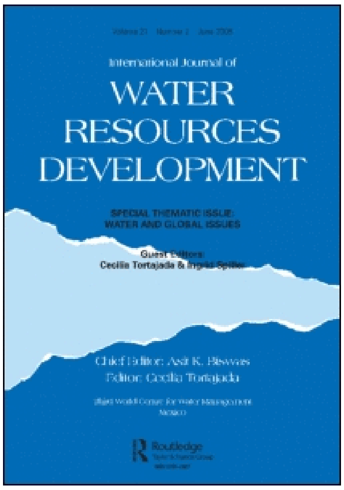

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Inland waterways for transportation of agricultural, industrial and energy products

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Inland waterways for transportation of agricultural, industrial and energy products

Asit K. Biswas

This paper examines the use of inland waterways throughout the world, particularly for the transportation of agricultural, industrial and energy products. It is found that there are great variations in their importance from one country to another. This discrepancy can be explained to a certain extent by geographical conditions, but lack of realization of the potential benefits to the national economies also plays an important role. Some countries – especially the oil-importing developing countries – are now making determined efforts to expand and modernize their waterways transportation systems, but generally there is a lack of national master plans for transportation, including inland waterways, so their development is still taking place on a piecemeal basis.

Inland bodies of water have been used as important corridors of transportation in different parts of the world from prehistoric times. The important ancient civilizations developed along the banks of major rivers like the Nile, Indus, Euphrates and Tigris because water could be used not only for agricultural and drinking purposes but also for transportation of goods and people. As civilization progressed and new technologies were developed, rivers were made navigable and canals were constructed to provide an intricate system of waterway networks through which agricultural, industrial, mineral and energy products could be transported. Many of the centres of industrial activities in Europe during the Industrial Revolution developed along the various rivers, since it provided easy availability of water for industrial processes, discharge of waste products to the rivers at minimal costs, and transportation of raw materials to factories and manufactured goods to customers.

Over the past several centuries, important waterborne inland transportation networks have developed along major rivers, including their tributaries, and lakes like the Ganges, Brahmaputra, Narmada, Chang Jiang and Mekong in Asia; the Nile in Africa; the Rhine, Main, Seine, Danube, Elba, Volga and Don in Europe; and the Mississippi and the Great Lakes in North America.

Naturally as technological and economic conditions have changed, the importance of inland transportation in specific countries has changed as well. The advent of air transportation and the construction of extensive highway and railway systems have sometimes reduced the importance of inland waterways. However, the increase in energy prices has given inland waterways an added advantage during the past decade, and many countries – especially the oil-importing developing countries that have potentials for this type of transport – are now making a determined effort to expand and modernize their existing waterways transportation.

It should be noted that inland waterways transport-

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ation, coastal and ocean shipping are often interrelated. Sometimes transportation of goods begins and/or ends in inland waterways, but the rest of the journey could entail coastal and ocean shipping. Similarly there are complementary relationships between road and rail transportation and waterway carriage of goods. The main focus of this paper, however, is on the transportation of agricultural, industrial and energy products through inland waterways.

Major considerations for inland waterways

As is to be expected, the major considerations for the use of inland waterways, rather than other forms of transportation, often vary from country to country, depending on economic, technical, social and political considerations. While certain considerations like cost-effectiveness or technical feasibility are universal, the priorities accorded to these factors, compared to other factors, could vary from one country to another, and also from one time period to another. In contrast, other considerations like employment potential often have different policy implications, depending on the countries concerned. Thus, for countries like Bangladesh, India and any other developing countries that have serious employment and underemployment problems, labour-intensive processes may often be preferred. In contrast, industrialized countries often prefer highly mechanized, automated and thus capital-intensive processes.

There are many major considerations for using inland waterways, and some of these issues are interrelated. Because of space limitations, only the following five major considerations will be briefly discussed here:

(i) economic efficiency;
(ii) employment potential;
(iii) energy use;
(iv) environmental factors; and
(v) socioeconomic requirements.

(i) Economic efficiency

It is a difficult task to determine the economic efficiency of any process, and inland waterways transportation (IWT) is no exception. Three factors need to be considered for determining total costs – capital, labour and operating expenses – which, when combined, form an operating system. The productivity of a system, however, depends on the system used (eg economies of scale for a barge), the extent of mechanization, the use of the latest technology and overall management. For example, labour cost reductions may often represent higher capital costs for mechanization. From a purely economic viewpoint,

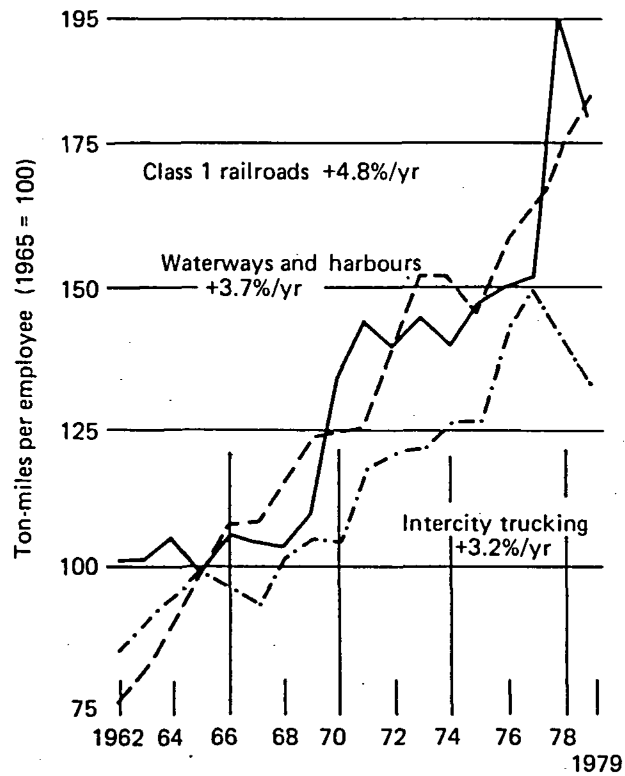

Figure 1. US waterways and harbours, Class I railroads and intercity trucking (index numbers).

increased mechanization is justified only if the increased cost of capital necessary is less than the savings in consequent labour costs.

In the USA, inland waterways transportation has to be classified as a capital-intensive, machine-dominated industry. According to the Interstate Commerce Commission (ICC, 1978), the depreciated investment in carrier property and equipment per employee of carriers regulated by the Commission was $75 346 in 1977. In contrast, the depreciated investment per employee in structures and equipment of all manufacturing industries in the USA in 1980 was only $16 900 (Department of Commerce, 1981). Corresponding statistics for inland waterways transportation in developing countries, where the emphasis is on labour, are significantly less.

Productivity in the USA increased during the period 1962 to 1979 for all three modes of transportation of bulk goods: by waterways, railways and highways. Figure 1 shows the changes in the index number by ton-mile per employee for these three modes of transportation (National Waterways Foundation, 1983). The index number for 1965 was taken to be 100. During this period, ton-miles per employee increased by the following rates per year:

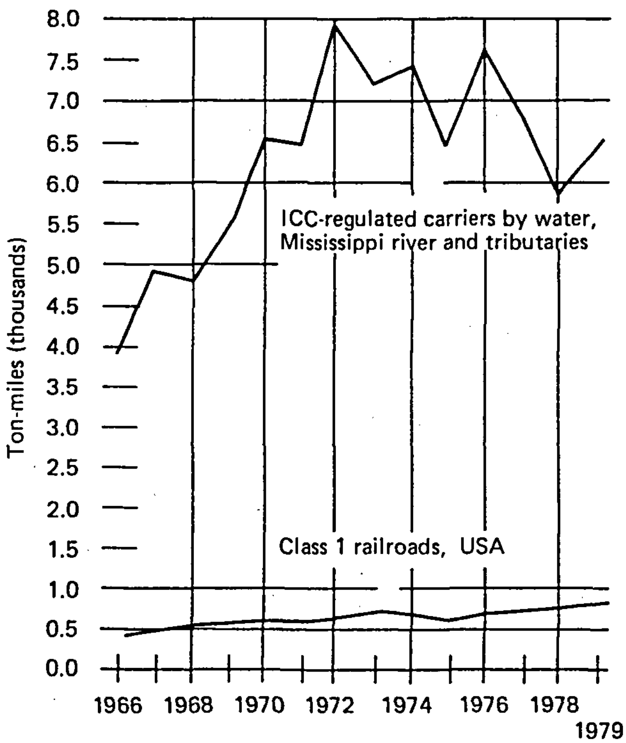

Figure 2. ICC-regulated carriers by water – Mississippi river and tributaries – and Class I railroads, USA (ton-miles per man-hour).

Class I railroads: 4.8%
Waterways and harbours: 3.7%
Intercity trucking: 3.2%

Figure 2 shows ton-miles carried per man-hour by the ICC-regulated carriers on the Mississippi river and its tributaries and Class I railroads (National Waterways Foundation, 1983). It should be pointed out that important differences in the service characteristics and goods composition of the two modes account for a substantial part of the differences indicated by the two graphs.

Figure 2 also indicates that output per man-hour continued to increase until 1972: in fact output increased by 9.0% per year from 1964 (the year the ICC started to report these statistics) to 1972. Probably one principal reason for the decline in output per man-hour from 1973 onwards was increasing energy costs. While inland waterways use much less energy per ton-mile, when compared to other modes of transportation which will be discussed later, its other expenses and revenues per ton-mile are also low. As a general rule, IWT's energy costs account for a higher percentage of overall operating expenses than in the case of railways. For example, the energy costs of ICC-regulated carriers in the Mississippi river accounted for 20.0% of their operating costs in 1979; the corresponding figure for the Class I railroads was only 9.9%.

For a developing country like India, analyses carried out by the National Transport Policy Committee (1980) of the Government of India indicate that the cost of operation of inland waterways transportation, computed for a 500-tonne self-propelled unit working at 75% load factor working for 300 days a year, is significantly lower than rail and road transportation of bulk products like coal and fertilizer. The cost advantages of IWT become even more favourable when larger-size vessels are used. For example, for a 1500-tonne vessel operating costs are less than half of the rail transportation costs and less than one third of the road transportation costs. Comparative estimates are shown in Table 1.

It should be noted that the intermodal cost comparison shown in Table 1 is valid for IWT for direct movement of cargo from one waterfront terminal to another. However, if multimodal movement and additional transshipment costs for IWT for surface transportation are considered, it was found that small-size, 500-tonne barge operations lost their cost advantage over railways, while 1000- and 1500-tonne barges maintained their cost advantages over railways, and even more over roads.

Intercomparison of actual transportation costs by different modes of transportation is not easy under the best of circumstances, because of the different processes involved, the nature of government policies towards different modes of transportation, pricing policies and subsidies. For example, costs for roadways are not fully paid by roadway operators (roads are generally constructed and maintained by federal,

Table 1. Operating costs for railways, road and IWT in paise[a] per tonne-km.

Distance (km)	Railways, diesel operation, single line, wagon load movement		Road transportation		IWT for self-propelled vessels, 75% load factor		
	Coal	Fertilizer	Coal	Fertilizer	500 tonne	1000 tonne	1500 tonne
50	23.6	23.4	27.0	35.0	13.7	10.3	9.4
100	14.6	14.3	21.0	17.4	9.1	6.5	5.8
300	8.6	8.4	15.0	19.0	6.1	4.1	3.4

Source: National Transport Policy Committee (1980).
[a] 100 paise = 1 Rupee; $1.00 = 13 Rupees.

state and local governments, who in turn seek to raise the necessary funds through taxation), but railways own and operate their tracks. IWT track costs are minimal, except when major locks need to be constructed. To some extent the marginal cost concept may resolve this problem, but even then it is not possible to trace each element of cost to particular kinds of services or quantities of output produced by different modes of transport.

(ii) Employment potential

For many developing countries that are facing serious unemployment and underemployment problems, the objective of employment creation is often an important component of the national transportation policy. However, maximization of employment generation is seldom the most important criterion for determining transportation modes. The sole use of the employment maximization criterion could very often lead to a transportation mode which is most labour-intensive per unit of investment but inefficient in terms of cost, time and service. Hence, in an interdependent economy, where transportation plays a crucial part, such an inefficient transport system could well jeopardize the overall employment level of the country by its failure to provide a cost-effective and timely service. Accordingly, the objective of employment creation needs to be analysed carefully by its impact on the economy as a whole.

Creation of employment, both direct and indirect, by various modes of transportation is a subject that has received inadequate attention in most developing countries thus far. Direct employment is created by the construction, operation and maintenance of the transportation system. Indirect employment is induced by a chain of forward and backward linkages. Backward linkages include employment generated due to the inputs necessary (materials and services) for the construction and operation of the system. Forward linkages include employments due to loading, unloading, service stations, wayside amenities, etc.

While it is comparatively easy to identify direct employments created by IWT, it is difficult to enumerate indirect employment creation with any significant degree of confidence, since both backward and forward linkages become weaker and weaker as one moves away from the industry where direct employments are created.

The National Transport Policy Committee (1980) estimated employment intensity of IWT for India; their results are shown in Table 2 for both passenger and freight services. In addition to the 33.59 person-years of employment indicated in the table, it was estimated that another 13.2 person-years of employment were generated for the construction and maintenance of navigational channel and terminal facilities per Rs100 000 of investment.

Table 2. Estimated employment intensity in inland waterways transportation.

Activity	Persons employed per Rs100 000 of investment
Passenger transport	
Public sector	
Mechanized	9.2
Private sector	
Mechanized	2.9
Country crafts	58.8
Freight transport	
Mechanized	1.4
Non-mechanized	20.8
Boat building	
Mechanized	14.8
Non-mechanized	NA
Indirect employment[a]	160
Overall average	33.59

Source: National Transport Policy Committee (1980).
[a]Includes freight handling, forwarding and clearing services.

Analysis by the Indian National Transport Policy Committee (1980) indicated that IWT provided a higher employment coefficient per unit of investment than any other mode of transportation. This comparative analysis is shown in Table 3. Interestingly, the next best form of transportation was found to be

Table 3. Comparative employment intensity in different modes of transport, India, 1977–78.

Transport mode	Employment in person-years per Rs 100 000 of investment: Direct	Indirect	Total
Inland water transport			
Operations	33.59		33.59
Development of navigational channel	13.20		13.20
Road construction and maintenance	15.0	12.50	27.50
Road transport operation			
Bullock-carts	27.0		27.0
Three-wheelers	13.42	3.73	17.15
Trucks	11.15	5.80	16.95
Buses	7.75	1.51	9.26
Taxis	2.76	0.95	3.71
Vehicle production (chassis)	1.78		1.78
Coastal shipping			
Sailing vessels	20.0		20.0
Other coastal shipping	2.40		2.40
Railways	3.64	0.66	4.30
Air transport	0.72	0.25	0.97

bullock-carts. The committee noted that both these forms of transportation required low capital investment but were slow-moving and can be used for specific cases and areas.

(iii) Energy use

Energy use by different modes of transportation has become an important criterion since 1972. Not only is the cost of energy used an issue but also the problem of the impact of imports of energy material on a country's balance of payments has equally become important, especially for oil-importing developing countries.

As far as transportation of bulk products is concerned, IWT is comparable more with railways and pipelines, since the uses of air cargo and roadways are not that relevant. In the USA, combined energy use by IWT, railways and pipelines in 1979 accounted for only 3.2% of the national consumption of petroleum fuels and was equivalent to only 1.5% of total energy consumption. These three modes of transportation, however, carried 80.4% of all the intercity ton-miles of freight (Transportation Association of America, 1981).

The US Congressional Budget Office (CBO, 1982) studied energy consumption per unit of freight movement by different modes. Their findings are summarized in Table 4.

It should be noted that there are many conceptual difficulties in comparing energy used by different modes of transportation from site A to site B. Whereas air cargo can travel more or less directly from one site to another, waterways must follow the river course, which often meanders. Similarly railways and highways may follow circuitous routes because of grades and other terrain conditions like crossings of hills and mountains. An example would best illustrate this point. The air cargo distance from Minneapolis to New Orleans is 1051 miles, but the distances by railways and by the Mississippi river are 1272 miles and 1828 miles respectively. Thus, for transportation of goods from Minneapolis to New Orleans, waterways will have to cover 1.74 times the air distance and railways 1.21 times. Such considerations make energy-efficiency comparisons in terms of BTUs per net ton-miles somewhat more complex. In other words, valid energy consumption comparisons between different modes of transportation can only be made for specific cases by analysing specific movements.

Similar analyses carried out by the National Institute of Training in Industrial Engineering (NITIE) for the National Transport Policy Committee (1980) show somewhat different results for India, as indicated in Table 5. According to this study, electric traction railways came out as the most energy-efficient form of freight transportation, followed by diesel traction railways, pipeline, IWT, diesel truck and steam traction railways. Since not all the assumptions of this analysis are clearly stipulated, it is difficult to compare this analysis with the CBO analysis.

The energy consumption for river transport in China was estimated at 12 g/tonne-km compared to 68 g/tonne-km for road transport (ESCAP, 1982a).

(iv) Environmental factors

Environmental factors have become important issues for transportation policies in both developed and developing countries.

In many ways IWT has important environmental advantages over other modes of transportation. In

Table 4. Energy efficiency for different modes of freight transport in BTUs per net ton-mile.

Transport mode	Operating energy[a]	Line-haul energy[b]	Modal energy[c]
Rail – overall	660	1 130	1 720
Trailer-on-flatcar	1 000	1 420	2 040
Unit coal train	370	590	890
Truck			
Average intercity	2 100	2 800	3 420
Barge – overall	420	540	990
Upstream	580	700	1 280
Downstream	220	340	620
Air			
All-cargo plane	26 250	27 250	28 610
Belly freight	3 570	3 710	3 900
Oil pipeline	325	450	500
Coal slurry pipeline	1 000	1 150	1 270

Source: CBO (1982).
[a] Propulsion energy including refinery losses.
[b] Combines operating energy with maintenance energy, vehicle manufacturing energy and construction energy.
[c] Adjusts line-haul energy for circuity but not for access energy.

Table 5. Comparison of energy efficiency of different modes of freight transport.

Transportation mode	BTU/tonne-km
Railways	
Electric	84.6
Diesel	255.5
Steam	3576.9
Diesel truck	1587.3
Barge	328.0
Pipeline	281.7

Source: National Transport Policy Committee (1980).

the important area of land use, requirements for IWT are minimal since, in contrast to railways and highways, no additional land is necessary for tracks and roads because waterways already exist. Similarly, noise and vibrations are almost non-existent for IWT, but they are important considerations for other forms of transport, except for pipelines. Pipelines in certain instances have contributed to difficulties in terms of the migration of animals and also for aesthetic reasons.

Probably the most important environmental considerations for IWT are the problem of oil spills and spills of hazardous substances. In this regard, it is useful to review potential risks due to spills of hazardous substances as reported in the USA. These are shown in Table 6. The study concluded that 'For this relative safety analysis, rail movements are found to be the most hazardous, in regard to human exposure index, with little difference in the safety of barges and trucks ... Expected property damage is about equally low for the barge and truck modes and somewhat higher for rail' (National Waterways Foundation, 1983).

Three other environmental factors that need to be considered are the impacts on water quality, bank erosion, and safe disposal of dredged material. In terms of water quality, IWT contributes to some deterioration in terms of disposal of organic wastes (human and otherwise), hydrocarbons and other foreign substances and turbidity. Organic wastes are seldom a major problem: it is normally localized and within the assimilative capacity of waterways. The issue of oil spills and other chemical substances has been discussed earlier. Safe disposal of dredging spoils and aquatic weeds seldom presents a serious problem, if planned properly. This, however, does not mean these problems should be neglected. For example, in Bangladesh alone nearly 1.0 million cubic yards of maintenance dredging and about 2.6 million cubic yards of capital dredging are carried out annually. However, no serious environmental problem has been reported thus far.

IWT does not appear to have any noticeable impact on wildlife, including waterfowls.

Table 6. Risks in annual expected number of people exposed if each chemical were shipped entirely by one mode.

	Expected number of people exposed			
	Urban		Rural	
Chemicals	Barge	Rail	Barge	Rail
Styrene	0.028	0.720	0.008	0.140
Acrylonitrile	0.008	0.160	0.004	0.016
Sulphuric acid	0	0.003	0	0.003
Liquid chlorine	0.280	0.490	0.120	0.130
Caustic soda	0	0.038	0	0.003
Benzene	0.012	0.048	0	0
Methanol	0.060	0.600	0.010	0.120
Ethylene glycol	0	0.006	0	0.004
Liquid ammonia	0.017	0.120	0.004	0.040
Sugar	0	0	0	0

Source: Arthur D. Little, as reported by National Waterways Foundation (1983).

(v) Socioeconomic requirements

There are some important socioeconomic requirements, in addition to those discussed earlier, for IWT. In developing countries, where most of the people live in rural areas, transportation is an important consideration for development. For example, as the National Transport Policy Committee (1980) has pointed out, out of a total of 575 936 villages in India, 407 297 are still to be connected by all-weather roads. For many of these villages, IWT is an important mode of transport. Similarly, in Bangladesh about 65% of freight traffic and 38% of passenger traffic is carried by IWT; the rest is carried by roads and railways (ESCAP, 1982a). Also, in the Jiangsu and Guandong provinces of China, IWT is the main mode of transport and accounts for more than 60% of the total traffic volume carried by all modes of transport. Under these conditions, IWT fulfils a very important socioeconomic need.

Present status of inland water transport

As might be expected, the recent rates of growth of inland water transport in different parts of the world have not been uniform. The growth rates have not been similar even within a specific region. For example, in Asia, cargo handled by inland waterways increased by 12% in China in 1982, and by 9.1% in Burma during 1982–83. In contrast, cargo handled in Bangladesh declined by 4% during 1982–83 (ESCAP, 1984).

The present status of inland water transport in three important regions – Asia, Europe and North America – will be briefly discussed here.

Asia

Inland waterways are an important means of transportation and communication for a significant percentage of people in Asia, especially those living in river basins and deltaic areas. Countries like Bangladesh and Thailand have always relied on transportation through their rivers which cover almost the entire length of the countries from north to south. The status of inland water transport in four Asian countries will be discussed.

(a) Bangladesh. Inland water transportation plays a major part in the economy of Bangladesh. Because the country is flat and low-lying, and approximately

one third of it is flooded for various periods every year during the monsoon season, navigation is an essential mode of transportation. The country has 15 000 miles of waterways, of which 5 240 miles are navigable during the monsoon season and 3 200 miles during the dry season. The three major rivers – Ganges, Brahmaputra and Meghna – carry an annual sediment load of some 2.4 billion tons, and thus Bangladesh Inland Water Transport Authority (BIWTA) has to conduct nearly 1.0 million cubic yards of maintenance dredging and 2.6 million cubic yards of capital dredging.

Currently IWT accounts for nearly 65% of the country's freight traffic and 38% of passenger traffic; the rest is carried by roads and railways (see Table 7, which clearly indicates the importance of the private sector in IWT).

In spite of the importance of IWT, navigation has declined in Bangladesh in recent years. For example, the length of waterways with 6 ft draft decreased from 2270 miles in 1973 to only 840 miles in 1981. Unstable river banks, a sharp reduction of channel depth in the low-water season, a high rate of siltation, inadequate channel markings, a lack of ports, substandard berthing facilities, a lack of telecommunication networks and a shortage of technical and managerial personnel have hindered further increases in IWT. A five-year plan has now been drawn up to resolve these problems. The budget of BIWTA for the fiscal year 1982–83 for the development of this sector was 50% higher than the allocation of the previous year.

(b) China. The total length of inland waterways in China is 430 000 km (ESCAP, 1982a). The total length of navigable waterways, according to a 1980 survey, was 107 829 km, which was nearly double the length of only 30 years earlier. The Chang Jiang (Yangtze) is the longest river in China, and flows a total distance of 6300 km. The Chang Jiang system (the river and its 700 tributaries) constitutes the most important navigable system of waterways in China – a total of some 70 000 km. Since the system is extensively connected to many other modes of transport – railways, highways, airports, sea, lakes and canals – it provides the very basis of the most extensive network of transportation in China. Once the present plan of south to north water transfer from the Chiang Jiang is completed, the navigation system will be further increased and improved (Biswas *et al*, 1983). The Chang Jiang Shipping Administration moved 48 million metric tons of cargo and 23 million passengers in 1980.

Table 7. Passengers and cargoes carried by inland waterways in Bangladesh.

	1975		1977–78	
	Public	Private	Public	Private
Passengers (millions)	1.55	36.68	2.00	41.21
Cargo (million metric tons)	1.31	1.56	1.59	2.10

The Pearl river (Zhu Jiang) and its 998 navigable waterways form the second most important navigation system in China after the Chang Jiang system. Formed by the confluence of three rivers, West river (Xi Jiang), North river (Bei Jiang) and East river (Dong Jiang), its navigational potentials are yet to be fully developed. The delta of the Pearl river is crisscrossed by some 823 branches and tributaries (ESCAP, 1982a), and has a total navigable length of 5332 km. The Pearl river has eight outlets to the South China Sea, and two of these outlets have an annual traffic volume of more than 5 million metric tons.

The 1747 km long Grand Canal is another important inland waterway that connects Beijing in the north to Hangzhou in the south. The traffic is very heavy in the southern part of the canal, and signal lights had to be installed at some sections to provide better traffic control. The traffic volume in 1979 was 36 million metric tons.

China currently has over 100 river ports which have an annual cargo-handling capacity of over one million metric tons. Another 200 ports have an annual cargo-handling capacity of over 100 000 metric tons. Nanjing and Wuhan are the two biggest ports, with annual capacities exceeding 12 and 10 million metric tons respectively. The overall throughput capacity has increased more than 19 times since 1979 (ESCAP, 1982a).

Both passengers and cargo carried by IWT have increased consistently in China in recent years as follows:

	1975	1977	1980
Passengers carried (millions)	207.16	221.29	250.00
Cargo carried (million tons)	288.42	317.22	330.00

This general discussion, however, does not indicate the importance of IWT in certain Chinese provinces like Jiangsu and Guangdong, where this mode of transportation accounted for more than 60% of traffic volume by all modes of transport.

During the recent past, the total length of navigable waterways has decreased significantly in China since insufficient attention was given to navigation during water resources development, which contributed to the blocking of navigation in many waterways. However, the Government of China currently considers navigation to be strategically important, since one fifth of total national freight is transported via inland waterways. A long-term plan to develop more navigable waterways and the modernization and extension of river ports have already been approved (Biswas *et al*, 1983). It is expected that waterways traffic will be double the present level by 1990.

(c) India. With a coastline of 5660 km, 178 ports (10 major, 23 intermediate and 136 minor) serving seven provinces and two union territories, and navigable inland waterways extending over 14 500 km, the potential for exploiting IWT in India is immense. The immediate hinterland for the coastal trade alone covers an area over 400 000 km^2 and some 92 million people. In spite of this potential, cargo shipped by coastal transportation increased from 1951 to 1962, but thereafter has continued to decline progressively.

IWT has started to receive more attention in India than ever before not only because of increasing pressure on the already capacity-constrained rail and road transport systems but also due to economics, especially energy as discussed earlier. Currently most of the inland waterways in the country suffer from navigational constraints like shallow water and narrow width during dry seasons, and bank erosion and siltation. Because of these constraints, only about 5200 km of major rivers and 485 km of canals can be used by mechanized drafts.

IWT is an economically suitable mode of transport in India for high-volume, low-value and non-perishable commodities like foodgrains, coal, iron ore, other minerals, fertilizers, petroleum products, salt, building materials and iron and steel. Goa accounted for the largest proportion of total originating traffic in 1976–77, including 3.924 million tonnes of iron ore (176.6 million tonne-km of traffic) and 254 000 tonnes of sea sand (7.62 million tonne-km). No accurate estimates of total bulk transportation by inland waterways in India are available at present.

Great potential exists for IWT for the movement of bulk commodities in the coastal belt and the riverine states of Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Andhra Pradesh, Kerala and Goa (a union territory). The present consensus is that for the development of IWT the Ganges–Bhagirathi–Hooghly river system, Brahmaputra, Sundarbans, Narmada, Mahanadi, Tapti, Godavari, Krishna, Mandovi and Zuvari river systems and the west coast canal system in Kerala offer potential. These waterways are being recommended for declaration as National Waterways so that an integrated development of IWT could be taken up under one unified authority at the national level.

Notwithstanding the IWT and coastal shipping potential and the advantages offered, these modes presently play an insignificant role in the Indian transportation system. The traffic carried by these modes in 1980 was only 0.5% in terms of tonne-km of total traffic moved in the country. IWT has also suffered due to the withdrawal of large supplies of water for irrigation, an essential requirement for increasing food production, but which has resulted in reduced lengths of navigable stretches as well as reduced time periods within which the rivers are navigable. In addition, the limited spatial accessibility of the navigable waterways makes multimodal movement inevitable resulting in increasing transport costs.

Hardly any comprehensive study of IWT traffic at the national level has been conducted so far. A study by the Indian Planning Commission in 1981 provided a perspective for transportation of coal by IWT and coastal shipping. The study identified IWT access for movement of coal from the Assam coalfield on the Burhi-Dehing river, the Bengal–Bihar coal belt, the Rajmahal coalfield on the river Ganges, the Raniganj coalfield through the extension of Durgapur Barrage linking with the DVC canal, the Singrauli coalfield through the river Son, and the Central India coalfields through the river Godavari. For the Ganges and the Narmada river systems, detailed technoeconomic feasibility studies have already been carried out. The results are highly impressive. Similar studies are underway for other rivers and canal systems.

A study of the Narmada Water Transport Project, conducted in 1982 by Consulting Engineering Services (India) Private Limited (CES), projected coal traffic at 24 million metric tonnes by 1990–91 and 49 million metric tonnes by 2005–06. In addition, CES projected 4 million metric tonnes of other traffic in 1990–91 and 8 million metric tonnes by 2005–06, mainly comprising salt, timber, fertilizer and edible oils.

According to another study by CES on the feasibility of IWT services between Haldia and Allahabad, the total IWT traffic by 2001 is expected to increase from over 7 million to 18 million metric tonnes in terms of originating tonnes, corresponding to 1600 to

Table 8. Cargo transported annually in Thailand by inland waterways.

Commodities	Annually transported by inland waterways in 10^6 metric tonnes
Sand and gravel	4.75
Rice and paddy	1.80
Maize	1.60
Sugar, salt, etc	0.70
Cement	0.65
Fuel, fertilizer, etc	0.60
Mineral ores	0.35
Logs	0.20 (million m^3)

Source: ESCAP (1982a).

4500 tonne-km. It is generally felt that with the development of IWT services on the navigable waterways considerable volumes of traffic can be generated to make these services economically viable in the long run.

The development of coastal shipping and IWT will go a long way in supplementing the internal transport system, particularly when freight traffic in the country is expected to increase from 240 billion tonne-km in 1977–78 to 650 billion tonne-km by 2000–01. The Government of India has now taken positive steps to promote the growth of water transport in the country. An increasing amount of investment is being provided in the national economic development plan to improve the infrastructural facilities and augmenting the shipping fleet and its tonnage.

(d) Thailand. IWT in Thailand is found primarily in the Central Plains which cover approximately one third of the territory. This includes the Chao Phraya river system, which consists of the Nan river and its main tributary the Yom, the Ping river and its main tributary the Wang, the Pasak and Chao Phraya, which separates into three main branches – the Sophan, Noi and Lower Chao Phraya rivers – the Maeklong and Bang Pakong rivers. Numerous canals interconnect these rivers. From surveys carried out in 1975 and 1976, annual traffic may be estimated as shown in Table 8.

Thailand is now in the process of developing its main Chao Phraya river system through a $53 million three-year programme during 1981–84. A second five-year plan has been drawn up (ESCAP, 1984). When the improvements are carried out, Chao Phraya is expected to carry 2.1 million metric tonnes by 1985 and 5 million metric tonnes by the year 2000, as against its present freight traffic of about 600 000 metric tonnes. The improved navigation system will be sustainable only by appropriate maintenance. It is estimated that an annual maintenance dredging of about 400 000 m^3 of silt will be necessary just before the dry season in order to ensure year-round navigation.

Europe

As in Asia, no uniform pattern of IWT emerges in the various countries of Europe. If the West European countries are considered, in general the total tonnage of goods carried has declined over the past decade, as shown in Table 9. The average length of haul/tonne has mostly increased, as can be seen in countries like Austria, France and West Germany. In East European countries, however, the reverse trends can be seen: tonnages of goods carried have increased significantly but the average lengths of haul/tonne have decreased somewhat (ECE, 1983).

If the two main international rivers, the Rhine and the Danube, are considered, no consistent pattern emerges in terms of freight carried. For example, total freight carried in the Rhine during 1970–82 is shown in Table 10. In contrast to the Rhine, however, freight transport on the Danube increased significantly during the period 1970 to 1981, but declined somewhat in 1982. The reduction can to some extent be attributed to the decline in economic activities.

Table 9. Total goods carried and distance carried by inland waterways in selected European countries.

Country	1970	1981	1982
Austria			
Goods carried (10^6 tonne)	7.59	7.17	6.62
Tonne-km in 10^6	1 293	1 428	1 377
Average length of haul/tonne	170	199	208
Belgium			
Goods carried (10^6 tonne)	91.57	97.20	90.56
Tonne-km in 10^6	6 743	5 442	5 004
Average length of haul/tonne	74	56	55
France			
Goods carried (10^6 tonne)	110.35	83.57	76.41
Tonne-km in 10^6	14 183	11 068	10 190
Average length of haul/tonne	129	132	133
Germany, East			
Goods carried (10^6 tonne)	13.66	16.63	16.83
Tonne-km in 10^6	2 358	2 359	2 290
Average length of haul/tonne	173	142	136
Germany, West			
Goods carried (10^6 tonne)	240.00	231.71	221.90
Tonne-km in 10^6	48 813	50 010	49 401
Average length of haul/tonne	203	216	223
Netherlands			
Goods carried (10^6 tonne)	241.45	253.8	241.13
Tonne-km in 10^6	30 743	31 792	31 386
Average length of haul/tonne	127	125	130
USSR			
Goods carried (10^6 tonne)	357.8	594.5	604.5
Tonne-km in 10^6	174 984	255 600	262 400
Average length of haul/tonne	486	430	436
Byelorussian SSR			
Goods carried (10^6 tonne)	5.30	11.25	12.11
Tonne-km in 10^6	1 224	1 961	2 065
Average length of haul/tonne	231	179	171
Ukrainian SSR			
Goods carried (10^6 tonne)	27.28	52.9	54.1
Tonne-km in 10^6	6 079	11 100	11 300
Average length of haul/tonne	222	210	209
UK			
Goods carried (10^6 tonne)	6.53	4.62	5.12
Tonne-km in 10^6	129	72	71
Average length of haul/tonne	20	16	14

Source: ECE (1983).

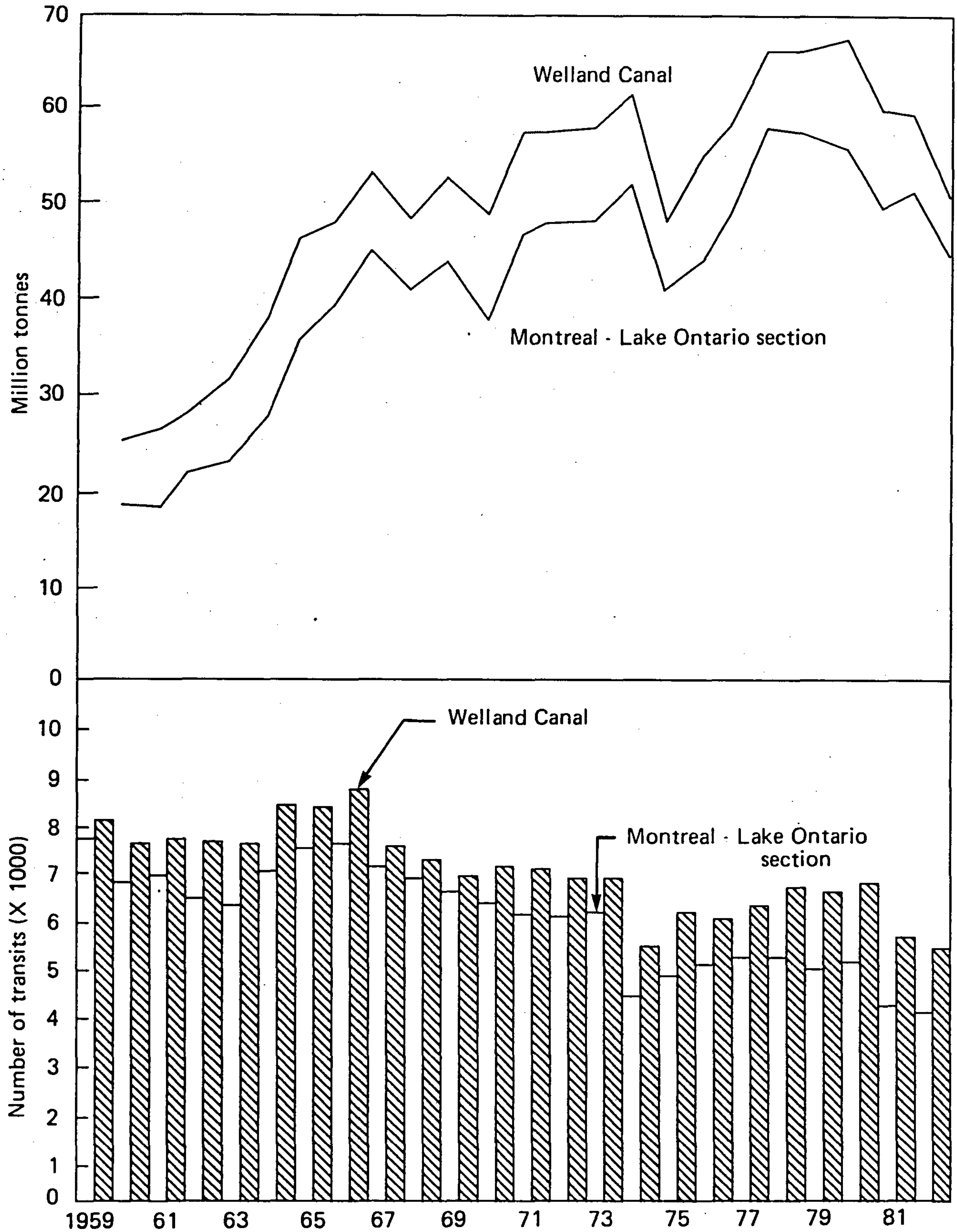

Figure 3. Cargo tonnages and vessel transits in the Montreal–Lake Ontario section of the St Lawrence Seaway and the Welland Canal, 1959–82.

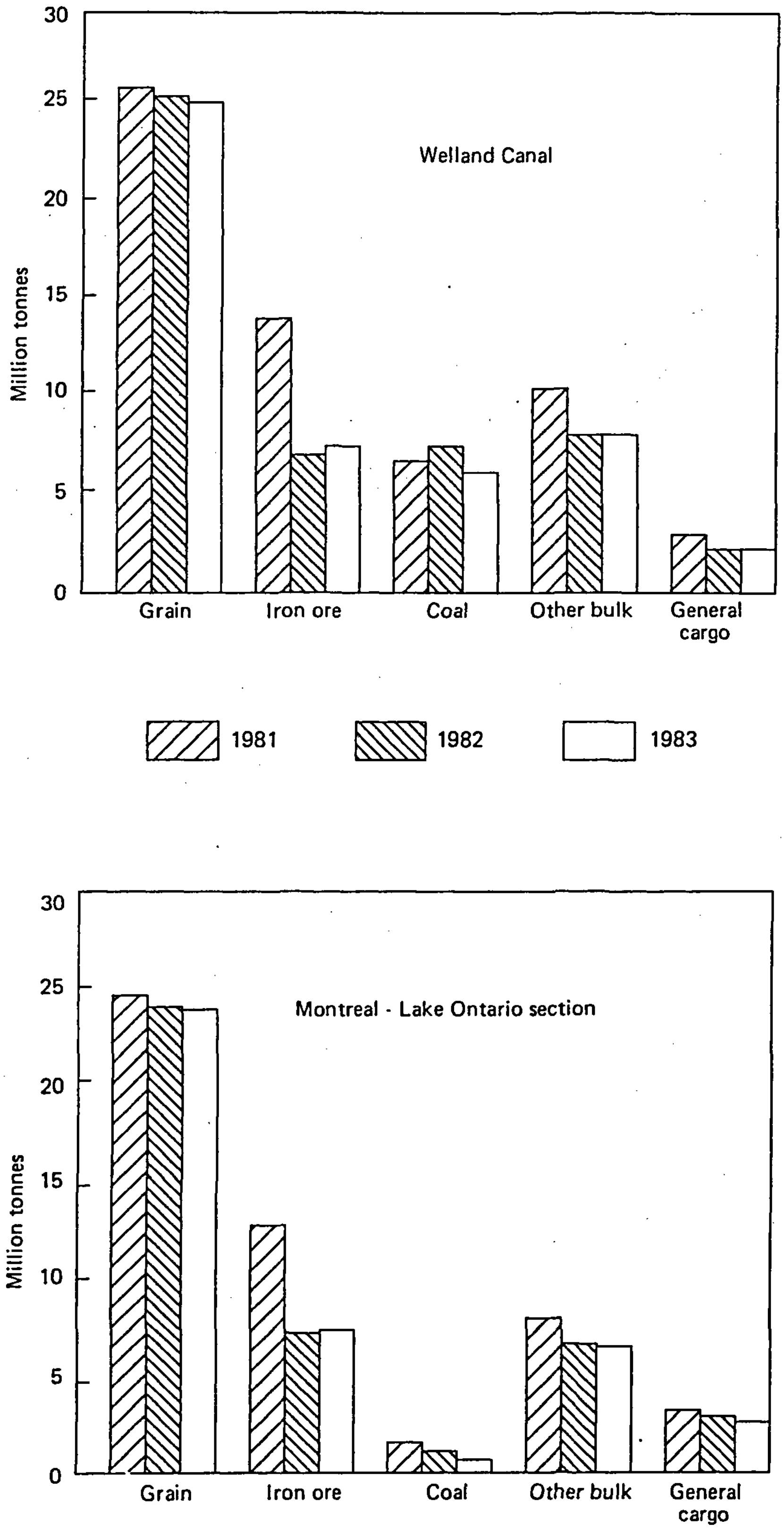

Figure 4. Bulk cargo traffic in the Welland Canal and the Montreal–Lake Ontario section of the St Lawrence Seaway, 1981–83.

Table 10. Freight carried on the river Rhine, 1970–82.

	Freight transport	
Year	Million tonnes	Million tonne-km
1970	274.42	51 567
1981	270.02	54 962
1982	257.34	54 391

Table 11. Freight transport on the river Danube, 1970–82.

Type	1970	1981	1982
A	34.06	56.97	52.96
B	19.89	23.16	22.20
C	1.52	6.00	4.60
Total	55.47	86.13	79.76
Index	100	155	143

A: Internal transport, goods carried between parts of the same country.
B: International transport, goods loaded in one coutnry but destination another, whether Danubian or not.
C: Goods entered by sea.

Freight transport on the Danube during 1970–82 is shown in Table 11.

North America

Transportation of bulk goods in Canada and the USA had different patterns as well.

(a) Canada. Water transport has historically played a dominant role in the Canadian economy because of the nation's size, geography and presence of a large number of water bodies. For example, Statistics Canada reported that in 1980 water transportation generated revenues of C$1.841 billion for 308 Canadian-domiciled for-hire, private, government and sightseeing carriers. Corresponding revenue for 1979 was C$1.626 billion. The largest portion of these revenues, C$1.224 billion, was generated by 210 for-hire carriers (corresponding figures for 1979 were C$1.039 billion by 191 carriers).

The most important waterways in Canada are the St Lawrence Seaway and the Welland Canal. The St Lawrence Seaway Authority was constituted as a corporation by an act of the Canadian parliament in 1951. The authority undertook to construct, maintain and operate the Canadian facilities between Montreal and Lake Erie to allow navigation by vessels of 79.25 decimetres draft. Similar facilities were simultaneously constructed in the International Rapids Section of the St Lawrence river by the St Lawrence Seaway Development Corporation of the USA. The Seaway was opened for commercial traffic on 1 April 1959. The St Lawrence Seaway Authority is also responsible for the operation and maintenance of the Welland Canal.

Cargo tonnages continued to increase in the Montreal–Lake Ontario and Welland Canal sections since the opening of the Seaway in 1959 to about 1979, as shown in Figure 3. Since 1979, the total cargo tonnages have declined (St Lawrence Seaway Authority, 1983). The various types of bulk cargoes carried in 1981 and 1982, and forecast for 1983, are shown in Figure 4 (St Lawrence Seaway Authority, 1982).

Among the major constraints for IWT in Canada are the shortness of the season due to the freezing of waterways, the relative inflexibility of capacity in some areas (the difficulty of moving tugs or barges in or out of the system), slowness, the restriction of services to river and canal communities – unless complemented by rail and road – and vulnerability to major variations in water levels in different river sections at different times during the year.

(b) USA. There are about 25 500 miles of commercially navigable inland waterways in the USA (National Waterways Foundation, 1983). Three different systems can be identified geographically: Atlantic Coast waterways, Pacific Coast waterways and the Mississippi river–Gulf Intercoastal system. There is no inland connection between these three systems. The Mississippi river system plays a dominant role in IWT in the USA since it carried 60.9% of all ton-miles of cargo on the federally-improved and maintained waterways in 1979.

If the total waterborne commerce in the USA is considered, it increased from 0.7 billion to 2.1 billion short tons between 1947 and 1979, a compound annual rate of increase of about 3.1%. This is shown in Figure 5 (National Waterways Foundation, 1983).

The total domestic waterborne commerce – internal, coastwise and Great Lakes – increased from 579 million to 1079 million short tons during 1947 to 1979. This is shown in Figure 6 (National Waterways Foundation, 1983).

The growth of transportation of major bulk commodities by inland waterways is shown in Figure 7. In terms of tonnage, coal is the most important commodity, and the amount moved steadily increased from 58 million to 130 million short tons during the period 1953 to 1979. The next most important commodity is petroleum products, which includes gasoline, residual fuel oil, distillate fuel oil and jet engine fuel. The amount of petroleum products moved increased from 52 million to 113 million short tons during 1953 to 1977, but declined to 103 million short tons by 1979. Similarly, transport of crude petroleum increased from 24 million to 60 million short tons during 1953 to 1972, but declined to only 47 million short tons by 1979. In contrast, the movement of grains increased dramatically from 4 million to 50 million short tons

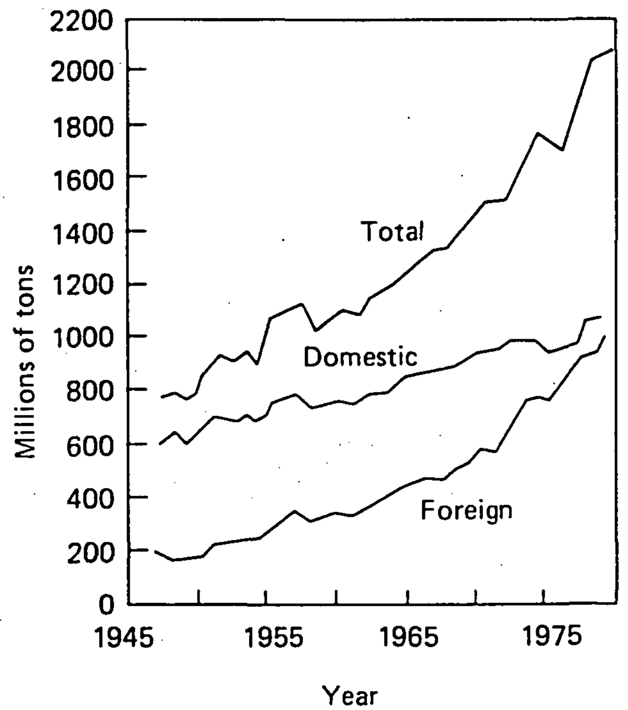

Figure 5. Net total waterborne commerce of the USA, 1947–79.

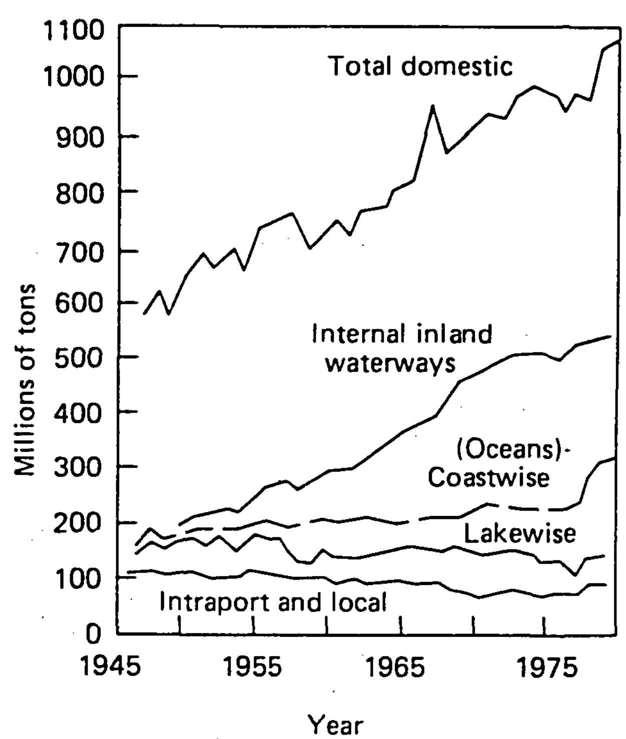

Figure 6. US domestic waterborne commerce by type of traffic, 1947–79.

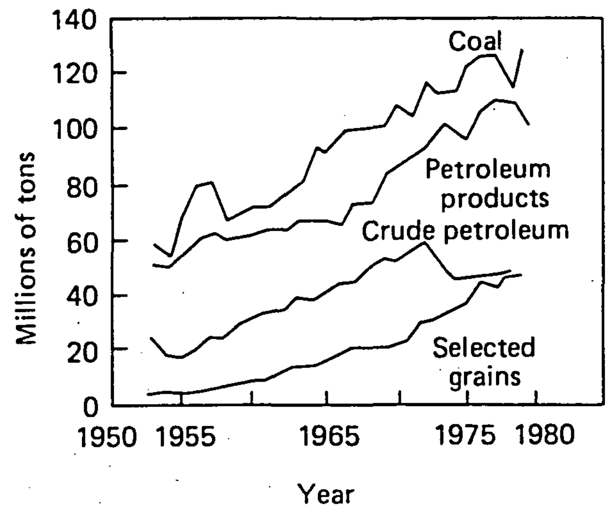

Figure 7. Leading commodities in US domestic waterborne commerce on inland waterways, 1953–79.

during 1953 to 1979 – which represents a 12.5 fold increase.

The total commodities carried by inland waterways in the USA in 1979 amounted to 535 million short tons, of which 54.5% consisted of energy materials, 13.6% non-metallic minerals excluding fuels and 13.3% agricultural supplies and products. The actual tonnages transported and percentages are shown in Table 12.

Table 12. Commodities carried by inland waterways (except local) in the USA, 1979.

Commodities transported	Millions of short tons	Percentage
Energy materials	291.5	54.5
Coal and lignite	125.7	23.5
Petroleum and coal products	118.6	22.2
Crude petroleum	47.2	54.5
Agricultural products and supplies	71.3	13.3
Farm products	51.8	9.7
Food and kindred products	12.2	2.2
Fertilizers	7.3	1.4
Others	172.2	32.2
Non-metallic minerals, excluding energy materials	72.5	13.6
Chemical and allied products	29.6	5.5
Marine products	10.2	1.9
Metallic ores	7.1	1.3
Primary metal products	8.6	1.6
Waste and scrap materials	12.4	2.3
Stone, clay, glass and concrete products	5.6	1.1
Lumber and wood products, excluding furniture	17.8	3.3
Pulp, paper and allied products	2.5	0.5
All other	5.9	1.1

Source: National Waterways Foundation (1983).

Conclusion

An analysis of the global situation with respect to inland waterways transportation clearly indicates the great variations in their importance and use from one country to another. While geographical conditions can explain this anomaly to a certain extent, lack of realization of the potential impact of IWT on national economies continues to be an important factor. While some countries like China are specifically expanding IWT activities because

> no use is made of farm land, the cost of investment in channel construction and maintenance is less than that for railways and roadways; energy is saved; industries set up along the rivers are helped by providing a convenient means of transport, water supply and drainage; inland water transport has a greater carrying capacity and can transport overweight and oversize cargoes; and it is almost pollution-free [ESCAP, 1982b],

other nations have made very little progress thus far.

On a global basis, expansion of IWT in developing countries has more potential than in developed countries, where this mode of transportation is more mature. Fortunately some developing countries have now started to recognize the potential of IWT, and are planning to integrate it properly in their national transportation frameworks. Still, the development of national master plans for transportation, including IWT, is lacking in most countries. Without a national transportation policy, development of IWT can proceed only on an *ad hoc*, piecemeal basis.

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