 24,348 with an annual growth rate for the last five years of 1.8% as the annual wage growth for the same period is 1.4% [2]. **Figure 9-1** summarizes the inland waterway industry's economic impact in the U.S. from 2018 to 2023 while **Figure 9-2** provides a performance overview of the industry, from 2015 to 2028 (projection), by the annual percentage change of revenue, Industry Value Added (IVA) (i.e. the market value of goods and services produced by the industry minus the cost of goods and services used in production, IVA is also described as the industry's contribution to GDP, or profit plus wages and depreciation) and businesses-establishments.

[2] company" is defined as an entity engaged in providing waterborne transportation along inland waterways.

Figure 9-1 Inland Water Transportation Industry in the US at a Glance

SOURCE: WWW.IBISWORLD.COM

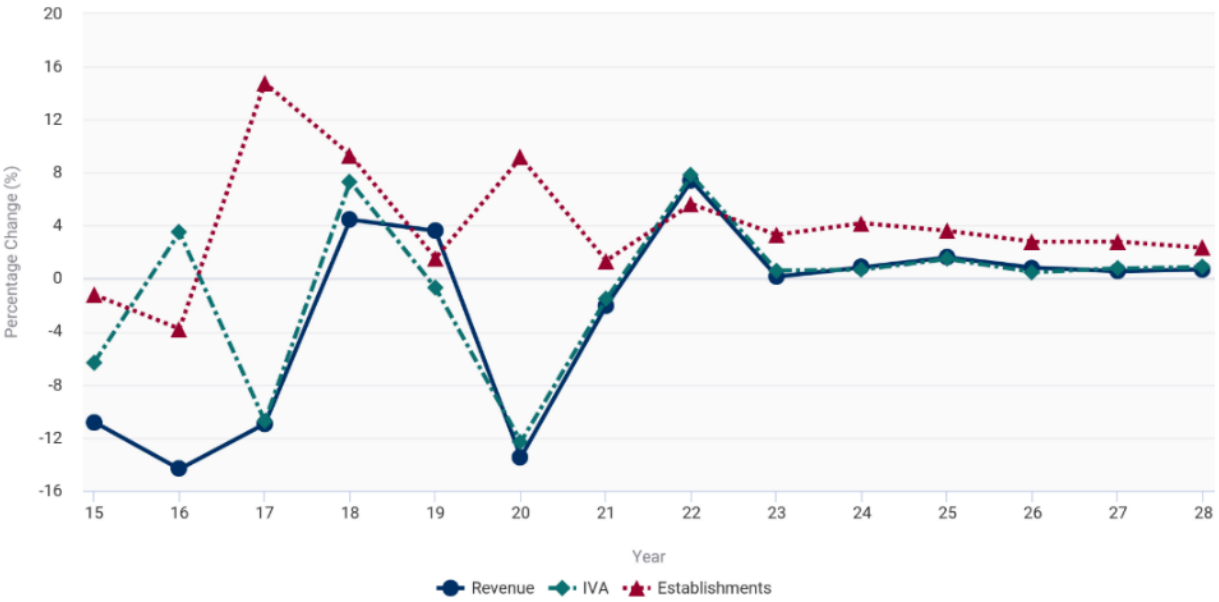

Figure 9-2 IWS Performance 2015-2028

SOURCE: WWW.IBISWORLD.COM

Activities in the inland water transportation sector are primarily service based, although there is both direct and no direct international trade. Additionally, even though industry operators may import fuel and equipment they use, as well as the goods they transport, all of these transactions are reported at the manufacturing level.

The industry's three largest companies (Ingram Industries, American Commercial Barge Line Llc, Kirby Corporation) account for nearly half of the industry's total revenue. The other half of the market share is mainly fragmented and is dominated by establishments that employ fewer than five workers. A concentrated customer base increases the risk for the owners, everyone who depends on the existence of the business, and for potential purchasers, who value businesses commensurate with the risk involved in their cash flows. The freight transportation services index (TSI) measures the annual output of the US transportation sector. When the economy grows and consumer spending increases, industrial, retail and trade activity increases. As a result, demand for freight transportation, including industry services, also increases. The freight TSI will likely increase in 2023. The industry is sensitive to changes in overall consumer spending. Increased consumer spending stimulates demand for consumer products and, in turn, for industry transportation services. In addition to generating demand for shipping-related services, an increase in consumer spending also stimulates demand for inland cruise services. Consumer spending will increase in 2023. When industrial activity climbs, the need for domestic and international transportation of goods, materials and commodities increases, leading to greater demand for inland water transportation services. The industrial production index dropped in 2020 during the pandemic. Following the pandemic, the industrial production index has grown.

The domestic production of corn, cotton, soybeans, and wheat is ultimately related to the need for agricultural transportation services. As a result, demand for the transportation of these commodities varies seasonally and is influenced by both the price of particular commodities and the summer harvests. Similar restrictions may apply to operations throughout the winter when ice buildup may cause some rivers to become impassable. The grain harvest was negatively impacted by the exceptional amount of rain that fell in 2019, which led to a substantial decrease in this segment's revenue share for the industry in that year. The demand for inland water transportation may be impacted by the relative cost advantages of other modes of transportation. Because rail also provides an affordable means of moving bulk freight, it poses a significant threat to road transportation. According to IBISWorld, the railroads have recently entered the conventional barge business by implementing cutting-edge scheduling and pricing strategies. The rail rate is less expensive than water transportation on numerous routes in the United States. The number of overlapping routes that both industries can use is constrained by geographic factors, hence IWTI operators only compete with rail transporters on a limited basis [2].

High fuel prices can increase the water transportation operating cost, which, in turn, can reduce revenue. An oversupply of cargo-carrying capacity can lead to increased competition for each load moved and lower prices. Significant capital investments are also required for the technology and support services that go along with operations. Since fuel is a significant industry input and oil prices have fluctuated more recently, including a significant drop in 2020, it is crucial for operators to pass costs on to customers in the form of fuel surcharges. During the pandemic in 2020, fuel surcharge revenue decreased. In 2021 and 2022, fuel surcharge revenue is anticipated to have grown.

Outlier growth refers to situations where industry growth in the current year is noticeably higher or lower than the average year since 2005. Costs are challenging to account for and indicate that revenue may be more unpredictable when revenue is considered to be an anomaly, which poses a danger to industry performance. Government regulations and policies can also increase revenue volatility as more strict environmental regulations mean companies may have to invest in new technologies or equipment to meet those requirements. As already mentioned, revenue has decreased at a CAGR of 1.1% to $7.9 billion over the past five years. **Table 9-1** provides an overview of inland transportation performance from 2014 to 2028. Decreased demand from the coal mining sector has significantly contributed to this revenue decline. The aforenoted internal and external factors are compiled in a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis for assessing IWS in the U.S. (**Figure 9-3)**.

Table 9-1 Performance Outlook of Industry

SOURCE: WWW.IBISWORLD.COM

Year	Revenue ($m)	IVA ($m)	Establishments (Units)	Enterprises (Units)	Employment (Units)	Exports ($m)	Imports ($m)	Wages ($m)	Domestic Demand ($m)	US oil and gas production index (Index)
2014	11,726	4,938	2,835	2,775	23,801	N/A	N/A	2,054	N/A	121
2015	10,458	4,627	2,801	2,740	24,854	N/A	N/A	2,190	N/A	122
2016	8,956	4,788	2,695	2,632	24,537	N/A	N/A	2,057	N/A	123
2017	7,975	4,273	3,093	3,026	22,813	N/A	N/A	1,889	N/A	128
2018	8,331	4,587	3,382	3,318	22,217	N/A	N/A	1,846	N/A	137
2019	8,632	4,555	3,435	3,370	22,992	N/A	N/A	1,917	N/A	139
2020	7,469	3,995	3,749	3,650	23,142	N/A	N/A	1,879	N/A	133
2021	7,318	3,934	3,800	3,707	22,928	N/A	N/A	1,857	N/A	136
2022	7,858	4,240	4,014	3,911	24,181	N/A	N/A	1,966	N/A	138
2023	7,870	4,266	4,147	4,049	24,348	N/A	N/A	1,977	N/A	139
2024	7,937	4,295	4,321	4,229	24,675	N/A	N/A	2,002	N/A	141
2025	8,064	4,360	4,477	4,387	25,147	N/A	N/A	2,039	N/A	143
2026	8,132	4,381	4,602	4,515	25,505	N/A	N/A	2,066	N/A	145
2027	8,178	4,416	4,731	4,649	25,811	N/A	N/A	2,088	N/A	147
2028	8,236	4,454	4,841	4,762	26,122	N/A	N/A	2,111	N/A	149

Figure 9-3 SWOT Analysis of Inland Water Transportation Industry

SOURCE: WWW.IBISWORLD.COM

IWS Economic Impact in TN

Tennessee experienced an average annual population growth of 0.9% over the past five years, reaching a total of 7,039,741 people in 2022. This places Tennessee as the 9th highest growth rate state in the US according to a recent report by IBISWorld. In terms of gross state product (GSP), Tennessee generated $350.7 billion in 2022, a 1.9% increase from the preceding five years. The state's employment rate is expected to grow from 3.2 million jobs in 2020 to 3.7 million by 2030, with an annual increase of 1.5%, which includes recovery from the lower employment base in 2020 due to the pandemic. The top three sectors for employment are Manufacturing, Real Estate and Rental and Leasing, Healthcare, and Social Assistance. The unemployment rate across the state in 2022 was 3.5%. In 2021, Tennessee's average annual nonfarm employment increased by 101,600 jobs, or 3.4%, with goods-producing jobs increasing at a rate of 4.5% compared to 4.0% for private service-providing jobs. The number of jobs in the government sector decreased by 0.6%. Construction, logging, and mining all increased 6,900 jobs, while manufacturing added 14,000 positions to the sector that produces goods [3]. The IWS of Tennessee could reinforce some of the pillar sectors of economic growth of the state, like manufacturing, construction, logging and mining.

Based on available data from the web-based tool developed for this report, it is derived that coal, farm products, petroleum, coal, soil, sand, and chemical products are the main commodities moved by the IWS. Consequently, manufacturing, agriculture, and oil and gas production are mostly impacted by inland waterways and coastal channel sectors. These sectors share the competitive advantage of the cost-effective benefit that the IWS provides. The sectors are also critical economic drivers, as they support a diversified national economy and contribute to a favorable balance of trade.

The IWTI in TN contributed revenues of **$938.6 million** on 2022 with an annual growth rate 5% from 2017 to 2022 (which is remarkable when compared to the national industry declining annual rate of -1.1% during the same period) and is expected to **grow** at an **annualized rate of 3.1%** from 2023 to 2027. During the same period IWTI establishments in TN decreased by an annualized -1.8%. IWTI employment in TN has increased an annualized 0.7% to 2,722 workers, while industry wages have increased an annualized 6.1% to $233.9 million. Over the five years to 2027, the revenue of IWTI in TN is expected to grow an annualized 3.1% to $1.1 billion, while the national industry is expected to grow 0.9%. Industry establishments are forecast to grow by 1.3% to 66 locations in TN. Industry employment is expected to increase by an annualized 1.1% to 2,879 workers, while industry wages are forecast to increase by 3% to $271.0 million. The following table (**Table 9-2**) summarises some fundamental economic factors (e.g. revenue, establishments, enterprises, employment, and wages) of the inland transportation industry in Tennessee from 2005 to 2026.

Table 9-2 Economic factors of IWS in Tennessee from 2005 to 2026

SOURCE: WWW.IBISWORLD.COM

Year	Revenue ($m)	Establishments (Units)	Enterprises (Units)	Employment (Units)	Wages ($m)
2005	638	43.0	9.00	2,619	133
2006	727	45.0	9.00	2,787	148
2007	789	46.0	9.00	2,743	156
2008	866	47.0	9.00	2,571	155
2009	959	46.0	10.0	2,588	155
2010	874	48.0	10.0	2,281	140
2011	931	47.0	10.0	2,170	134
2012	933	56.0	9.00	2,394	143
2013	856	51.0	10.0	2,415	149
2014	916	49.0	10.0	2,416	159
2015	774	49.0	10.0	2,425	162
2016	685	49.0	10.0	2,415	157
2017	735	68.0	13.0	2,632	174
2018	820	55.0	10.0	2,460	181
2019	889	56.0	10.0	2,571	197
2020	802	60.0	10.0	2,606	201
2021	847	61.0	11.0	2,621	213
2022	**939**	**62.0**	**11.0**	**2,722**	**234**
2023	980	64.0	11.0	2,779	243
2024	1,011	65.0	12.0	2,818	251
2025	1,043	66.0	12.0	2,854	259
2026	1,070	66.0	12.0	2,875	266

Inland Water Transportation in Tennessee contributes 11.9% (or ~$940 billion) to the total national IWS industry's **revenue of $7.9 billion**, **ranking Tennessee 3rd out of 43 states** in total industry revenue. Davidson County contributes most to the state industry's total revenue, with 44.4% of state revenue coming from the county. **Table 9-3** shows the top 4 counties by highest revenue.

Table 9-3 Top 4 Counties of Tennessee by Revenue

SOURCE: WWW.IBISWORLD.COM

County	Revenue $	Annual Growth Rate (2021-22)	Share of State
Davidson County	417.1m	10.8%	44.4%
Shelby County	312.9m	10.8%	33.3%
Hamilton County	104.3m	10.8%	11.1%
Knox County	104.3m	10.8%	11.1%

Employment for Inland Water Transportation in Tennessee totals an estimated 2,722 which increased an annualized 0.7% over the past five years. **TN employs the 4th-most IWTI employees nationwide**. The largest number of industry employees in Tennessee is concentrated in Davidson County. Davidson County employs 1,210 individuals, 44.5% of all state industry employees.

Table **9-4** illustrates the top 4 counties by highest employment.

Table 9-4 Top 4 Counties of Tennessee by Employment

SOURCE: WWW.IBISWORLD.COM

County	Employment	Annual Growth Rate (2021-22)	Share of State
Davidson County	1,210	3.9%	44.5%
Shelby County	906	3.7%	33.3%
Hamilton County	304	4.1%	11.2%
Knox County	304	4.1%	11.2%

Total wages for Inland Water Transportation in Tennessee, in 2022, amounted to **$233.9 million**, with an an average annualized increase of 6.1% between 2017 to 2022. Currently, the average wage of Inland Water Transportation employees in Tennessee **is $85,933**, which is **5.8% higher than the industry's national average wage of $81,214**. Davidson County has spent the most on total wages within Tennessee, with 44.4% of the state's total wages coming from the county. **Table 9-5** shows the top 4 counties with the highest IWTI employment in TN.

Table 9-5 Top 4 Counties of Tennessee by Wages

SOURCE: WWW.IBISWORLD.COM

County	Wages $	Annual Growth Rate (2021-22)	Share of State
Davidson County	104.0m	9.8%	44.4%
Shelby County	78.0m	9.8%	33.3%
Hamilton County	26.0m	9.8%	11.1%
Knox County	26.0m	9.8%	11.1%

The number of Inland Water Transportation establishments in Tennessee accounts for 1.5% of the 4,147 establishments within the national industry, **ranking Tennessee 19th for the number of IWTI establishments** within the US. The largest distribution of industry establishments in Tennessee is concentrated in Davidson County. Davidson County and accounts for 38.7% of the total establishments within the state (**Table 9-6**). **Figure 9-4** illustates an overview of the economic impact of each one of the four counties for Tennessee. Overall, **TN** pays more than industry average, has slightly more growth potential, while having fewer IWTIs

Table 9-6 Top 4 Counties of Tennessee by Establishments

SOURCE: WWW.IBISWORLD.COM

County	Establishments	Annual Growth Rate (2021-22)	Share of State
Davidson County	24	0.0%	38.7%
Shelby County	20	5.3%	32.3%
Hamilton County	10	0.0%	16.1%
Knox County	10	0.0%	16.1%

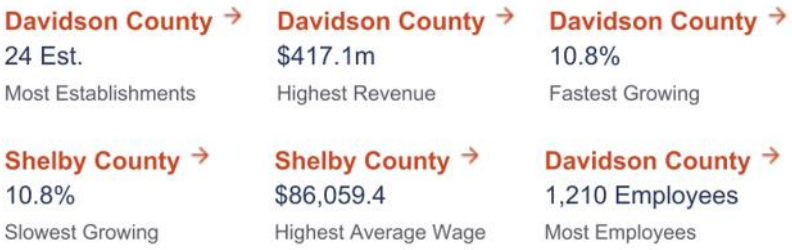

Figure 9-4 Tennessee IWS Economic Impact Overview by County

SOURCE: WWW.IBISWORLD.COM

Chapter 10 Conclusions and Recommendations

States often allow port operators and facilities to deal with their own issues regarding infrastructure and business development. As competition has increased, however, it is becoming increasingly important to undertake a coordinated approach to the development of a comprehensive transportation plan that includes roads, rail, runways, and waterways.

Ports depend on the critical infrastructure that is mostly outside of their control regarding access. Waterways are managed by the US Army Corps of Engineers with aids to navigation managed by the US Coast Guard. Rail right of way is in most cases the property of the railroads and roads including collector roads and interstates are under the control of the State. It is essential to understand that a port facility depends on efficient intermodal connections that involve all these corridors. A marine facility is an intermodal transfer point bringing together all these corridors for effective cargo movement. When a corridor is inefficient, it has a direct impact on the facility, the shippers who use the transportation system and the State's economy.

Rail and trucking compete with marine facilities, but they are also facility partners. Regions of the State have parochial interests that often pit the ports in a State against each other. Often the global view is not obvious where a State can compete with port facilities throughout the river system as well as North America. The inability of a State's facilities to compete with other States will result in the shift of manufacturing, agriculture, jobs, tax revenue and the like to States where the efficiency of a transportation system is more effective, and costs lower with choices for shippers. To that end, the State must take a proactive role in looking at transportation as a whole and coordinating all aspects of its system while minimizing parochial interests where possible.

The review of Tennessee port facilities as well as the results of written and interview surveys resulted in several suggestions for addressing local and Statewide issues. In addition, examples of effective State involvement in other areas where successful were reviewed under this project.

10.1 Ports and connectivity

The State has over 92 intermodal facilities of which 57 are port facilities on the three inclusive rivers.[3] The State is also served by 33 common carrier railroads including six Class 1 railroads and 23 short line railroads. There are 3,048 miles of rail track in the State served by all the railroads. In a typical year, more than 220 million tons of freight originate in, terminate in, or pass through Tennessee by rail, including millions of tons of motor vehicles, food, chemicals, and other products made or grown in Tennessee itself.

[3] Tennessee Freight Facts, State of Tennessee

There is also a substantial amount of cargo that eventually, if not totally, moves by truck. The State has 95,523 miles of public roads of which 13,884 miles are State-maintained roadways and 81,639 miles are local-maintained roadways[4]. Over 10,000 trucking companies move over 90% of the State's freight on the roads in Tennessee. From an intermodal perspective, the State's shippers, manufacturers, and agricultural interests have several choices for transportation services and good intermodal connectivity.

Overall, the State competes with other regions of the country to attract new business development with transportation alternatives being a key factor. In 2023, there were 7,137 Tennessee manufacturers profiled in the Register® & Tennessee Manufacturing Industry Database. In addition, there was an average of 334,000 manufacturing employees in Tennessee in 2020, with an average annual compensation of $71,751.48 in 2019. Manufacturers in Tennessee account for 15.32% of the total output in the State, employing 11.47% of the workforce.[5] All of these manufacturers depend on some form of transportation as does agriculture and the population in general.

Around 12% of the Nation's tonnage is international with 88% to 90% being domestic cargo moved within the United States.[6] There are 218,839 jobs at 13,397 establishments in transportation and logistics clusters (largest in US), with $16.6 billion in earnings, $287,741,180,700 in total exported goods (2012 dollars). Approximately 260 companies moved to TN and over 1,000 had either logistics or supply chain connections in the last several years. The State's largest commodities included gravel: 46,016,041 tons, non-metallic minerals: 26,353,433 tons, and gasoline: 20,074,959 tons. Major commodities by value include electronics: $89 billion, motorized vehicles: $67.6 billion and pharmaceuticals: $61.5 billion.[7]

A key area highlighting intermodal connectivity is Chattanooga which is connected to three Interstate highways (I-24, I-75, and I-59) and a significant inland port. The Appalachian Regional Port is located Southeast of the Chattanooga metropolitan area and connects directly to the Port of Savannah GA, one of the fastest growing ports in the United States. The port's facilities have a capacity to handle 50,000 containers per year, with an estimated increasing annual volume of 33 million tons passing through the region by 2035.[8] The area also supports multiple short line and Class 1 railroads (Norfolk Southern, CSX) and freight rail services connecting to international shipping in Savannah. Overall, it is a good example of a regional area with diverse and efficient intermodal connectivity.

Many of the raw materials that support manufacturing throughout the U.S. travel on Tennessee rivers via barge. Depending on the material, a barge can handle between 1,700 and 1,900 short tons of cargo. For example, over 50 million tons of goods move up and down the Tennessee

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[4] Tennessee Department of Transportation
[5] https://www.nam.org/State-manufacturing-data/2020-tennessee-manufacturing-facts/
[6] IAMPE Annual Trade Statistics
[7] Tennessee DOT
[8] Ibid

River every year[9]. About 2 million tons of commerce are now exported each year on the Tennessee-Tombigbee Waterway (Tenn-Tom). There are also over 17 ports and terminals along the Tenn-Tom waterway with rail and truck access.

Barge traffic is critical in the State's transportation planning. Movement by barge, particularly bulk commodities, has a larger overall capacity and these commodities can be handled most cost effectively on a barge which also reduces truck traffic, a major source of greenhouse gases. Barge traffic is also very safe and the number of personnel accidents, vessel incidents and pollution events in barge and towboat operations remain the lowest in the transportation industry.[10]

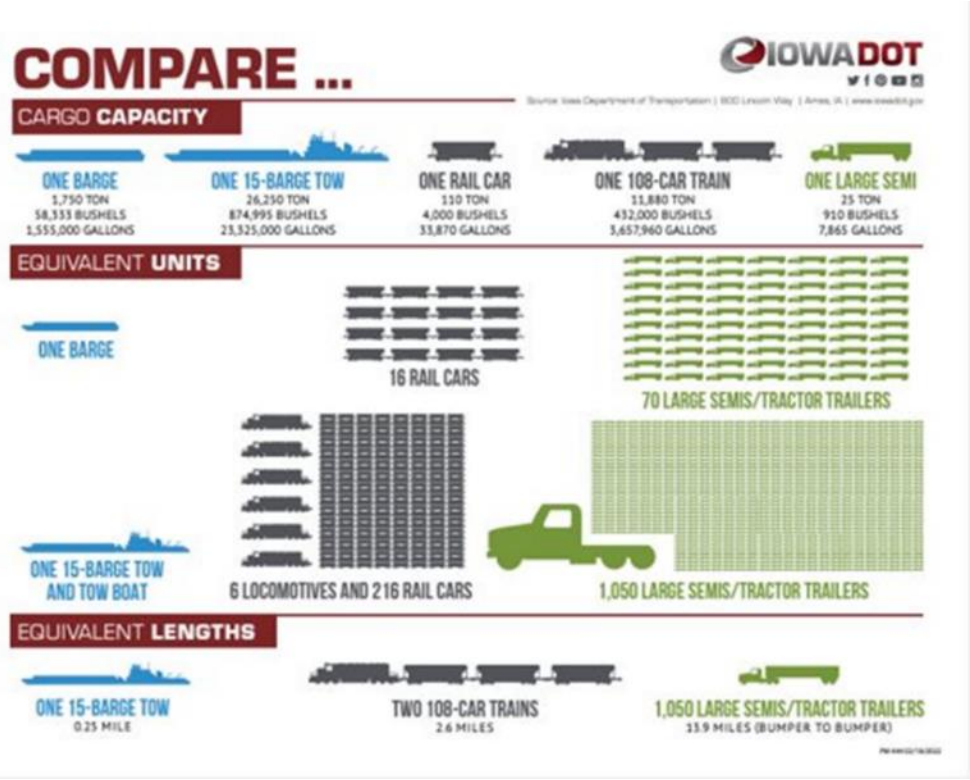

Figure 10-1 Capacity of Transportation Systems by Mode (Source: Iowa DOT)

[9] Tennessee Valley Authority

[10] American Waterways Operators and US Coast Guard

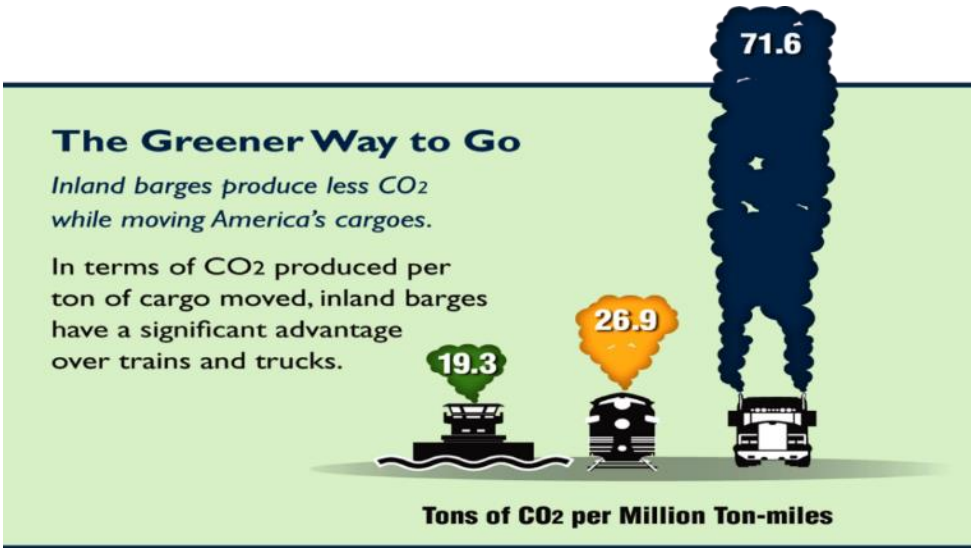

Figure 10-2 Greenhouse Gas Emission by Mode (Source: National Waterways Foundation)

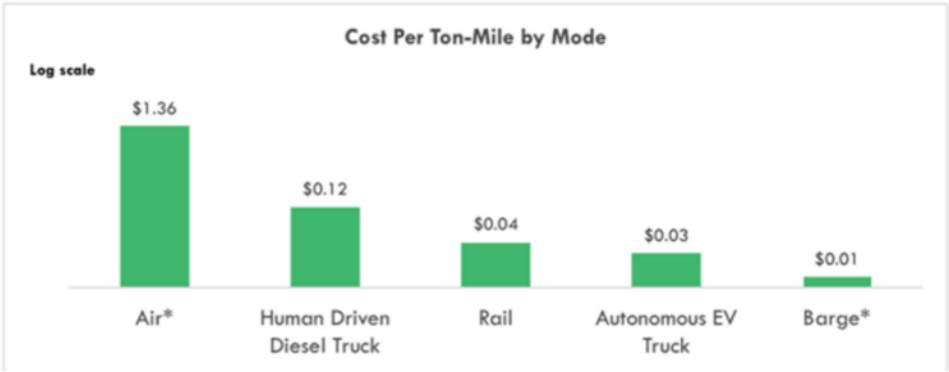

Figure 10-3 Cost Per Ton Mile by Mode of Transportation (Source: ADK Management)

Waterways nationwide, however, handled only 3.9% of the domestic moves with the highest volume moved by trucking at 11.5 billion tons, or 63.8% of the total moves in the U.S. Rail moved 16.2 billion tons, 9% of total domestic tonnage nationwide. As shown, a 15-barge tow can carry 1,050 semi-trucks, or 216 rail cars. If barge cargo moved to surface systems truck traffic would increase by 83% and rail traffic would increase by 25%.[11] Overall, the U.S. Government has failed to address the importance of inland river transportation (and intermodal transportation) in systematic policies which has been left mostly to the States.

10.2 Needs assessment

In the remainder of this part of the report, and as a result of the Port and Terminal Survey conducted by the University of Memphis and the International Association of Maritime and Port Executives (IAMPE), the key improvements that are perceived as needed in the State of Tennessee to enhance commerce and support transportation activities are summarized.

[11] US Dot 2021 Annual Transportation Report

10.2.1 State Coordination

State's often allow free market opportunities to dictate the development and growth of port facilities. Many States place a strong emphasis on roadway construction and maintenance and the increasing demand of traffic on metropolitan and rural roadways. While cargo moves are highest by truck, many of these cargoes can be handled by barge for cargo destined to other river locations or internationally. The movement by barge represents a reduction in roadway maintenance and construction costs for the State.

State DOT's are taking a more active role in coordinating the development of intermodal activities in a more comprehensive manner. Many facilities need infrastructure improvement which can be supported through Federal government grants and State earmarks. Several States have created port councils under their DOT's and economic development agencies to determine how best to meet the demands of transportation infrastructure improvements. These government created council functions similar to Metropolitan Planning Organizations (MPO) but are focused on port development and intermodal connectivity. The DOT ensures that there is coordination between the other road and rail activities that are ongoing to improve overall efficiency. Massachusetts and Florida have active councils as does Chicago/Western Lakes and Ohio.

In addition to coordinated infrastructure improvements and policies that benefit the ports and associated transportation, these councils also support staff who collect data. This allows Governors and legislatures to make fiscally responsible investments, support Statewide business development tied to ports. It also involves other associated transportation modes to develop State policies that lead to the improvements of all aspects of the State's transportation system. These remain the key elements in remaining competitive with other regions nationally.

For example, State policies in Georgia led to port improvements, airport improvements, road and rail improvements, development of inland ports, tax incentives for investment in property and new distribution centers, vocation training for the next generation of labor and other key policies that have made the Port of Savannah one of the fastest growing in the nation.[12]

RECOMMENDATION: Create by State legislation, a Tennessee Ports Council chaired by the Lieutenant Governor and including the Commissioner of DOT and the Commissioner of Environment and Conservation and representatives of each major community or county where there is commercial port activities present. The Council should also have an Executive Director and at least two full-time staff, one of whom shall be dedicated to logistics research and the other to grant writing.

10.2.2 Data Management

Data is one of the most essential elements in making good decisions. Data for Tennessee resides in various pockets that would be better coordinated as part of a master database managed by the State. The gathering and maintaining of useful databases are one of the most essential efforts that must be undertaken by port facilities and transportation entities. Database

[12] Georgia Port Authority

development is a full-time effort and must be focused on dynamic information gathering and use. Good data is the foundation of business development in the private sector as well as applying for grants.

RECOMMENDATION: The new Tennessee Ports Council should employ a full-time Database Administrator who shall work with other State agencies to create and maintain an accurate database of cargo movements and volumes, business interests dependent on transportation, and budgets dedicated to transportation system improvements related to river facilities and associated infrastructure.

10.2.3 Grant Support

Most Federal agencies have grant programs that can be used for the improvement of transportation infrastructure. The most recent is the Port Infrastructure Development Program (PIDP), a discretionary grant program administered by the Maritime Administration. Twenty percent of the program is restricted to smaller inland ports. In most cases, however, private entities may not be able to access public funds. There are also grant match requirements for most Federal grant programs. Parochial interests can dilute the amount of money needed to undertake and complete projects.

RECOMMENDATION: As part of developing the proposed Port Council, a full-time grant writer should be employed to undertake grant applications on behalf of the State and identify match requirements from the State and private sector. Where appropriate, also administer funds as directed by the Ports Council for public and private port improvement. This would also involve the GSA requirements for tracking grant processes.

10.2.4 Business Development Support

As mentioned, data collection is a critical factor when trying to understand the impact of competitive forces, other States, logistic chain changes and other industry fluctuations. While every port and terminal generally undertake its own sales and marketing effort, coordinated efforts with the State can facilitate identifying opportunities and attracting cargo on a larger scale as opposed to singular efforts. Similar to economic development efforts, a State coordinator who would supervise data collection, retention and use would provide a supportive method of identifying potential activities for the State's businesses to attract. Some opportunities that can be of value to the State include:

1. Capturing of cargo from congested surface modes
2. Expansion of agricultural exports
3. Expansion of energy exports
4. Domestic connections to international gateways
5. Lower cost, environmentally sound transportation
6. Strong agricultural production access
7. Widened source of petroleum, petro-chemical, neo-bulk commodities
8. Impacts of changing international opportunities, Panama Canal, expanding South American/Asian markets
9. Green energy component manufacturing

***RECOMMENDATION*:** The Port Council when established should employ a full time Business Development Director who would coordinate efforts with port and terminal, as well as rail and road interests, to support sales and marketing staffs to grow general business activities Statewide.

10.2.5 Waterway Issues

The three most important river systems in Tennessee are the Mississippi, the Tennessee, and the Cumberland which in essence are all part of the same system. Both the Tennessee and Cumberland rivers eventually flow north into the Ohio River, which in turn flows into the Mississippi. The Clinch River flows into the Tennessee River but does not have regular commercial traffic.

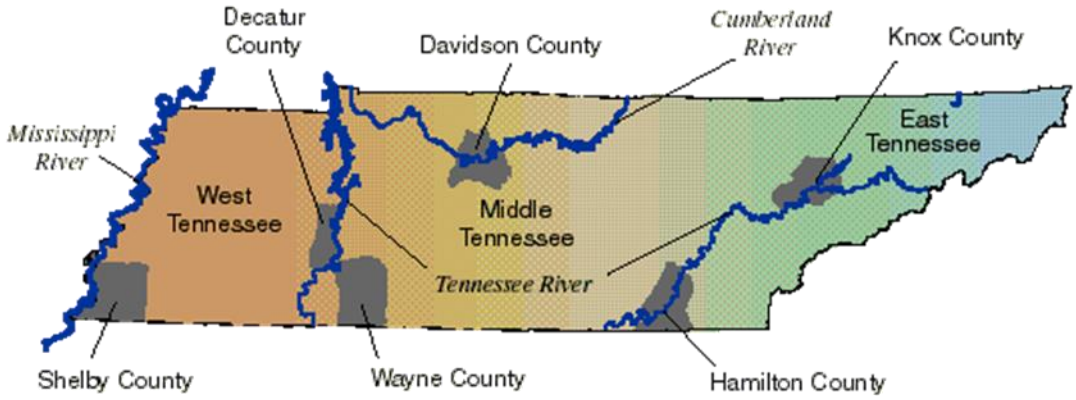

Figure 10-4 Tennessee Rivers

The river system passing through the State has approximately 887 miles of riverfront with navigable waterways.[13]

River issues in the system include a wide range of diverse potential problems which delay cargo movement and drive cargo to other modes of transportation. These include:

1. Pooled (lock controlled) River
2. 9/12 and 15/16 barge tows
3. 9-10' drafts-Smaller Tows
4. Channel maintenance issues (dredging)
5. Ice season (closed December - February)
6. Environmentally sensitive areas
7. Air draft restrictions
8. No ice breaking services
9. Environmentally sensitive areas, invasive species, fish barrier
10. Bank revetment issues

[13] Tennessee Valley Authority

11. River levels
12. Strong currents
13. Variable river flows
14. Debris
15. Flooding
16. Transit Delays
17. Lock transits
18. Lock maintenance delays
19. Lock silting
20. River ice and freezing
21. High/low water extremes 1-6 months per year
22. Other Issues[14]

While the US Army Corps of Engineers is responsible for waterway issues, and the US Coast Guard for Aids to Navigation, waterway safety and pollution, the demand on financial resources in these agencies, personnel availability, permitting requirements and a host of other demands limits the reaction of those agencies when issues arise. Often individual port facilities can stand alone when advocating for issues to be addressed. Having the State identify and advocate actions with Federal agencies generally allows those agencies to prioritize addressing key concerns that impact the State's commerce. This includes any legislative advocacy at both the Federal and State levels.

RECOMMENDATION: The Port Council should review all proposed Federal projects, set State priorities and work with key agencies through Council staff to ensure attention is paid to key issues that impact the State.

10.2.6 Roadway Issues

Overall, the Tennessee DOT has a very effective method of identifying and addressing road and highway issues within the State. Funding sources often favor the roadway network because of the steady stream of resources through the National Highway Trust Fund. Many States DOT's are set up around the solicitation and utilization of that funding. Accordingly, an internal advocate to balance the emphasis on roadways is critical. This is particularly important when access to port facilities can be hampered by planning that does not fully address traffic volumes, weight and ease of access to port facilities.

RECOMMENDATION: The State DOT should create a senior position within the department focused on port and waterway planning in conjunction with and support of the Port Council.

10.2.7 Rail Issues

The State has a number of Class 1 and short line railroads that provide service to port facilities as well as handling of intermodal cargo serving agricultural, manufacturing and bulk cargo movement. While railroads generally do an effective job of maintaining and utilizing their

[14] Inland Rivers Ports and Terminal Association Basin Meeting Reports

infrastructure, often State policies have an indirect and negative impact on rail right of ways. The large Class 1 railroads are focused on developing hubs, as well as inland port facilities, to optimize transport of commodities. Smaller short line railroads have taken on some of the class 1 infrastructure and customer service. As mentioned, railroads and trucking are both competitors and partners with port facilities. Shippers need transportation choices which in many cases will involve all of these modes. The development of policies which take into account rail service and advocacy for Federal funding are essential to both shippers and port facilities.

RECOMMENDATION: The proposed DOT Port position should also work closely with rail personnel in DOT to ensure that the transportation network is properly protected and funded as appropriate. A strong emphasis on the services provided by the State's short line railroads should continue. The State needs to carefully consider, and as appropriate protect, rail right of ways for current and future freight and passenger traffic.

10.2.8 Equipment and Infrastructure

The need for cargo equipment and other port-related equipment is ongoing. The Federal government has made several programs available for funding publicly owned equipment and some private terminal equipment with additional limits on private sector receipt of funding. The most effective means of attracting Federal grants and loans is if the State is the primary sponsor for funding applications and contributes to local matches along with the private sector for specific needs. In several States, the State would receive the grant money, and then do a long-term lease or lease to buy agreement with a private port or terminal operator. The private sector would contribute to the local match, and this would allow the private sector to upgrade its equipment, which in many cases is very expensive, with public help. Funding priorities can be established by the proposed Port Council and applications submitted through TDOT who would allocate funds based on need and local match contributions. These Federal funds could also be combined with State allocations to address the expanding need for new equipment.

RECOMMENDATION: The State DOT should establish a program, supported by Federal and State grant funding, for purchase of new cargo handling equipment for port and terminal facilities. Infrastructure improvements, while generally the responsibility of the facility, can be addressed through a State low interest loan program for specific upgrades to facility infrastructure. In addition, this would create a coordinated process for Federal Emergency Management Agency (FEMA) application and award disbursement in the event of a significant flood or other environmental incident. The State can also assist with the US Army Corps or State regulated permitting processes.

10.2.9 Dredging

Dredging of public waterways as well as waterway infrastructure such as chevrons and weirs are the responsibility of the US Army Corps of Engineers. Normally berth dredging is the responsibility of the facility. Often disposal options need to be identified for the private facility, and a permitting process undertaken with Federal government and State agencies. The State as an advocate can assist with these processes internally and with the Federal government. Low-cost loans for permitting and dredging can also be set up through the State DOT.

RECOMMENDATION: The State should establish under DOT a dredging advocate and program to address the dredging of public and private facilities as well as river infrastructure as appropriate.

10.2.10 Vessel Operations

Vessel Operations are the responsibility of the operator however coordination with the State can assist the private operators with mitigating the potential impacts of environmental conditions as well as support shippers in the event of waterway restrictions. Such restrictions include:

1. Operations during water level extremes
2. Current impacts on course of river
3. River ice
4. Current impacts on docking/turning
5. Dredging (as noted)

RECOMMENDATION: A reporting system coordinated with the State regarding waterway conditions and safety issues should be established under the TDOT Port position.

10.2.11 Other Issues

The leadership of the State is critical in addressing those issues which will impact the commerce of Tennessee in general. While roads, runways and rail are essential, so are the port facilities of the State which depends on its river commerce also. The State, through DOT and the proposed Port Council need work closely to identify issues that impact the ports and well as the entire transportation system to the benefit of the State's shippers, manufacturers, and agricultural interests. On any given day, any of the following issues can have an adverse impact on Tennessee's river commerce[15]:

1. Capital and investment limitations
2. Project complexities and permitting push work beyond grant periods
3. Lack of consistent investment by public sector
4. Dredging and infrastructure repair/replacement rising costs
5. Finances
6. Costs and terms variable along river communities
7. Infrastructure impacts
8. Levees and channelization create downstream issues
9. Dam impacts on water flows
10. Need to build "high" on banks
11. Piers and structures extending into river
12. High demand for riverfront property
13. Extreme environmental conditions
14. Impacts of extreme low water
15. Flood impacts on facilities
16. Increasing demand on facilities and waterways

[15] Inland Rivers Port and Terminal Association and IAMPE Inland Executive Management Program

17. Operational delays
18. Silting and river shifting
19. Aging Infrastructure
20. Consistent funding
21. Weather extremes
22. Seasonal rise of waterways
23. Waterway traffic restrictions
24. Emergency response
25. Undermined infrastructure
26. Vessel casualties and debris
27. Post flood runoff and pollution
28. Impacts on regional eco-systems
29. Economic impact of transport and logistics disruptions
30. Post incident return to normal operations and system restoration
31. Image issue related to river ports and system
32. "Parochial efforts" in business development
33. Lack of nationwide systematic transportation policies that integrate land and water modes
34. Limits of "on the job" trained executive management
35. Lack of predictable transportation services and schedules
36. Financial capability to move large cargo volumes
37. Time and cost impacts
38. Cargo sources not near river
39. Down bound-up bound imbalance
40. Wider access to international markets
41. Safety
42. Security
43. Emergency management

***RECOMMENDATION*:** Overall, the Tennessee Department of Transportation needs to integrate a further expansion of port and maritime issues into their DNA. This agency emphasis should extend beyond political cycles giving waterfront and transportation interests a level of confidence that all aspects of the transportation system receive consistent and balanced attention from the State.

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