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The United Nations World Water Assessment Programme

Insights

Inland Waterborne Transport: Connecting Countries

Sobhanlal Bonnerjee, Anne Cann, Harald Koethe, David Lammie, Geerinck Lieven, Jasna Muskatirovic, Benjamin Ndala, Gernot Pauli and Ian White

International Navigation Association (PIANC)

United Nations Educational, Scientific and Cultural Organization

World Water Assessment Programme

The United Nations World Water Development Report 3
Water in a Changing World

Coordinated by the World Water Assessment Programme, the United Nations World Water Development Report 3: Water in a Changing World is a joint effort of the 26 United Nations agencies and entities that make up UN-Water, working in partnership with governments, international organizations, non-governmental organizations and other stakeholders.

The World Water Development Report is the United Nation's flagship report on water, published every three years since 2003. It offers a comprehensive review of the state of the world's freshwater resources and provide decision makers with the tools to implement sustainable use of our water. The report provides a mechanism for monitoring changes in the resource and its management and tracking progress towards achieving targets, particularly those of the Millennium Development Goals and the World Summit on Sustainable Development. It offers best practices as well as in-depth theoretical analyses to help stimulate ideas and actions for better stewardship in the water sector.

The third edition of this report, Water in a Changing World, addresses a number of key themes; including climate change, the Millennium Development Goals, groundwater, biodiversity, water and migration, water and infrastructure, and biofuels. The report gained from the involvement of a Technical Advisory Committee composed of members from academia, research institutions, non-governmental organizations, public and professional organizations. To strengthen the scientific basis as well as possible implementation of the report and its recommendations, interdisciplinary expert groups were also created for a number of topics, including 'Indicators, Monitoring and Databases', 'Business, Trade, Finance and Involvement of the Private Sector', 'Policy Relevance', 'Scenarios', 'Climate Change and Water', 'Legal Issues' and 'Storage'.

The report is published with an accompanying case studies volume, which examines the state of water resources and national mechanisms for coping with change in twenty-three countries and numerous small island developing states.

The present side publications series provide more focused, in-depth information and scientific background knowledge, as well as a closer look at some less conventional water sectors. These publications include scientific side papers, sector and topic-specific 'insight' reports, and a dialogue series.

Published by the United Nations Educational, Scientific and Cultural Organization,
7 place de Fontenoy, 75352 Paris
07 SP, France

ISBN 978-92-3-104110-5

Cover graphics by Peter Grundy,
www.grundini.com

Cover design and typesetting by
publish@picapublish.com

Printed by Sava Printing
http://savasmat.com.tr

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All photos provided by the Directorate for Inland Waterways, 'Plovput', Belgrade.

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The International Navigation Association (PIANC)

1. Introduction

Inland Waterborne Transport (IWT) has contributed to the development of mature economies over many centuries and created many bridges between nations. In this century it can help developing nations to achieve several of the Millennium Development Goals (MDG). In particular, IWT can help to meet MDG 1 (Eradicate Extreme Poverty and Hunger), by lifting the least developed nations out of poverty and can assist in achieving MDG 7 (Ensure Environmental Sustainability) and MDG 8 (Develop a Global Partnership for Development). IWT provides a safe, environmentally sustainable form of transport, which is a key element of sustainable economic development. Such transport of goods and people can stimulate the development of regional economies and connect land-locked countries to the sea.

IWT can help meet these goals because it is the most environmentally friendly mode of transport. Sustainable water management requires the integrated use of waterways, thus benefiting a very large number of people because of the significant linear development that occurs alongside rivers, both large and small. However, because so many rivers cross national boundaries it is essential that the integrated use of waterways be taken forward on an intergovernmental, collaborative basis. This is evidenced by the various international navigation commissions that exist on the major river systems throughout the world.

As well as providing access to drinking water – one of life's essentials – rivers can also provide hydropower, irrigation and a means of transport, all of which are economic drivers for the least developed countries. One cannot have trade, exports and economic growth without transport systems. Many of the least developed nations, particularly in Africa have great unrealized potential for IWT. The potential, capacity and economic benefits of IWT are discussed in the following sections, and illustrated by the case studies contained within this report.

Of all forms of transport, IWT has the least effect on climate change and the least environmental impact. IWT is a safe, sustainable, efficient, and reliable form of transport that fuels the economic drivers for development, without which societies cannot flourish. It does need to be developed on an intermodal basis with existing and proposed rail and road services. IWT is inherently energy efficient, and requires the least amount of fuel per tonne-kilometre of cargo carried. As road freight is transferred to inland waterways and coastal routes, traffic congestion can be reduced even in the most urbanized areas.

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Acronyms

AGN	European Agreement on Main Inland Waterways of International Importance
ANTAQ	Brazil's Agencia Nacional de Transportes Aquaviarios)
ATONs	Aids to navigation
CCI	Clinton Climate Change Initiative
CICOS	International Commission of the Congo – Oubangui-Sangha Basin
CCNR	Central Commission for Navigation on the Rhine
DRPC	Danube River Protection Convention
ECMT	European Conference of Ministers of Transport
EIA	Environmental Impact Assessment
GHG	Greenhouse gas
IADC	International Association of Dredging Companies
ICPDR	International Commission for the Protection of the Danube River
IPCC	Intergovernmental Panel on Climate Change
IWT	Inland Waterborne Transport
KMD	Kolkata Metropolitan District
MDG	The Millennium Development Goals
MIS	Management Information Systems
MRC	Mekong River Commission
NAP	Navigation Program, Mekong River Commission
ODA	Overseas Development Administration, United Kingdom.
PIANC	International Navigation Association
R & D	Research and Development
RORO	Roll-on/roll-off vessels
SEPA	State Environmental Protection Administration, China
TVA	Tennessee Valley Authority, United States.
TEU	twenty foot (6.1 m) equivalent unit, a standard container
USACE	United States Army Corps of Engineers
WFD	Since its adoption in 2000, the Water Framework Directive is the operational tool that sets the objectives for water protection in Europe.
WODA	World Dredging Association
Transboundary	Waters that cross international boundaries

Rivers and their floodplains are among the most altered ecosystems in the world. Energy production, freshwater transfer, agriculture, deforestation, pollution, urbanization, drainage, river regulation, and flood protection schemes can lead to ecological deterioration and the loss of important functions, which in turn could threaten future uses of these systems.

The provision of navigation infrastructure and operations can also impact the ecological character and functions of waterways. Likewise, a degradation of waterway conditions from any of the above factors might adversely impact the suitability of that waterway for navigation uses. Navigation should ideally be undertaken in a fashion that is in resonance with the other needs of the waterway, including the full range of physical, chemical, and biological functions as well as the social constraints and requirements placed on the system.

Water resource systems that can satisfy, to the greatest extent possible, the changing demands placed on them over time, without degradation, can be called 'sustainable'. Sustainability, as defined by many global organizations and Millennium Development Goal 7 (Ensure Environmental Sustainability), means 'meeting the needs of the present without compromising the ability of future generations to meet their own needs'.

To achieve sustainability, navigation development and operations must consider the long-term impacts to the aquatic ecosystem. With this awareness, many countries in the world have already enacted environmental laws and regulations and the navigation sector has developed guidelines and recommendations to support the best environmental practice. As a result of growing knowledge and experience, and new challenges such as climate change, this development is an ongoing process. In the navigation sector PIANC (the International Navigation Association) is the global organization that provides guidance for sustainable waterborne transport, ports and waterways.

Navigation has the potential to offer a cleaner and more energy-efficient means of transport than other alternatives. However, to address the challenge of integrating economic, environmental, and social aspects in terms of sustainable development, guidelines for sustainable operation and management must be further developed and employed.

So using Inland Waterborne Transport can and does connect countries and contribute to the Millennium Development Goals. It can make a difference, not only by providing transport but also by being developed along with other beneficial water uses in the context of integrated river basin management.

Box 1 Millennium Development Goals

- Goal 1: Eradicate extreme poverty and hunger
- Goal 2: Achieve universal primary education
- Goal 3: Promote gender equality and empower women
- Goal 4: Reduce child mortality
- Goal 5: Improve maternal health
- Goal 6: Combat HIV/AIDS, malaria and other diseases
- Goal 7: Ensure environmental sustainability
- Goal 8: Develop a Global Partnership for Development

2. Background

Rivers were at the centre of the earliest civilizations. The Nile is known as the River of Life and has been revered in Egypt since ancient times. It is the longest river in the world, stretching for 6,670 km. Similarly, in China the Yangtze River has been an important transport route for several thousand years. And in North America, the St. Lawrence River and Great Lakes provided a natural route for explorers and settlers that enabled them to penetrate deep into the interior of the continent.

The first intergovernmental agreements were stimulated by navigation of shared rivers and waters. Throughout the world, rivers were the first highways. Waterborne transport allowed trade to happen, enriching and advancing civilizations.

An inland waterway project played a key role in the formation of the United States. The Patowmack Canal was part of a major project conceived by George Washington to make the Potomac River more navigable. His vision was a fully navigable Potomac with improved channels and five bypass canals that would connect the Atlantic seaboard to upriver ports and (via a road portage) to the Ohio River country and lands far to the west, which were wild frontiers at the time. In order for the canal to work, Virginia and Maryland (located on opposite banks of the river) had to resolve differences and distrust and agree to free trade on Potomac waters. In solving the political problems that blocked agreement over the waterway, George Washington started a chain of events that led to the writing of the Constitution of the United States. The canal project was built, and it made the Potomac navigable for a critical period of history, bringing western lands into the United States when they might otherwise have evolved as separate countries (Garrett, 1987).

In Europe, the Central Commission for Navigation on the Rhine (CCNR) is the oldest international organization in the world. The initial goals of the CCNR were to guarantee equal treatment as well as freedom of navigation on the Rhine and to ensure its prosperity. The CCNR is the governing body for navigation on the Rhine. It was established in 1815 by the Congress of Vienna and now has as its main legal basis the Mannheim Convention, which was signed 140 years ago.

3. IWT in the context of Integrated Water Resources Management (IWRM)

When undertaking any analysis of the protection of, and the future development of a river basin, it is essential that a holistic approach be undertaken. To achieve this, whether in terms of trade or in terms of biodiversity, an Integrated Water Resources Management (IWRM) approach must be adopted. This approach allows for all current operating conditions and constraints to be identified while encompassing the needs and demands of all relevant stakeholders.

Accordingly, a balance can be struck between protecting and enhancing the river ecosystem and all other water uses including navigation, fisheries, water supply, irrigation, hydropower, and land drainage. Through IWRM, it is possible to both protect and enhance the environment and at the same time allow physical development to take place.

It is possible, by having a balanced approach, to develop and install a programme of mitigation measures that can not only compensate for any detriment caused by physical development, but can also allow past damage to be remedied. The beneficial use of dredged material for the creation of wetlands and the nourishment of beaches are examples of how this integrated approach can be applied.

One of the essentials of IWRM is the involvement of all relevant stakeholders and the development of a transparent planning process, both at the macro and micro levels, to ensure that an adequate balance and understanding is created that allows for the differing needs of the communities located within the catchment or river basin, and to encourage trust between them.

This process may take a number of years, as is currently the case within the European Union with the development of the Water Framework Directive. But it is essential that such a partnership be formed to ensure that all regulators, communities and users, whether current or future, are working together to deliver a sustainable plan.

Within such a process, current thinking derived both from experience and research, can be drawn together to overcome what are perceived as negative impacts on a waterway, such as the creation of fish barriers, increasing scour damage and other changes to the riverine regime.

By adopting this process, it will be possible to satisfy diverse, and what may appear to be opposing demands on the catchment. The provision of weirs and locks can assist with land drainage and flood storage. The improvement in water channels when competently undertaken will also improve the biodiversity along the river. The improvement in social wellbeing caused by increasing access to the river all along its length will also allow the development and installation of water treatment facilities for both drinking water and sewage, thereby progressively increasing the water quality of the catchment itself.

4. Benefits of Inland Waterborne Transport (IWT)

Traditionally, the benefits of using inland waterways and investing in projects to improve rivers for navigation have included lower costs for the transport of goods compared with other modes, fewer traffic delays, a better safety record, and an increase in the movement of people and goods that encourages domestic and international trade. Increasingly, however, the benefits of IWT are being viewed in a broader sense, including factors such as lower levels of air pollutants, reduced greenhouse gases, less highway congestion, and an improvement in overall safety.

4.1. Navigation as an engine for economic development

It is no accident that most of the world's major cities are located either on a navigable river or a coastal harbor at the mouth of a navigable river. Rivers provide water for drinking and other uses and are ready-made transport routes – all of which are key requirements for flourishing urban centres.

In North America, the St. Lawrence River and Great Lakes provided access to the interior of what is now the United States and Canada, enabling exploration and later settlement of the area. The inland waters that make up the Great Lakes St. Lawrence system stretch westward over 3,700 km from the Gulf of St. Lawrence to the western tip of Lake Superior. The need to maintain and improve navigation on this system stimulated early international treaties between the United States and Canada. Such co-operation was necessary because the boundary between the two countries runs up the middle of the system.

Similarly, the Ohio, Mississippi, and Missouri rivers opened up the western frontiers of the United States. Development of the Mississippi and Ohio rivers for reliable year-round navigation, which occurred with the construction of a series of locks and dams in the early- to mid-20th century, provided Midwestern farmers with an economical way to get their grain to New Orleans and thus to world markets. Both producers and consumers of other bulk commodities such as coal took advantage of the lower cost of inland waterborne transport, and this helped to stimulate the economic development of the Appalachian region. A large share of coal is moved by barge, and many power plants are located on major navigable rivers.

Today, in countries such as China, Argentina, and Brazil, inland waterways are stimulating and supporting rapid economic growth. Reliable, affordable transport networks are still a prerequisite for economic development. In many of the less developed

countries, more intense use of inland waterways is moving goods in and out of regions and helping economies to grow. Expansion of highway and railroad networks often takes more time and requires much greater investments, in comparison with waterways. Therefore greater use of inland water transport can provide a critical economic advantage.

In China, the rapid economic development of Jingsu, Shanghai, Zheijiang, and Guangdong provinces is largely attributed to the presence and effective use of an extensive system of waterways. This system includes the Yangtze River, Grand Canal, and many tributaries and canals with a total length of more than 24,000 km (Hochstein, 2003). The Three Gorges Dam has enabled year-round navigation from the mouth of the Yangtze at Shanghai all the way (2,838 km) up to Chongqing, a metropolitan area with a population of thirty million people.

Improvements in the inland waterways in South America have aided the agricultural development of vast regions in Bolivia, Paraguay, and Brazil by providing transport of soya beans and other agricultural products to the international market. Prior to this, the cost of transporting these products over land was prohibitively high.

Another economic benefit of IWT stems from the fact that the development of rivers to enhance navigation is often coupled with hydroelectric power. The same pools that are needed to ensure adequate depths for vessels provide water storage and head for the generation of hydroelectric power. This can bring cheap electricity to millions of people and improve their quality of life.

4.2. Energy efficiency

Water transport is inherently more energy efficient than either rail or truck. Inland waterways are the most energy efficient way to move bulk commodities such as coal, grain, iron, steel, aggregates, petroleum, and chemical products. In the United States, barges move one tonne of cargo an average of 576 miles per gallon (245 km per liter) of fuel. Railroads can move the same amount of cargo an average of 413 miles per gallon (176 km per liter), and a truck only 155 miles per gallon (66 km per liter) (Kruse et al., 2007). Because of this efficiency, transporting freight by water generates fewer air emissions than rail or truck (Kruse et al., 2007).

4.3. Safety

Safety is another advantage of IWT. Accidents on the waterways are rare, and IWT has a very low injury and fatality record compared with the rail and truck transport of freight. Safety statistics in the United States for all modes of freight transport show one injury in the inland marine sector for every 125.2 in the rail sector and for every 2,171.5 in the highway sector. Fatality statistics are much the same, with one fatality in the inland marine sector for every 22.7 in the rail sector and for every 155 in the highway sector (Kruse et al., 2007).

IWT also moves hazardous materials safely. Although spill rates are low in all transport modes, inland waterways have the best record. While trucks have a spill rate of 6.06 gallons per one million ton-miles (22.9 liters per 1.4 million tonne-kilometers), rail cars lose only 3.86 gallons per one million ton-miles (14.6 liters per 1.4 million tonne-kilometers) and barges lose 3.6 gallons per one million ton-miles (13.6 liters per 1.4 million tonne-kilometers) (Kruse et al., 2007).

4.4. Relief of highway congestion

Road congestion is reaching crisis proportions in many urban areas. Total congestion costs for 2005 for urban areas in the United States were $78 billion, including 4.2 billion hours of delay and 2.9 billion gallons (11.02 billion liters) of excess fuel consumed (Schrank and Lomax, 2007). In addition to the obvious delays, congestion exacerbates other externalities of truck transport by increasing air emissions and the rate of accidents. Longer commutes can also have a negative impact on labour productivity and quality of life. Congestion also leads to higher costs of truck freight operation through driver wages and has a negative impact on manufacturing industry and the service sector by reducing the reliability and predictability of deliveries (Sudar, 2005). One 15-barge tow carries the load of 216 rail cars and 1,050 large truck tractor-trailers (Kruse et al., 2007).

In more developed countries, where road and rail networks move the majority of the freight, inland waterways alleviate congestion by transporting significant amounts of cargo that would otherwise be on roads. And in most cases, inland waterways have unused capacity and could accept more cargo and thus relieve even more of the congestion. The annual traffic on America's inland waterways carries the equivalent of 58 million truck trips each year (Kruse et al., 2007).

5. IWT and the environment

The use of rivers for navigation can have environmental impacts, particularly when improvements are made to facilitate navigation. Dams change free-flowing rivers into reservoirs, and can prevent fish movements. However, fish ladders can overcome these problems, and the reservoirs themselves generate valuable benefits for hydroelectric power, boaters, anglers and for general riverside recreation. Navigation also requires dredging in order to maintain safe depths in channels, which in the past has been seen as an environmental problem. But in recent years this thinking has turned around and dredged material is viewed as a valuable resource, which can be used to create wetlands and wildlife habitat and to nourish beaches.

5.1. Impacts from vessels

5.1.1. Vessel emissions with regard to climate change

The assumptions, definitions and findings of the fourth assessment report of the Intergovernmental

Panel on Climate Change (IPCC, 2007) represent a peer-reviewed body of knowledge that identifies observed changes in climate and projected future changes. Projections for the year 2100 suggest a global mean sea level rise of a few decimetres and a greater frequency and intensity of extreme weather events. Even if emissions of greenhouse gases, especially carbon dioxide, stop today, these changes would continue for many decades and in the case of the sea level rise, for centuries. Navigation, like many other sectors of the economy, will face serious risks from climate change, including unstable and unfavourable weather conditions, which make navigation difficult or even impossible. In 2008, against this background, the International Navigation Association published a review of the state-of-the-art knowledge about climate change with regard to navigation (PIANC, 2008*a*).

It is estimated that about 4% of global greenhouse gas (GHG) emission are due to anthropogenic causes, whereas the main emissions come from the seas (40%), vegetation (27%) and the soil (27%). Of the anthropogenic emissions, transport and traffic are responsible for about 23% of energy-related GHG emissions and to this figure, navigation contributes less than 10% (PIANC, 2008*a*). As some 90% of global merchandise is transported by sea, it is easy to imagine that the portion of inland navigation compared to maritime navigation is much smaller. That makes GHG emissions from navigation appear small compared to road transport or other human activities. However, with the world maritime fleet growing steadily and with inland navigation's substantial modal share in some of the growth regions of the world such as China, navigation's share of GHG emissions may increase by as much as 75% in the next twenty years.

Navigation, and especially inland waterborne transport, is characterized by low energy consumption and therefore a small carbon footprint; in addition it has a good potential for reducing it even further. Its climate-friendly image makes it already attractive for shippers of cargo. Carbon pricing or other regulatory measures will make it even more so and will give it a competitive edge over other modes of transport, especially road transport and aviation. Because it is relatively climate-friendly and becoming a tool for the mitigation of GHG emissions in tomorrow's world economy, navigation may even be a double winner from climate change. Fuglestvedt et al., (2008) prepared a comprehensive analysis of radiative forcing by subsector of transport. Road transport was found to be the largest contributor to warming while shipping causes net cooling (Fuglestvedt et al., 2008).

Although navigation, and especially inland navigation is not a main driving force to increase climate change caused by GHG emissions, the navigation sector should evaluate the possibilities of contributing to a reduction of anthropogenic GHG emissions to emphasize navigation as an environmentally sound mode of transportation. Numerous measures for the reduction of GHG emissions from navigation have been identified – and are already implemented in many cases (PIANC, 2008*a*). Most of the measures can, to varying degree, be applied to both maritime and inland navigation. Effective mitigation measures are the reduction of fuel consumption and the use of alternative fuels. Under the umbrella of the Clinton Climate Initiative (CCI) – a network of forty large cities worldwide – large ports aim to reduce emissions from ships while they are in the ports. One measure is that ports grant advantages to ship owners (e.g. reduction of port fees) when they operate in a climate-friendly manner. In this context the International Association of Ports and Harbours (IAPH) has developed a toolbox for port clean air programs (International Association of Ports and Harbours 2008). Further GHG reduction potential can be attributed to the use of material and energy during construction and scrapping of vessels as well as construction, maintenance and demolition of the shipping infrastructure.

However, research suggests that navigation may well be one of the winners of climate change, most likely due to regulatory measures for climate change mitigation. As transport demand for some traditional cargoes of navigation will decrease, demand for other cargoes will increase as the industry producing or consuming these cargoes benefits from climate change and in particular from the regulatory-market economy dimension of climate change. For example, producers of biogenic fuels will create transport demand for their raw materials as well as for their final product. Other industries being identified as winners of climate change and traditionally relying on transport by navigation are, for example, the chemical and the construction industries (Heymann, 2007).

5.1.2. Impacts from vessels on inland waters

The challenge for river decision makers is to balance the needs of the aquatic ecosystem with the development of inland navigation as a viable and environmentally friendly mode of transport, to understand and quantify the effects of vessels, and to determine the relationship of these physical effects to the aquatic ecosystem. PIANC has recently published the report 'Considerations to reduce Environmental Impacts of Vessels' (PIANC, 2008*e*) on inland waterways which provides a deeper insight into the most important impacts and their ecological effects, ideas about possible and most effective mitigation measures and a structured way to find solutions. Because vessels vary widely in size and propulsion type, depending on their different fields of application, and also because aquatic ecosystems vary so much from site to site, it is not possible to create a comprehensive overview of all possible interactions between vessels and the environment. Consequently the PIANC report supports finding the best environmental practice for the navigation of vessels through the inland aquatic ecosystem in a structured way.

Impacts from moving vessels can be classified into primary and secondary vessel-induced impacts and their consequential environmental stress factors as well as direct and indirect impacts on biota. Moving vessels primarily induce drawdown, return currents, transversal stern waves, and slope supply flows. Impacts can include mortality in fish larvae caused by propeller impact:

- larval stranding due to drawdown,
- the de-watering of marsh areas adjacent to waterways,
- the resuspension and transport of sediments in littoral zones that support aquatic macrophytes and spawning habitats,
- scour and/or burial of benthic organisms,
- the introduction of invasive non-native species,
- fish barriers,
- the transport of unnatural sediment in sensitive side channel areas,
- the resuspension of contaminated sediments, and
- air emissions and noise from vessels.

Aquatic invasive species are a major problem in the Great Lakes St. Lawrence system and in certain other inland waters such as the Black Sea and the Caspian Sea. The prime mechanism for introduction of these species is ships' ballast water. Perhaps the best known invader is the zebra mussel, which has exploded in numbers, clogging water pipes, drains, and vents and damaging docks, boats, power generation facilities, and water treatment plants. Economic impacts of the zebra mussel are estimated to be at least US$1 billion. The United States Transportation Research Board has investigated means to prevent further introductions of aquatic invasive species via commercial shipping, and has recommended that access to the Great Lakes through the seaway be restricted to vessels taking protective measures aimed at ensuring that they do not harbor living aquatic organisms. A comprehensive, technology-based aquatic invasive species control program is outlined in their recent report (Transportation Research Board, 2008).

Mitigation measures for the environmental impacts of navigation can include specific navigation rules, adapted vessel design, adapted fairway design, modified revetments and alternative bank-protection measures. Furthermore it is of importance that illegal discharges of oil, fuel or other waste substances from ships have to be prosecuted worldwide in order for the aquatic environment to be properly protected.

The above-mentioned impacts of inland navigation must be considered in the context of an environment that is subject to greater impacts, such as major pollution events from land-based installations. Inland waterways, whether navigated or not, are commonly subjected to diffuse pollution from agriculture or road runoff, alien infestations that may out-compete or pre-date native species and water-borne events. Navigation may suppress or reduce the wildlife numbers, however, unlike some of these other waterway impacts, navigation does not cause acute mass mortalities of some or all species in a waterway.

It is an accepted fact that among all modes of transport, IWT appears to be the one with the smallest ecological footprint, particularly when compared with road transport systems. IWT will maintain this position into the foreseeable future, even with anticipated increases in traffic and a changing fleet with larger and highly powered vessels.

Trends in IWT include:

- a different fleet in the future
- changed cargo types
- modified permissions, e.g. allowing for larger vessels, higher ship speeds and draughts arising from adapted fairway dimensions
- a modified channel morphology, e.g. caused by erosion or sedimentation processes
- changed habitat properties.

The increasing importance of container transport, especially on large rivers, for example, the Rhine and the Danube in Europe, led to a further adaptation of vessel dimensions in these areas, resulting in single units of up to 23 m wide and 135 m long, and push tow convoys consisting of 6 barges, each 34 m wide and 270 m long. On the Lower Mississippi River, it is common to have convoys of 30 barges, leading to dimensions of about 64 m by 440 m (some convoys have been in excess of 40 barges, with significant operational economies of scale). Fairway depth of the largest rivers in Europe and the United States allows for draughts of between 3 m and 4 m, and in European canals of up to 2.8 m.

Given the environmental sensitivities, it is important to note that highly efficient mitigation of operation-related impacts is in many cases relatively easy to achieve, for example. by adequate licensing of vessels and by implementing operational restrictions with respect to permissible vessel speed, and by requiring vessels to maintain adequate fairway distance from ecologically sensitive. The proper adoption of the mitigation measures will sustain existing uses and improve the ecological quality of the waterways in most cases. A proper classification system of a waterway network automatically leads to a situation where vessels are adapted to waterways and not the reverse. With adequate rules and regulations, regular inspections and maintenance, and with proper supervision and enforcement, no doubt IWT is and will remain the most environmentally responsible and safe transportation mode.

5.2. Maintenance and development of inland waterways

Awareness of the importance of the environment and its natural resources for life on earth has greatly increased within the last two decades. Consequently, at International, European and national levels, various new or updated environmental conventions and regulations have come into force, which have directly or indirectly affected the maintenance and the development of inland waterways. For example, in Europe, the Birds Directive (European Union, 1979) and the Habitats Directive (European Union, 1992) have led to NATURA 2000, a network of over 26,000 protected areas covering all EU Member States and a total area of around 850,000 square kilometres, representing more than 20 per cent of total EU territory. Together, these directives constitute the backbone of the EU's internal policy on biodiversity protection. Since adoption in 2000, the Water Framework Directive (WFD) is the operational tool setting the objectives for water protection in Europe. As it is the most substantial piece of EU water legislation to date, it will be the major driver for achieving sustainable management of waters in the EU Member States for many years to come. The WFD requires all inland and coastal waters to reach 'good status' by 2015. It will do this by establishing a river basin district structure within which demanding environmental objectives will be set, including ecological targets for surface waters. It aims to bring about a healthy water environment by taking due account of environmental, economic and social considerations (European Union, 2000).

Against this background PIANC published in 2003 the report '*Guidelines for Sustainable Inland Waterways and Navigation*', which includes a recommended procedure for both strategic and project planning based on an assessment of the interactions between inland navigation, the ecosystems on which navigation is practised, and the other potential users of those systems. The report is aimed primarily at mid-level managers involved in IWT planning and operations, but is also useful to a broader audience involved with navigation or water management. Attention is given to the audience in developing countries (PIANC, 2003).

The report '*Inland Waterways and Environmental Protection*' from the European Conference of Ministers of Transport, 2006 stated that inland navigation can contribute to making transport more sustainable, particularly where it substitutes for road transport, but inland shipping and especially the development of waterways can create considerable environmental impacts. The nature and extent of the impacts depend on the kind of work concerned and, to a large degree, on the characteristics of the water body itself. The kind of mitigation techniques that can be employed can also differ markedly, for example between sections of river with rocky bed and banks, and reaches with sandy or muddy bottoms situated in floodplains. Foremost among the potential impacts are hydromorphological pressures. Without careful attention, alterations can interfere with communications between the main channel, side branches and backwaters. Permanent changes to water levels and flows affect the whole river valley bottom and notably the ecology of floodplains. On the other hand, new works for navigation can be designed to improve water quality or biodiversity and create valuable habitats.

5.2.1. Environmental assessment procedures

The overall goal of environmental policy is sustainable development. A key element on the way to this goal is nature conservation, which is brought about by taking into account economic, social, cultural and regional requirements. The backbone of environmental policy is a legislation that enforces environmental assessment procedures as well as enforcing the protection of biodiversity and waters within the EU member states.

PIANC and the European Conference of Ministers of Transport (ECMT) provide in their reports (PIANC, 2003; ECMT, 2006) structured ways in which to use existing environmental assessment procedures for a successful implementation of development projects on inland waterways characterized by case studies from various countries.

Environmental Assessment (EA) is a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. The process involves analysing the likely effects on the environment, recording those effects in a report, undertaking a public consultation exercise on the report, taking into account the comments and the report when making the final decision, and informing the public about that decision afterwards. In principle, environmental assessment can be undertaken for individual projects such as a dam, (Environmental Impact Assessment) or for plans, programmes and policies (Strategic Environmental Assessment) (Herpertz et al., 2008). For example, the EU set into force the Environmental Impact Assessment (EIA) Directive to ensure that environmental consequences of projects are identified and assessed before authorisation is given (European Union 1997). To guide project owners, a specific plan of procedures (EIA procedure) was established with key steps in the following order:

- Project Preparations
- Notifying the competent authority
- Screening
- Scoping
- Carrying out environmental studies
- Submitting environmental information to the competent authority
- Reviewing the adequacy of the environmental information

- Consulting with the statutory environmental authorities, other interested parties and the public
- Considering the environmental information before making development consent decisions
- Announcing the decision
- Carrying out post-decision monitoring if the project is granted consent
- Some countries in Europe have already derived specific national plans of procedures for waterways from this general EU EIA procedure (ECMT, 2006).

5.2.2. Management of dredged material

Dredging is the excavation, lifting and transport of underwater sediments and soils for

- the construction and maintenance of ports, waterways, dykes and other infrastructures
- the reclamation, and maintenance of river flow
- beach nourishment
- the extraction of mineral resources, particularly sand and gravel, for use in the construction industry
- the environmental remediation of contaminated sediments

Globally, many hundreds of millions of cubic metres of sediment are dredged annually, with most of this volume being handled in coastal areas. A portion of this total represents capital dredging, which involves the excavation of sediments to create ports, harbours, and navigable waterways. Maintenance dredging sustains sufficient water depths for safe navigation by periodic removal of sediment accumulated due to natural and human-induced sedimentation. Maintenance dredging may vary from an almost continuous activity throughout the year to an infrequent activity occurring only once every few years.

Sediments are a basic component of habitats that support aquatic life. Because dredging and dredged material placement inherently involve the disturbance of existing substrates, they may have an impact on the environment. To prevent or limit these impacts many national and international conventions have been developed. This has resulted in procedures such as the Dredged Material Assessment Framework of the London Convention (LC-DMAF), which is applicable worldwide. Originally drafted as guidance for marine placement of dredged material, the LC-DMAF can be applied to inland projects as well. One component of the LC-DMAF is the conduct of a thorough environmental impact assessment (EIA) to identify potential effects of a given dredging project prior to its execution and to reduce uncertainty about the scales of those impacts.

A central element of the LC-DMAF is dealing with contaminants present in the sediments to be dredged. Usually navigation is not the polluter but has to deal with the contamination in maintenance and development projects. This increases the costs and sometimes the duration of plan approval procedures. Recent development also takes into consideration any valuable environmental features of the dredging or placement sites. Environmental management has been extended to virtually all projects, including those with uncontaminated material and less valuable habitats.

PIANC has published, in close co-operation with the World Dredging Association (WODA) and International Association of Dredging Companies (IADC), a number of valuable reports about the environmentally sound handling and management of dredged material (see http://www.pianc-aipcn.org/ and Bray 2008). Based on this knowledge, the most recent PIANC reports Dredging Management Practices for the Environment – A Structured Selection Approach' (PIANC, 2008*b*) and 'Dredged Material as a Resource – Options and Constraints' (PIANC, 2008*c*) provide up-to-date guidance and a number of recommendations including noting the benefits of relocating dredged material into aquatic systems, and of monitoring to minimize uncertainty about the interaction between dredged material and its receiving environment. A clear trend is to develop a better understanding of the sediment quantity and quality dynamics on a river basin scale and to set up sediment management plans for each single river (e.g. Rhine River, Germany).

5.2.3. Working with nature – the concept

Worldwide, methodologies and technical solutions that allow for the integration of environmental alternatives and opportunities into waterway management already exist in the public domain. Experiences and existing investigations on their practicability, however, still need to be comprehensively gathered. In addition, more guidance is required to support the transfer of the principles of sustainable management and 'working with the river' into practicable applications. There is a mandate from society for the transport sector to provide both safe and efficient waterways as well as a sustainable waterway management that preserves the environmental value of our rivers. In order to fulfil this mandate and to take the opportunity to constructively influence the process, it will be necessary for the transport sector to get proactively involved in the development and implementation of environmental regulations.

In many parts of the world,, there are good-practice examples of approved, integrated approaches that take into account the expertise, experiences and interests of various participants. Nevertheless, in order to meet the challenges of a changing climate and environment, even more communication, co-operation and integration will be required for a sustainable waterway management in the future. Accordingly, PIANC has taken the principle of 'working with nature' towards fully integrative approaches of waterway management (PIANC, 2008*d*).

The concept of working with nature is an integrated process that involves working to identify and exploit win-win solutions which respect nature and are acceptable to both project proponents and environmental stakeholders. It is an approach that needs to be applied early in a project when flexibility is still possible. By adopting a determined and proactive approach from conception to project completion, opportunities can be maximized and – importantly – frustrations, delays and associated extra costs can be reduced.

While the requirement to consider the potential environmental impacts of proposed projects for ports, navigation or associated infrastructure is well-established, the process of so doing is often complicated and difficult. If the design concept has progressed for a project before environmental issues are considered, environmental impact assessment necessarily becomes an exercise in mitigation or damage limitation, potentially resulting in sub-optimal solutions and missed opportunities. Working with Nature requires that a fully integrated approach be taken as soon as the project objectives are known – i.e. before the initial design is developed. It encourages consideration of how the project objectives can be achieved given the particular, site-specific characteristics of the ecosystem.

Working with nature is about more than preventing or mitigating the environmental impacts of a pre-defined design. As variously described by others, it sets out to identify ways of achieving the project objectives by working with natural processes to deliver environmental protection, restoration, or enhancement outcomes.

Fundamentally, therefore, working with nature means doing things in a different order:

- establishing project needs and objectives
- understanding the environment
- making meaningful use of stakeholder engagement to identify possible win-win opportunities
- preparing initial project proposals/designs to benefit navigation and nature
- Working with Nature thus requires a new way of thinking which leads to a subtle – but important – evolution in the way we approach waterway project development.

6. Selected case studies of world inland waterways

6.1. Rhine River – The CCNR – sustainable navigation and economic development

Inland navigation, or IWT, promotes economic development and supports environmental sustainability as has been successfully demonstrated by navigation on the Rhine. It's a comprehensive legal regime, adapted over time to the changing expectations of society, which encourages intensive stakeholder involvement during preparation, decision-making, and implementation, and an integrated river basin approach – all of which are prerequisites to reducing the environmental impact of IWT as far as possible. Clear economic benefits and a small environmental footprint ensure that Rhine navigation is accepted by society.

The Rhine, with a watershed of some 185,000 km (Central Commission for Navigation of the Rhine, 2007) and a length of 1,320 km, of which some 850 km are navigable, is not one of the very large rivers in the world, but perhaps the busiest inland waterway, with more than 300 million tonnes of cargo (Central Commission for Navigation of the Rhine, 2007) and 2 million containers (TEU) (Central Commission for Navigation of the Rhine, 2008*a*) transported each year, resulting in 45 billion tonne km (Central Commission for Navigation of the Rhine 2008*b*).

The Central Commission for Navigation on the Rhine (CCNR), the oldest international organization in the world, is the governing body for navigation of the Rhine. It was established in 1815 by the Congress of Vienna and has the Mannheim Convention, which was signed 140 years ago, as its main legal basis. Membership of the CCNR has changed over time. Today, the governments of the riparian states Switzerland, France, Germany and the Netherlands, as well as the government of Belgium are members of the CCNR. The goals of the CCNR are to guarantee equal treatment of the skippers of different countries and to ensure the development of Rhine navigation. As a prerequisite for achieving these goals, it has set up a single regulatory system for most aspects specific to inland navigation, such as regulations concerning the design and manning of vessels. In fact, the CCNR has made the Rhine a waterway without borders.

The CCNR, with its very progressive legal regime, was set up shortly before the beginning of the industrialization of the Rhine basin, which then became home to many 'global players' in manufacturing, chemicals, steel etc.

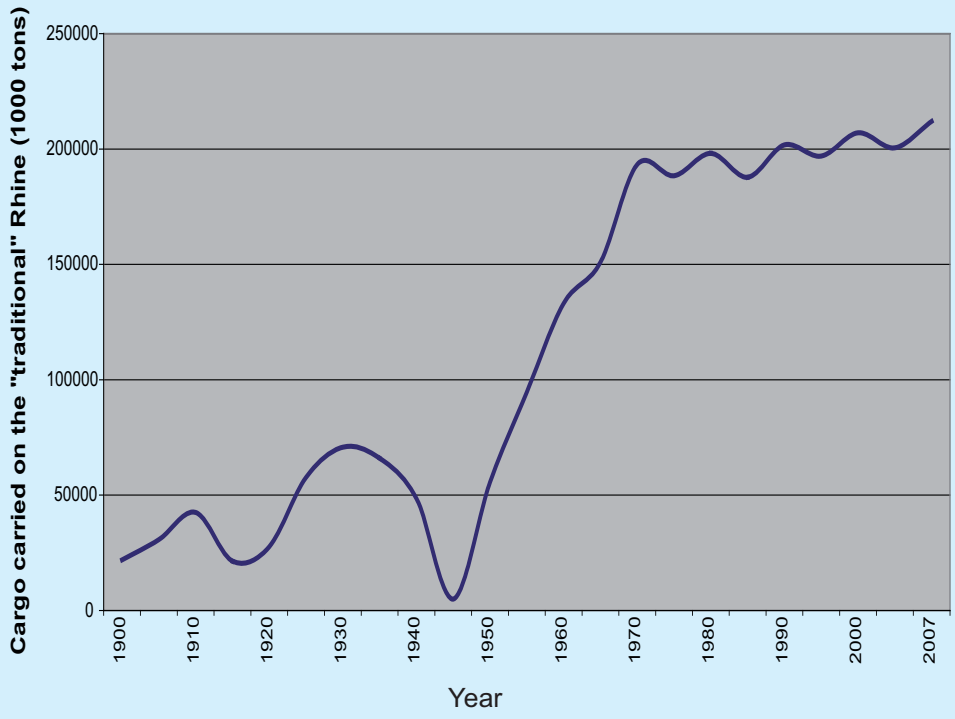
The largest BASF factory, (a major chemicals manufacturer), was founded around 1850 in Ludwigshafen on the upper Rhine in Germany. Today, the factory employs 35,000 people (BASF, 2008a). More than 45 per cent of its total cargo turnover is through inland navigation. The biggest of the three ports operated by BASF in Ludwigshafen receives, on average, eight vessels a day, almost 3,000 a year, loading or unloading some 3.3 million tonnes of mostly dangerous goods annually. Rhine navigation ensures the safe, reliable and economical supply of the factory, securing stable employment in the factory and related businesses. ThyssenKrupp is one of the leading steel producers in the world. Its first steel works

were founded at the end of the 19th century in Duisburg in northern Germany, ideally located with docks on the Rhine River. The Duisburg refinery is still ThyssenKrupp's main plant. The supply of base materials from Rotterdam to the ports in Duisburg is secured by ThyssenKrupp's own shipping company, with push convoys and 'Just in Time' delivery of 60,000 to 80,000 tonnes of ore and coals a day. At present the total deployed fleet consists of 10 push boats and around 100 pushed barges, which takes care of this transport 24 hours a day, seven days a week. Convoys of four or six push barges transport about 11,000 tonnes and 16,000 tonnes per trip respectively (Thyssenkrupp Steel Veerhaven, 2008). As each of them equals several dedicated heavy cargo trains, it becomes clear that without the Rhine and its possibilities for very efficient, high volume transport, steel production in Duisburg and other locations in the Rhine basin would not be competitive.These two examples show that the industrialization and economic development of the Rhine basin was not accidental, but rather was the consequence of the Rhine providing a reliable infrastructure for the cheap transport of large quantities of goods, and the Mannheim Convention guaranteeing the freedom of navigation, especially in cross-border traffic. Since the advent of modern IWT, marked by the introduction of steam powered inland navigation vessels in the first half of the 19th century, the amount of cargo, carried on the Rhine, has constantly increased, as shown in Figure 1. Rhine navigation has been one of the pillars of its riparian countries' economic development.

And the success story of Rhine navigation continues because it has also established itself as an effective conduit for carrying containers. In the last 15 years, the number of containers (TEU) travelling on board Rhine vessels has increased almost tenfold and now stands at around two million per year. Rhine navigation is the ideal means to connect the seaports with hinterland terminals. Also, in this case, the CCNR provided a helping hand by ensuring a minimum bridge height of more than nine metres above the water level, thus allowing boats to efficiently carry more than four layers of containers.

The shipping sector tends to see the Rhine as an Autobahn for IWT. However, the Rhine is also one of the most important tourist attractions in Europe and in 2002, the Upper Middle Rhine Valley, was designated a UNESCO World Heritage Site. The thousands of cargo vessels passing through this valley each year, carrying some eight million tonnes of cargo, did not negatively influence this designation. This can be taken as a clear sign that Rhine navigation integrates well into the picturesque landscape of the Rhine valley and that it is very much accepted by society. Rhine navigation itself is also part of the tourism industry, providing important employment, as passenger transport – be it by day excursion vessels or cruise ships – has been perhaps the fastest growing sector of inland navigation in Europe for the past few years. Germany alone counts almost 1000 day excursion vessels for 240,000 passengers and some 50 cabin vessels for more than 5000 passengers. This fleet is operated by around 350 enterprises with an annual turnover

Figure 1 **Development of transport on the Rhine**



of €260,000,000 (Bundesverband der Deutschen Binneschiffahrt, 2008), most of it probably generated in the Rhine basin. Surely, the founding fathers of the CCNR could not have imagined the astonishing amount of cargo transported today on the Rhine. However, they laid the legal foundations for this success story by creating a unified regulatory framework that deals not only with economic questions such as market access and the abolishment of shipping dues, but also with safety and ease of navigation.

The most important regulations of the CCNR are

- the Rhine Police Regulation (organizing river traffic),
- the Vessel Inspection Regulations (overseeing the design and manufacture of vessels and their equipment),
- the Rhine Patent Regulation (dealing with boatmasters' licences),
- the ADNR (regulating the transport of dangerous goods).
- Initially, the safety of the vessels and their cargo was at the heart of these regulations, but over the years, the protection of the environment has become their most prominent target, progressively limiting emissions from the vessels and their engines, requiring treatment of waste and demanding double hull tankers.
- The CCNR has no legal competence for the management of the river itself, including ecological issues. These issues fall under Community law and are covered by the Fauna Flora Habitat Directive (European Union, 1992) and the Water Framework Directive (European Union, 2000), protecting natural habitats on the shores and even in the fairway, and improving the quality of the water bodies.

Today, CCNR regulations, complemented by Directives of the European Community, deal with all aspects of inland navigation, including the waterway itself, and ensure that navigation on the Rhine is not only very economical, but also safe, environmentally friendly and therefore socially acceptable (Pauli, 2003). Figures 2 and 3 show that on typical routes for Rhine navigation, such as Rotterdam-Duisburg and Antwerpen-Ludwigshafen, IWT has not only much lower transport costs than the other modes of transports, but also the lowest external costs. Beside the regulatory efforts (Pauli, 2002), technological developments played a major role. The engines of the vessels have become cleaner (Pauli, 2008) and quieter and the vessels have grown in size, carrying increasing amounts of cargo (Rieken, 2008). Over the last 20 years, the average carrying capacity of a dry cargo vessel on the Rhine has increased by almost 60 per cent and the capacity of a tanker by more than 40 per cent. Therefore external costs have

Table 1 **Important milestones in the CCNR regulatory work**

1838	First regulation concerning the transport of certain dangerous goods
1850	First police regulations adopted for navigation on the Rhine
1904	First inspection regulations with safety requirements for vessels
1922	First regulation for the issue of boatmasters' licences
1968	First radar rules for inland navigation
1971	First prescription for the transport of dangerous goods on the Rhine (ADNR)
1995	Revised Police Regulation, Inspection Regulation and ADNR, adapted to the technical progress in inland navigation
1996	The signing of a convention regulating waste disposal in inland navigation
2000	First regulations for exhaust emissions from inland navigation engines
2007	Revised Regulation for the issuance of boatmasters' licences (patents)

Figure 2 **Financial transport costs**

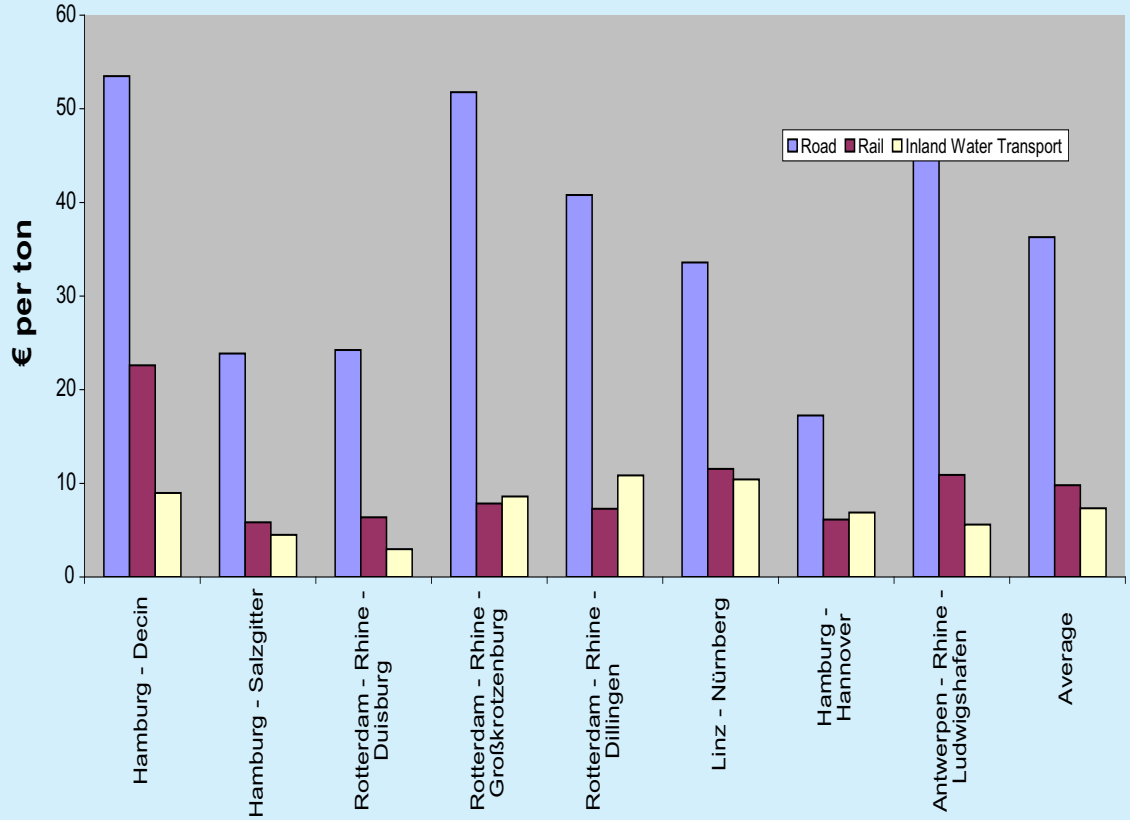
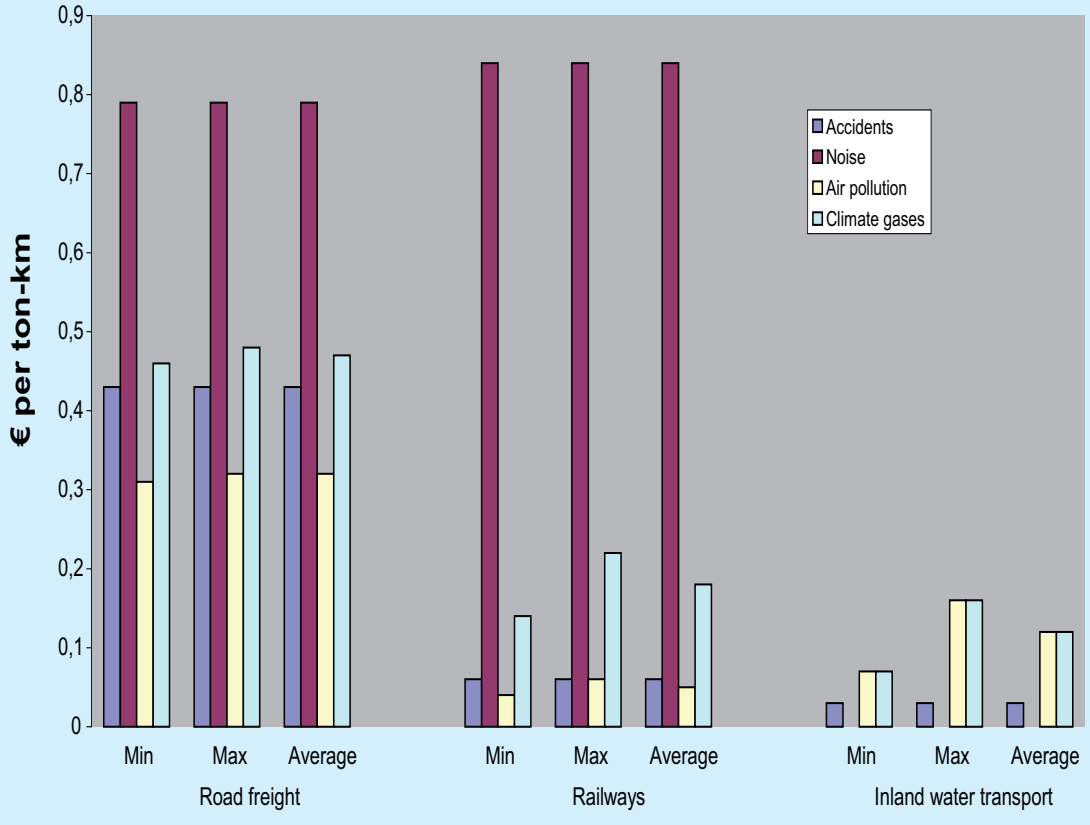


Figure 3 **External costs on selected routes**



decreased substantially and are now only a fraction of those incurred by road and rail. This is equally true for the transport of bulk cargo and of containers (PLANCO Consulting, 2007).

The CCNR has traditionally co-operated closely with ship-owners in its work, ensuring high quality regulation and proper implementation. In 1848, the CCNR held a hearing of the ship-owners, the first formal participation of stakeholders in the decision making of the CCNR (Van Eysinga and Walther, 1994). Over the years, other stakeholders in the logistical and technological processes of inland navigation – such as chemical industry in its role of freight forwarder, and the shipyards as builders of the vessels – became part of that stakeholder involvement, participating in the decision-making processes of the CCNR. The member states, responsible for the development of the infrastructure, co-operate with local communities and other water users. Regarding water ecology, the CCNR closely co-operates with the International Commission for the Protection of the Rhine (ICPR). A good example of this co-operation is the joint workshop of the two 'Rhine Commissions' in April 2008 on best practices for water protection and waterway development, resulting in concrete recommendations, mainly for the responsible government agencies (Central Commission for Navigation of the Rhine, 2008c). On a European level, the CCNR actively supports the development of the 'Common Implementation Strategy' for the EU Water Framework Directive, together with PIANC and other stakeholders from the navigation sector.

Navigation on the Rhine has shown that with a comprehensive dedicated regulatory framework, the active involvement of a wide range of stakeholders, and the implementation of new technology, sustainable navigation is possible and can be the basis for the economic development of a river basin.

6.2. Mekong River

The role of navigation in meeting the Millennium Development Goals in the Lower Mekong basin

The Mekong River basin includes parts of China, Myanmar, Viet Nam, nearly one third of Thailand and most of Cambodia and the Lao PDR. From its headwaters thousands of metres high on the Tibetan Plateau, the river flows through six distinct geographical regions, each with characteristic features of elevation, topography and land cover. With a total land area of 795,000 square kilometres, so much water flows into the mainstream Mekong from the surrounding basin area that, on average, 15,000 cubic metres of water passes by every second (Mekong River Commission, 2005).

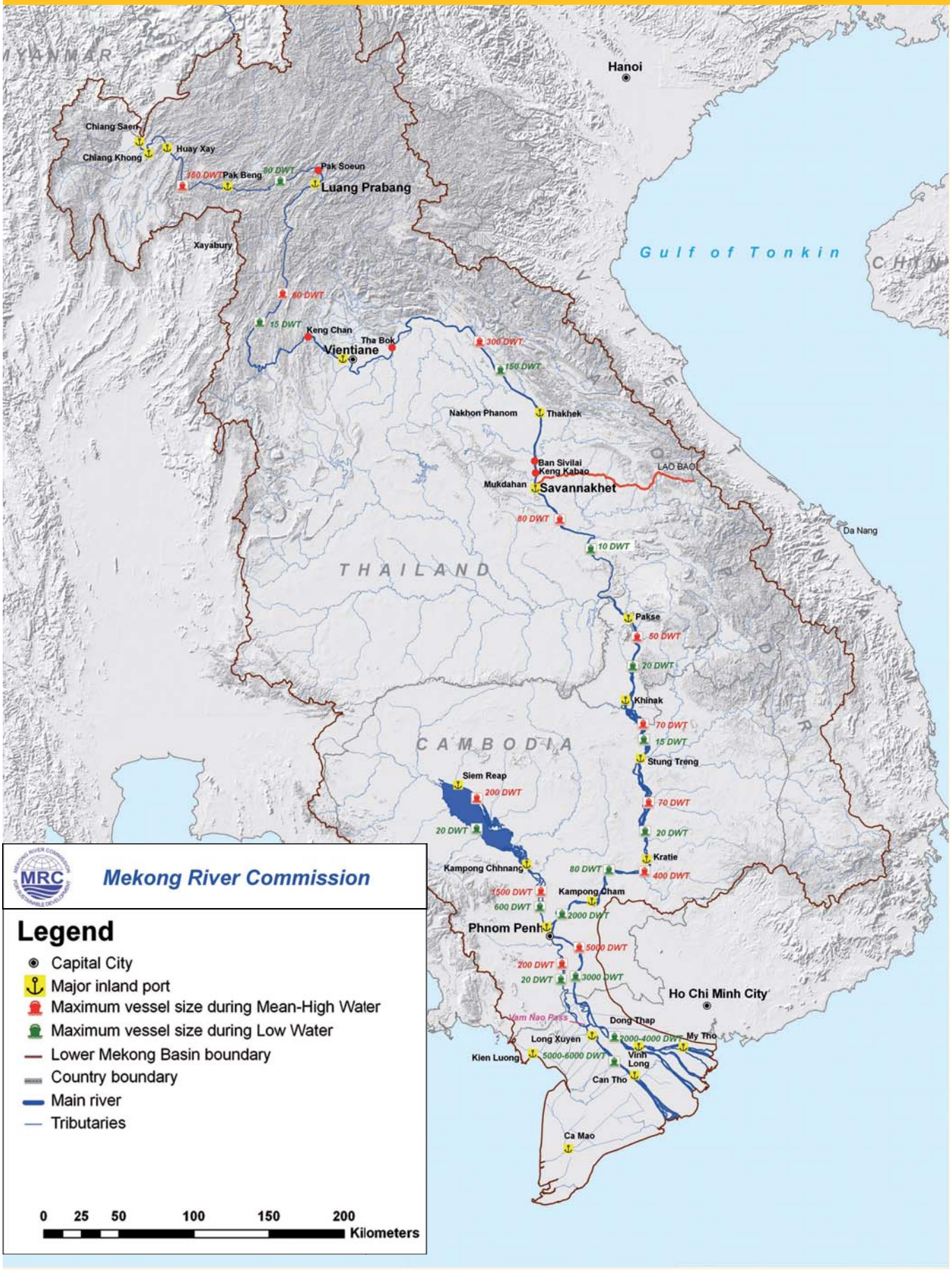
There has been a long history of navigation on the Mekong River, however a series of wars and political instability in the late 20th century resulted in a lack of development in the navigation sector. Only in the early 1990s did growth of navigation infrastructure begin in earnest, with consideration being given to projects for rebuilding Cambodian maritime infrastructure. At the same time, China began exploring the feasibility of using the Mekong River as a trade route for its southwestern provinces (Starr, 2003). Figure 4 shows the potential of the Mekong River as a navigational route between many of the landlocked regions it flows though. Although the river is currently used as a trade route for China and Thailand in the upper basin, and Viet Nam in the lower basin, there is still much undeveloped navigation potential. Even with the natural barrier of the Khone Falls, the river has the capacity to serve as a major trade and transport route for all of the countries along its banks.

The establishment of transport links is an essential step in promoting economic growth in the more disadvantaged countries of Cambodia and the Lao PDR. Although there has been substantial development in many of the Mekong countries in recent years, not every country has shared in this progress. Years of political turmoil in Cambodia and the geographic disadvantage of the Lao PDR have meant that the progress of these nations towards achieving the Millennium Development Goals (MDGs) has been slower than that of their neighbours.

The Navigation Programme (NAP) of the Mekong River Commission (MRC) plays three roles in facilitating the achievement of the MDGs by its member countries. Its primary role is in the realization of MDG 8 (Develop a Global Partnership for Development), by encouraging the growth of trade in the region and enabling access to trade in landlocked areas. The second role of the NAP is to pursue MDG 7 (Ensure Environmental Sustainability). Despite the benefits offered by inland waterway transport there is an associated environmental risk. It is the role of the NAP to ensure that increasing navigation on the river does not have a negative impact on the environment. The third task of the NAP is to ensure that citizens in all the MRC member countries are able to access the critically important social infrastructure required for the achievement of MDGs 2, 4, 5 and 6. These goals are all related to improving the health and educational outcomes of the people in least developed countries. Success in this area will require an adequate transport network that enables people to access educational and health facilities. Navigation plays an important role in providing this access, particularly in the Mekong delta countries of Cambodia and Viet Nam, where annual flooding renders many transport routes impassable.

To ensure the sustainable growth of navigation on the Mekong River, the MRC has formulated a strategy for developing the navigation sector. This strategy takes into account the role of the MRC as a transboundary organization and devises methods of leveraging its role as a regional coordinator. The aim of the strategy is to promote freedom of navigation in an environmentally sustainable manner that will increase trade opportunities for the mutual benefit

Figure 4 **Navigation potential in the lower Mekong Basin**



of MRC member countries. Two recent projects in Viet Nam and Cambodia illustrate the work that the NAP is doing to promote the achievement of the MDGs in alignment with this strategy. The first project was for the introduction of a legal framework for cross-border navigation to remove trade barriers and stimulate economic growth. The second project was for the introduction of an information system and aids to navigation to improve the efficiency of inland waterway transport.

The legal framework for cross-border navigation between Viet Nam and Cambodia

The frameworks governing navigation development in the region are politically complex. In the lower Mekong basin the MRC has a mandate to undertake navigation development based on Article 9 of the 1995 Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin. Despite the existence of this mandate, legal frameworks governing cross-border navigation have been in disarray due to a lack of regional co-operation. The initial framework for cross-border navigation in the region had been set out in the 1954 Paris Convention on Regulating Maritime and Inland Navigation on the Approach to the Port of Saigon. Since the signing of this document, changes in the political situation and later agreements resulted in the undoing of many of the navigational rights granted by the 1954 convention.

The lack of a cohesive legal framework for navigation had created a number of regulatory obstacles restricting navigation on the river. These hindrances included:

- restrictions on night navigation for foreign vessels on the Vietnamese stretches of river;
- regulations preventing master mariners from obtaining Pilotage Exemption Certificates (PEC);
- a prohibition on vessels bound for Phnom Penh using the Bassac River and Vam Nao pass;
- inefficient management of the fairway resulting in an increased risk of damage due to obstructions from fishing nets and poles;
- restrictions on the trade of certain goods;
- formalities, delays and detentions due to the time taken to complete multiple customs formalities; and
- inconsistent duties and taxes.

As a result of these obstacles, several shipping companies have ceased services to Phnom Penh Port and donors have withdrawn funding for further development of the port.

To address these barriers to cross-border navigation, the NAP undertook a project to develop a common legal framework that would promote cross-border navigation between Cambodia and Viet Nam. This document was designed to be a foundation for cross-border navigation between all the MRC states.

The NAP conducted an assessment of the earlier intergovernmental efforts to develop cross-border navigation and it became clear that greater efforts were required to develop a workable legal framework. The programme then played a key role in facilitating discussions between Cambodia and Viet Nam on the establishment of a draft protocol and road map to establish a legal framework for cross-border navigation. Part of this facilitation involved arranging a fact-finding mission to the Scheldt River basin for representatives involved in the discussions, to enable them to observe a practical example of cross-border navigation. To enhance the capacity-building aspect of this process, an international legal expert was engaged to work with riparian professionals in the development of the new treaty. Observers from Thailand and the Lao PDR were also present in order to consider the potential issues that would be faced by their countries during the future consideration of a cross-border framework.

In June 2008, the final draft agreement between Cambodia and Viet Nam for cross-border waterway transportation was completed and submitted to the legal taskforces of the two countries. Once agreement has been reached between the partners, the agreement will be submitted to the governments for final approval. Signing of the document is expected during the third quarter of 2008. Numerous companies have already expressed an interest in commencing shipping operations from Phnom Penh. It is also expected that the growth in trade will encourage international donors to renew funding for the development of the port, all of which will contribute to the achievement of MDG 8 by the countries in the region.

Aids to navigation and the management information system in Phnom Penh port

Phnom Penh Port is the only international river port in Cambodia. Its location in the capital city of Phnom Penh, in close proximity to the country's major areas of production and consumption, makes it an important trade link. The accession of Cambodia into the The Association of Southeast Asian Nations (ASEAN) and the World Trade Organization (WTO) has opened the country to full competition from other emerging markets. Garment manufacturing is a vital industry for Cambodia, but the lack of a textile industry means that this sector is dependent upon imports. In order to remain competitive and boost industry, it is essential that regional transport infrastructure is as economical as possible. To progress toward MDG 8 Cambodia needed to maximize the efficiency of its port and shipping operations.

Two projects were implemented under the NAP that have allowed the port to become more competitive and at the same time provided a foundation for regional development. These projects were to establish a system of aids to navigation (ATONS) from the Cambodia-Viet Nam border to Phnom Penh and to introduce a management information system (MIS) for Phnom Penh Port. The projects were finalized between 2006 and 2007.

A system of 56 lighted buoys and eight leading markers was installed along a 100-kilometre-long stretch of the Mekong River from the Cambodia-Viet Nam border to Phnom Penh port. Prior to this system being installed, the lack of a proper system of ATONs had hindered shipping going to and from the port. Night navigation had been impossible. The ultimate goal of the project was to make accessing Phnom Penh Port more efficient, reduce the risk of accidents and improve safety in the channel. An earlier project between the NAP and the Bangkok-based United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) had resulted in the establishment of harmonized specifications for the ATON system, meaning that there was already a vital regulatory system of technical standards established at a regional level.

The new ATON system has increased the usable passage time by 45 per cent. By defining an accurate channel along the length of the river, the project has ensured that ships can take advantage of the maximum water depth afforded by the river. To ensure the sustainability of the new system, the project featured an integral training component for local staff. Cambodian waterways employees were involved in the installation of the system and attended training workshops. This training continued over a 12-month period to provide knowledge retention and improved learning outcomes for the local staff. Since installing the ATONs, container movements at the port have grown steadily.

The project has made a strong contribution to MDG 7 by ensuring environmental sustainability in its implementation. There has been no direct negative impact on the environment as a result of the implementation of the project. Environmental outcomes in the region have been supported through the improved safety and a reduction in the number of accidents has been attributed to the project. Benefits have also been realized through the promotion of inland waterway transport as a transport mode that requires less fuel and generates fewer emissions than land-based alternatives. The channel marked by the new ATONs was designed to minimize the requirement for dredging. Topo-hydrographic surveys of the river were carried out and the ATON system configured to follow the natural channel. This has minimized changes to river morphology and ensured minimal disruption of important habitats.

A second project for the installation of an MIS at Phnom Penh Port also supported progress towards the MDGs. Lack of financial resources and technical competence had hindered efforts to replace the existing analogue information systems at the port. These outdated processes had placed the port in a situation where it was no longer competitive with its regional neighbours, putting the country's economic growth and export mechanisms at risk. To rectify this situation, the NAP co-ordinated a Belgian-funded project to audit existing systems, upgrade communications infrastructure and implement a new information system.

The new MIS allows the port to maintain a database of goods movement into, through, and out of the port and is used by all port departments and related agencies, such as customs, shipping lines, freight forwarders, agents and trucking companies. The MIS is compatible with the national Electronic Data Interchange system being developed by the World Bank. This system allows the port and its customers to communicate directly, preventing expensive telephone and fax communication. It also reduces the need for customers to be present to arrange freight handling. The use of a standardized database will allow for future interconnection with other major ports in the region, including Saigon and Can Tho. This regional information system will provide a vital service for efficient co-ordination of vessel routing, traffic and readiness of cargo.

The port's database also contributes to protecting the riverine environment. Authorities now monitor the carriage and transfer of dangerous goods to prevent illegal and unregulated transportation of petroleum products and hazardous chemicals. Knowledge of where these goods are located on board ships or in port storage helps to prevent accidents, accelerates search and rescue, and aids in containment in the event of spills, fires or explosions. The combination of the MIS and the ATONs has removed bottlenecks and ensured continued trade growth in the region.

Future Developments

To build on the success of navigation development as a catalyst in stimulating economic growth, the NAP has a number of complementary projects in progress that will further promote navigation in the lower Mekong basin.

These projects include condition surveys of dangerous areas for navigation. The output of these surveys will be used to produce topo-hydrographic maps. Information from the surveys will also be used to design a system of ATONs that will extend the navigability of the lower section of river up to Kompong Cham and will improve the safety of navigation in the reaches from Luang Prabang to Pakse. The navigational aids will complement the work being completed under the Quadripartite Agreement in the upper Mekong basin.

Additional projects designed to stimulate economic growth include the establishment of tidal monitoring stations in the Mekong and Basaac estuaries. These systems will generate significant economic benefits for the region by improving efficiency at major ports and maximizing the available time for ships to enter the river system. Improvements in efficiency will lower transport costs and encourage trade across the region, providing a tangible benefit to lower Mekong countries in helping to achieve MDG 8.

The NAP has also established a Navigation Advisory Board (NAB). The NAB is an assembly of high-ranking officials and experts from member states that are responsible for providing input to the NAP. The board

has already held a number of meetings and is proving to be an effective platform for strengthening regional cohesion and reinforcing riparian ownership by involving interested parties from all member states. This structure ensures the NAP maintains strong links to its member states and further facilitates the MDG 8 goal of building a partnership for development.

Recommendations

The role of the MRC is to facilitate projects that benefit the entire basin. The key to navigation development in emerging economies is to identify low-cost projects that offer the opportunity to realize immediate benefits without sacrificing long-term sustainability. Developing frameworks for cross-border navigation fits this criterion. Promoting changes to legislation that will facilitate trade costs very little, yet is an essential action required for trade promotion. Implementing a legal framework for cross-border navigation is also a foundation for the achievement of MDG 8, as it formalizes the partnership between nations required for development.

It is important to recognize the need to remedy the economic imbalances between countries in a basin. Boosting a national economy benefits the individual country as well as its trading partners and neighbours. Providing the basic infrastructure to ensure the operation of a safe, efficient and reliable navigation industry is essential for trade development. The provision of aids to navigation and information systems that promote the most efficient use of the waterway and improve productivity in ports offers all countries in the basin the opportunity to share the benefits of development. The NAP has seen, through its projects in Cambodia and Viet Nam, the increased trade that results from improvements to safety and efficiency.

The social and economic benefits that stem from navigation development do not need to occur at the expense of the environment. Many of the projects designed to improve efficiency also have the benefit of improving safety. Aids to navigation that allow vessels to operate more frequently make navigation safer by indicating a correct path and reducing collisions. Information systems that boost efficiency at ports also ensure that the locations of dangerous goods are known, thus quickening response times in the event of an emergency. These safety improvements build on the existing benefits of inland waterway transport in helping to achieve MDG 7 (Ensure Environmental Sustainability).

Inland waterway transport must be recognized as both a catalyst and an enabling mechanism for the achievement of the Millennium Development Goals. It contributes directly to the achievement of MDG 8 (Develop a Global Partnership for Development). It also provides the opportunity to achieve MDG 7 (Ensure Environmental Sustainability-), by offering a low-impact alternative to other modes of transport. Finally it offers essential access to the services required to meet many of the other Millennium Development Goals.

6.3. Tennessee Valley Authority – Tennessee River

Background

The Tennessee Valley Authority (TVA) was created as a federal corporation in 1933 during the Great Depression to develop the Tennessee River and its tributaries for the purpose of navigation, flood control, and the production and distribution of electricity. It also provided re-forestation, erosion control, industrial and community development, improved farming techniques, fertilizer development, and the establishment of recreational facilities. Today it remains a principal manager of water resources across a large, regional river basin.

Improvement of the navigability of the Tennessee River is the first purpose mentioned in the TVA Act. It was an important mission for two primary reasons. First, including navigation in the TVA Act provided a constitutional basis for TVA. There was no precedent for creating a federal electric power or flood-control agency. However, the Interstate Commerce Clause of the United States Constitution had provided the rationale for a strong federal role in improving the nation's waterways since 1824 when the United States Army Corps of Engineers (USACE) was authorized to improve the Mississippi and Ohio Rivers for commercial navigation.

Second, the founders of TVA recognized the importance of good transportation in improving the economy of the region. The Tennessee River had served as an important communication and transportation artery since the earliest Native American settlements in the Valley; but the river was shallow and hazardous in many places, dropping 157 m over its 1,046-km length. It sufficed for canoes and flatboats, but as vessel technology changed, the river could not support modern navigation.

Before TVA, private companies and local communities had made several small, underfunded, ineffective attempts to improve the Tennessee River. But the job was too big and the resources were inadequate. After a century of effort, controlling depths on the Tennessee River averaged less than a metre, which was far too shallow for modern commercial navigation. TVA's plan (adapted from a preliminary plan by the USACE) was to build a series of multiple-purpose dams on the Tennessee River and its tributaries that would accomplish the multiple objectives of navigation, flood control, hydroelectric power, water supply, recreation, and irrigation. The comprehensive plan, published in 1936, called for the construction of seven high dams to create a continuous navigation pool on the main stem of the Tennessee River stretching from its headwaters at Knoxville to its confluence with the Ohio River near Paducah, Kentucky.

The Tennessee River basin encompasses most of the State of Tennessee and parts of six other south-eastern states: Mississippi, Georgia, North Carolina, Kentucky, Virginia, and Alabama. Historically, the economy

of this part of the United States, which includes the mountainous region referred to as Appalachia, was depressed. In many parts, resources were meager, and agricultural land was scarce and often rocky or hilly. In addition, the mountainous terrain and poor land-transportation networks isolated industry from markets. The region's economy was generally characterized by poverty, depressed living conditions, poor education, and little hope for change.

TVA helped the valley's economy in several ways. TVA's dams created reservoirs and improved river navigation. TVA also decreased flooding and erosion. Its facilities provided electric power, which allowed industries and businesses, and accompanying jobs, to locate in the region.

TVA created desperately needed jobs for thousands of workers with the construction of dams on the Tennessee River and its tributaries. In addition, TVA taught farmers how to improve crop yields, produced fertilizers, helped to replant forests, controlled forest fires, and improved wildlife and fish habitats (Tennessee Valley Authority 2008).

The navigation system

Today, TVA manages one of the most technically advanced and complex multiple-purpose river systems in the world. Nine main river dams form a staircase of quiet pooled water and controlled currents, a continuous chain of reservoirs that stretches along the entire length of the Tennessee River. TVA's operation of tributary flood storage reservoirs helps to maintain a steady water level on the main river that guarantees year-round passage for vessels requiring a 2.7-metre draught (the amount of water it takes for them to float). Even deeper water for more than half the river's length makes for improved towing efficiency.

Nine main and four auxiliary locks on the Tennessee River make it possible for both recreational and commercial vessels to pass easily from one reservoir to another. The largest lock, at Pickwick Dam, is 33.5 metres wide and 305 metres long. The lock at Kentucky Dam is the busiest on the entire system, handling over 27 million tonnes of river freight per year. Almost all of these locks are in operation 24 hours a day, 365 days a year, and all are available for use without charge.

The growth of commercial navigation on the Tennessee River waterway has been a major factor in the economic development of the region. Since the full navigation channel was completed, private industry has invested more than $8 billion in waterfront plants, terminals, and distribution facilities. Much of this investment has been made in recent years with approximately 52 percent ($4.2 billion) occurring since 1980. Industries along the waterway provide direct employment for about 31,000 area residents.

The development of waterfront industrial and navigation facilities has led certain areas within the Tennessee Valley region to become major industrial growth centres. The municipalities that have benefited the most also contain the most active river ports on the system, e.g. Decatur, Alabama; Guntersville, Alabama; Chattanooga, Tennessee; and Calvert City, Kentucky.

The Tennessee River navigation system has proved to be a valuable asset to the Tennessee Valley region and to the nation as well. It has been a major factor in reducing transportation rates charged by other modes, increasing commodity movements by Valley shippers, and attracting high-wage industry to the region. About 54 million tons (49 million metric tonnes) of diverse commodities move on the Tennessee River each year, saving shippers and consumers about $500 million in transportation costs. Coal accounts for the majority of traffic on the Tennessee River, about 40 per cent. A large portion of that traffic is delivered to TVA coal-fired steam plants on the Tennessee and Cumberland Rivers. The rest goes to other utilities and manufacturing plants in the southeastern United States. Construction materials such as stone, sand, and gravel comprise the second largest group of commodities and are exported from the limestone-rich quarries of the Tennessee Valley. Other major groups of commodities shipped on the Tennessee River include grains, chemicals, iron and steel, and petroleum products.

Grain shipments are a good example of the value water transportation brings to the region. Normally, industrial location theory would suggest that grain processing is a classic case of location near source of input rather than market because the manufacturing process reduces the bulk of the product. However, the availability of low-cost water transportation provides the advantage of location near markets. For example, several plants on the upper Tennessee River near Knoxville imports large quantities of grain by barge from the Midwest to convert to animal feed, vegetable oils, and high-fructose corn syrup (a product used extensively in the soft drink and baking industries). Location near large southeastern United States markets gives these companies a distinct advantage over competitors.

Recreation is a rapidly growing use of the waterway. More than 28,000 recreational craft use the locks in an average year. The increasing number of inter-reservoir trips by long-distance recreational boaters and tour vessels stimulates local tourism and helps create opportunities for riverside communities to redevelop their waterfronts. But the waterway does not benefit only the Tennessee Valley region; it is a national resource that benefits the nation's economy. About 80 per cent of the goods shipped on the Tennessee River either originate or terminate outside the region, encompassing origins and destinations in just about every state in the country.

Hydroelectric power

The Tennessee Valley Authority provided electricity for the first time to thousands of rural residents in the 1930s. Federal workers travelled to homes

to teach residents how to use electrical appliances, including cookers and refrigerators. The generation of electricity from TVA hydropower dams made the most striking changes to life in the region as electric lights and appliances made the area's businesses and farmers more productive. The presence of electricity also brought new industries into the region, adding more jobs. TVA activities helped to improve the area's economy by increasing wages, improving public health, and adding employment opportunities.

During World War II, the United States used aluminum to build airplanes, weapons, and other necessary war materials. In order to provide electricity for aluminum plants, TVA began one of the largest United States hydropower construction programs ever undertaken in the United States. At the zenith of the TVA war effort early in 1942, twelve hydroelectric projects and a steam plant were simultaneously under construction, and employment totaled 28,000 workers.

After the Depression and war years, TVA continued its presence in the Tennessee Valley with the building of coal-fired and nuclear power plants to supplement its hydroelectric power. It also expanded its electricity transmission and distribution system, thus contributing to the region's quality of life in general.

TVA now operates one of the largest electric power systems in the United States Twenty-nine hydroelectric dams, one pumped-storage plant, eleven coal-fired plants, three nuclear plants, and five combustion-turbine plants generate electricity for distribution over an area of about 207,000 square kilometres (80,000 square miles), providing power for eight million users. The TVA system produced more than 156 billion kilowatt-hours of electricity in 2007.

Flood Risk Management

More than one hundred communities with flood problems have been helped by the TVA, which has offered technical guidance and built improved channels and detention dams. In addition to the nine major dams on the main course of the Tennessee River, twenty other TVA dams function on the tributaries of the Tennessee River, storing excess water in flood season and lowering flood levels on the Ohio, Mississippi, and Tennessee Rivers. TVA's flood reduction efforts prevent an estimated $211 million in annual damage to areas adjoining the Tennessee River, as well as another $21 million in possible losses along the Mississippi and Ohio Rivers.

Other ongoing TVA programmes

In co-operation with state and other agencies, TVA conducts research and development programmes in watershed protection, water and air quality protection, and wildlife and fish preservation. In addition, in co-operation with citizen associations, the TVA continues to encourage the economic development in the Tennessee Valley. Its innovative loan and industrial-incentive programs allow regional companies to expand and outside companies to relocate to the Tennessee Valley.

TVA protects and improves water quality and aquatic life in the Tennessee River system. Engineers and scientists monitor water conditions and identify pollution problems in specific watersheds. These teams of experts work with landowners, government officials, interest groups, and local communities and businesses to find ways to protect water quality without limiting the river's other uses.

Conclusion

By managing the dams, reservoirs, locks, and power plants along the Tennessee River as an integrated system, TVA is able to get the most value from the available water. Dam releases are scheduled to reduce flood damage and ensure water is available where and when it is needed. Every drop is used and reused to float barges, spin hydroelectric turbines, cool thermal generating plants, provide water for industry, drinking, and to support recreation, and aquatic life. The TVA in the United States is a good example of how Integrated Water Resources Management (IWRM) has significantly contributed to the transformation of the entire basin from grinding poverty to prosperity.

6.4. Congo River

History and the condition of the infrastructure

The Congo River –formerly the Zaire River – is Africa's most powerful river and the second-largest in the world, with a discharge of 40,000 cubic metres per second. It is the world's fifth -longest river, and drains a basin of 3.7 million square kilometres. The Congo is very much an international river flowing through nine countries: the Democratic Republic of the Congo, the Central African Republic, the Republic of Congo, Angola, Cameroon, Burundi, Rwanda, Tanzania and Zambia.

The river itself is as turbulent as its history, though it begins peacefully enough in the savannahs just south of Lake Tanganyika. Gradually the river widens and picks up speed until it enters the 'Gates of Hell,' a 120-km-long canyon of impassable rapids. The river then flows through lush tropical rainforest as the Lualaba or Upper Congo. During its journey to the sea, the Congo River crosses the equator twice. Because the watershed of the Congo drains land from both the Northern and Southern hemispheres, it does not have the great seasonal fluctuations that many other great rivers experience. Its flow is relatively stable because part of the watershed is always in the zone of rain.

Navigation on the Congo River network has fostered economic development in Africa's interior, far from the coast. Varied activities include the production of palm oil on the banks of the Kwilu, centred on the port of Kikwit, and the establishment of coffee plantations in the Kisangani area.

Before such developments could be undertaken, however, it was necessary to overcome the barrier to the sea formed by the Congo's lower course. That feat was accomplished in 1898 with the opening of

the railway between Matadi and Leopoldville (now Kinshasa) and in 1934 by the completion of the Congo-Ocean rail line on the right bank between Brazzaville and Pointe-Noire. So inland water transport on the Congo has been part of an intermodal system since the last century.

The Congo is the most important inland waterway system in Africa. Within the territorial limits of the Democratic Republic of the Congo alone, there are 14,500 kilometres of navigable waterway. Of this total, about 1,000 kilometres are accessible in all seasons to barges with capacities of between 800 and 1,100 tonnes, depending upon the height of the water. The amount of goods transported by water is not known exactly, but is very modest in comparison with the traffic on European rivers. Cargos consist mainly of agricultural products, wood, minerals, and fuel. The commercial traffic at the port of Kinshasa is less than a million tonnes per year.

Yet, river transport is essential for communication with regions that are inaccessible by road. There are three principal water routes, all of which converge on the downstream terminus at Kinshasa on the Malebo Pool. These run from Kisangani, from Ilebo on the Kasai, and from Bangui on the Oubangui.

River transport, however, could play a much greater role in economic and human development in Africa. It has actually declined since the states of the Congo basin became independent in 1960, because of serious problems with aging equipment, a lack of maintenance of the infrastructure, and the poor functioning of the public waterway agencies. In Congo, only the section from Ilebo to Kinshasa is still commercially important, because it constitutes the river link (the other link being a railway between Kinshasa and Matadi), by which part of the copper production of Katanga is conveyed to the coast.

The political instability of recent years has hindered economic development in the Congo's riparian nations. The inland waterways of the Congo region are recovering slowly, but most harbours are in poor condition and lack of maintenance as well as the absence of marked navigation channels contribute to frequent boat accidents. Also, weak regulation of river transport enables illicit levying to occur, and this impedes trade and the free movement of goods in the region.

While the river system facilitates water transport, it hinders land transport. Only a small number of bridges cross the Congo and its tributaries. The Kongolo rail and road bridge over the Lualaba was reconstructed in 1968, and a bridge over the Congo at Matadi was opened in 1983.

The nations of the Congo River basin understand the great potential of the river to serve as a transport and communications axis. The Congo River offers opportunities for sustainable hydropower, navigation, and irrigation, but intergovernmental co-operation is necessary for these benefits to be realized.

Concerning the energy theme, the Congo River possesses one of the largest hydroelectric potentials in the world: 150,000 MW, of which 44,000 MW (more than double that of the Three Gorges in China) could come from the single site of Inga. Less than 2 per cent of this potential is exploited, a figure emblematic of the under-development of hydraulic infrastructure on the continent.

However, the amount of electrical service available in the countries of the Congo basin is weak (5 per cent in the Central African Republic, 31 per cent in Cameroon, 7 per cent in Uganda), particularly in the rural areas (1 per cent in the Democratic Republic of the Congo against a 6 per cent urban median). This constitutes a major obstacle in attaining the Millennium Development Goals.

The CICOS (Commission Internationale du Bassin Congo-Oubangui-Sangha or International Commission of the Congo-Oubangui-Sangha Basin)

The general principles of international fluvial law for the Congo basin were affirmed in the 1885 Act of Berlin, modified in 1919 by the Convention of St. Germain en Laye. The accord that instituted a uniform fluvial regime and created CICOS was signed on 6 November 1999 by the four chiefs of state of Cameroon, the Central African Republic, Republic of the Congo, and the Democratic Republic of the Congo (CICOS ,1999). The rider to the accord, signed 22 February 2007, enlarged the mandate of CICOS to include the integrated management of water resources (CICOS, 2007*a*). Angola presently has observer status with CICOS.

The statutory bodies of CICOS are:

- the Committee of Ministers (decision)
- the Committee of Management (advice)
- the General Secretariat (fulfilment).

Actions undertaken by CICOS and its member countries to improve navigation are:

- The development of the five-Year Strategic Plan of Action for Interior Navigation, adopted by ministerial decision on 13 December 2007 (CICOS 2007*b*).
- The training of navigation personnel. The Kinshasa Regional Training Center for Interior Navigation is in the process of being set up.
- The elimination of physical and non-physical barriers along the different corridors (struggle against bureaucratic 'harassment,' the refloating of wrecks that hamper navigational passage and access to harbor works).
- The application of the CEMAC/RDC code of interior navigation.
- The reduction of the risk of ecological and humanitarian catastrophe.

- The maintenance of navigable waterways, dredging, buoying and hydrographic works; construction and rehabilitation of ports and alongside quays.
- The expansion of cargo and passenger transport; the construction of small boats; and the installation of a radio communications system.

In addition, CICOS will record the low water levels of basins, notably for the tributaries located in the Northern Hemisphere, such as those of the Ubangi and the Sangha rivers. The Ubangi experienced numerous low-water interruptions in navigation believed in each instance to occur at a rate of:

- 4 days each year from 1935 to 1971,
- 40 days each year from 1972 to 1982,
- 107 days each year from 1983 to 1989,
- more than 200 days each year since 2002.

Conclusion

In this region, which is characterized by disputes both within and between nations, the joint development of the Congo basin offers a chance to overcome conflicts. The CICOS project is focusing on dialogue among the member countries and the promotion of direct personal contacts at both leadership and working levels.

Better and safer navigation on the Congo River will benefit the population of the region directly as well as generating economic development that will help to alleviate poverty. Greater use of the Congo River for economic purposes, coupled with preservation of the diverse ecosystem will improve the living conditions of the people of the Congo basin now and in the future.

In conclusion, it should be remembered that the forest of the Congo basin constitutes the second lung of the planet, irrigated by the second largest river in the world. Without doubt, even though less damage has been done through deforestation than to its South American neighbor, its preservation is vital. The effects of climate change have been felt in the basin already since 1970 through a lowering of the outflows of the Ubangi that have caused interruptions in navigation. The construction of a dam at Palambo would be a remedy for this problem. Innovative financial vehicles are in the process of being put in place to create credits for the reduction of greenhouse gas emissions. Knowing that the principal of polluter-pays has its basis in the water domain, these mechanisms are designed to foster the protection of the water resource of the basin.

6.5. Yangtze River

The Yangtze, which stretches for more than 6,300 km, is the longest river in China and the third-longest in the world, after the Nile and the Amazon. The river's vital role as a means of transport for both freight and passengers has remained undiminished for many centuries. Today, it carries cargo volumes on par with the Rhine and the Mississippi. The Yangtze is also vital to millions of Chinese as a source of drinking water and to farmers for irrigation, and its numerous tributaries are a major source of hydroelectric power generation. The Three Gorges Dam alone accounts for 3 per cent of China's current annual installed capacity. When it is fully completed, the dam will generate the equivalent of burning 50m tonnes of coal a year.

Balancing the different interests of all the disparate user groups of any major river is always a challenging task but there is little doubt, in the Yangtze's case, that the scales have been tipped in favour of industry in recent decades. The sheer scale of industrialization along the river has seriously affected water quality levels and the rich wildlife that it supports, especially in the lakes and wetlands of the lower reaches.

According to an official report, about 10 per cent of the river's trunk-line was in critical condition in 2007. In addition, 30 per cent of its main tributaries, including the Mijiang, Xianjiang and Huangpu rivers, contained high levels of ammonia, nitrogen, phosphorous and other pollutants.

In fact, few stretches of the Yangtze are in good condition. In 2006, just 31 per cent of the river's water was officially categorised as being of first- or second-class quality, with 35 per cent declared worse than third-class. Professor Yuan Aiguo, from the China University of Geosciences in Wuhan, has warned that unless action is taken, 70 per cent of the water could be fourth- or fifth-class quality within five years. This would lead to the disappearance of many water plants and the continued decline in fish stocks and wildlife.

Industrial heartland

The Yangtze dominates China's inland water transport sector, being the only river that connects the eastern, central and western parts of the country. Starting from the Tibet-Qinghai plateau, it runs through China's most important industrial and agricultural areas, before flowing into the East China Sea near Shanghai.

The eight provinces and municipalities along the navigable trunk-line are home to about one-third of the national population and an even larger share of economic output. Chemicals, paper-making, shipbuilding, iron and steel, and automobiles are particularly prominent industries. The Yangtze ports play a vital role in transporting raw materials, components and finished goods to and from major industrial bases such as Chongqing, Wuhan and Nanjing.

The river is now set to get more important still as a result of a number of central government initiatives that began in the 1990s, and which have a direct impact on the Yangtze. These include the development of the Pudong district in Shanghai and the construction of the Three Gorges Dam. Another

is the launch of the 'go west' campaign, which is designed to open up the interior and reduce the growing wealth gap between coastal areas and the interior of the country. In support of this campaign, Beijing is investing heavily in developing the Yangtze River and its supporting road, rail and air cargo network.

Long regarded as China's 'golden waterway,' the Yangtze and its 3,600 or so tributaries have a combined navigable length of more than 70,000 kilometres, making up 70 per cent of China's total inland waterways. It is also the country's busiest river, accounting for 80 per cent of all cargo volumes. Despite these impressive statistics, however, the river remains a sorely under-used resource; only in the lower reaches is the river used at anything like its true potential. The ports in Jiangsu province, from Taicang near the coast to Nanjing some 300 kilometres inland, handled two-thirds of the Yangtze's total cargo in 2007, and around three-quarters of its container throughput.

One reason for the skewed nature of traffic volumes is the No. 1 Yangtze Bridge in Nanjing. Built in 1968 with an air draught of only 24 metres, the bridge prevents vessels larger than 10,000 dwt (deadweight tonnes) from passing. Other inhibiting factors include still inadequate facilities at many of the inland ports, poor connections to the road and rail networks, low water levels in the drier winter months, the bottlenecks experienced at the Three Gorges shiplocks and the high number of small and outdated vessels on the river.

As a result of these factors, the majority of manufacturers and shippers choose to transport goods by truck to and from inland destinations. Despite the high fuel costs involved in using roads to transport goods over long distances, it is still the preferred mode for most suppliers that prioritize timeliness and reliability. Recognizing that investors in the interior need improved transport infrastructure, the central government is spending heavily on road, rail and airport facilities, as well as on the Yangtze itself. By bringing the river and rail more into play, the potential for intermodality will be promoted across the heartland of China. Manufacturers will be encouraged to integrate more than one transport mode as part of their supply chains and this in turn will lead to a more efficient use of fuel.

Coming years will see the opening of a riverside expressway, a riverside highway and a riverside railway, all running parallel to the Yangtze. These projects are designed to correct a historical bias in the orientation of China's rail network. Most rail lines run north-south to compensate for the absence of a major natural waterway flowing in this direction.

As for the Yangtze, large amounts of money are being invested to improve use levels along its whole navigable length. Between 2006 and 2010, the central government will invest 15 billion China Yuan renminbi[1] in developing the river, in areas such as waterway management, port construction, shipbuilding standardization and shipping security projects. These projects will build on recent improvements to the waterway that mean that central government planners are already close to creating an all-year-round shipping channel for barge fleets of up to 10,000 dwt all the way from Chongqing to the sea, thereby linking the future economic powerhouse of China's vast interior region to outside world markets. By summer 2009, when the Three Gorges Dam project is completed, the average river journey time between Chongqing and Shanghai will be halved to no more than seven days. A non-stop container service already exists that takes as few as five days.

To support an anticipated surge in shipping activity, money is being poured in to expand and modernize the river's major ports. In Chongqing, for example, which is located further upstream than any other significant port on the Yangtze, a new container terminal is being built six kilometres from the city centre. Cuntan Terminal will be the largest and most modern container terminal on the upper Yangtze when it is completed in 2009. There is also a trend towards greater specialization at the ports. Until fairly recently, many of the 24 major ports had no dedicated container berths or terminals; they handled general, break-bulk and container cargoes together. In recent years, however, we have seen ports such as Nantong become particularly strong in transporting metal ore, Zhangjiagang in timber, Taizhou in non-metal ore for export, Jiangyin in iron and steel, Nanjing in containers, and Wanzhou and Chongqing in RoRo transport. This allows the ports to concentrate their limited resources on building up their particular area of strength, to service their hinterland and prevent unnecessary duplication and competition. The Yangtze River Administration, the department under the Ministry of Transport that is in charge of the Yangtze, is keen for this trend to continue, giving priority to developing dedicated terminals for containers, coal, ores, RoRo and petrochemicals. The ports are also being encouraged to develop their logistics business, and the central government is promoting strategic alliances between them, along with regional co-operation and co-ordination.

By 2020, the central government hopes to have a network of well-equipped, efficiently run, multi-functioning ports, with Chongqing serving as a regional hub on the upper reaches of the river, Wuhan performing the same role on the middle reaches and Shanghai, supported by Nanjing, as the hub for the lower reaches. However, developing the ports is only part of the Yangtze modernization programme. Developing the waterway itself represents another enormous challenge.

1 US$ 2.2 billion as of February 2009.

The waterway

The upper reaches of the river, which flow through mountainous terrain, have traditionally been treacherous for vessels because of their narrow bends and numerous shoals and rapids. Pebble shoals are a major problem for shipping. Dredging projects have removed the shoals but, due to a lack of shipping volume, particularly of large vessels, maintenance work has not been kept up. The natural changes of the riverbed, combined with unregulated mining activity in the region, have caused these shoals to reappear. The Ministry of Communications has prioritized a new dredging project as one of its major projects to be completed by 2010.

The section between Chongqing and Yichang, on the upper reaches, has improved significantly since the construction of the Three Gorges Dam. The narrow bends and treacherous shoals have disappeared because of the dam. The reservoir's water level is expected to reach 175 m in 2009. The Three Gorges Dam has had its greatest impact on the middle reaches of the river, between Yichang and Wuhan. Historically, this stretch has been a priority for Yangtze waterway maintenance during the dry winter months. However, the regular cycle of storing and releasing floodwater from the reservoir has changed the silting pattern on the riverbed here, making maintenance work a lot more complicated than before. There are also claims that the dry season is being prolonged and the draught problem worsened.

The lower reaches between Wuhan and Liuhekou in Taicang, covering a total of 1,020 kilometres, are the busiest stretch of the river, despite having their share of shoals and sunken vessels on the riverbed, not to mention the numerous low bridges that span the river.

Between Wuhan and Nanjing, vessels of 10,000–30,000 dwt can sail all year round. Ocean-going vessels of 5,000 dwt can reach Wuhan during the flood season. Ocean-going vessels of 20,000 dwt and oil tankers of 24,000 dwt can sail all the way from the Yangtze mouth to Nanjing at high tide. The section between Nanjing and Wuhu is maintained all year round for the passage of ocean-going vessels. The section between Wuhu and Wuhan is open to ocean-going vessels between May and early November. At the mouth of the river, there used to be two notorious shoals that prevented 25,000 dwt ocean-going vessels from entering Shanghai port until high tide. An ongoing three-phase dredging project at the river mouth has successfully removed these sandbars. Upon completion of phase two of the project at the end of 2005, the water depth had reached 10 metres. The third phase started in 2006, with the aim of further deepening the channel to 12.5 metres; it will be completed in 2009.

In 2004, waterway officials discussed at great length a plan to extend the water depth of 12.5 metres from the mouth of the river further upstream. They hope to dredge to this depth all the way to Nanjing by 2009, allowing 70,000 dwt vessels to sail throughout the year. All maintenance activities are based on the government's blueprint to deepen the lower reaches of the river, smooth the middle reaches and extend the upper reaches (to Shuifu). Its ambition is to allow 10,000 dwt tug-barge fleets to sail all the way from Shanghai to Chongqing.

Navigational rules on the Yangtze are also changing for the better. Since 2003, two stretches of the river have adopted a traffic lane system whereby, following international norms, all vessels are required to sail on the right-hand side. Previously, foreign masters frequently complained about the haphazard approach to navigation adopted by many smaller ships. Greater use of the traffic lane system should help to improve safety levels and reduce accident rates. It has also paved the way for round-the-clock sailing, one of the major liberalizations since the river was first opened to foreign ships in 1983. In 1998, China decided to gradually ease restrictions on night sailing.

Round-the-clock sailing is already possible between Yichang and Shanghai, and could be extended further upstream once the Three Gorges Dam project is completed in 2009.

Vessel standardization

Another key factor to improving use levels along the river is the standardization of vessels. Average vessel sizes on the Yangtze are increasing rapidly, but they are still low by international standards. By the end of 2006, there were 118,000 vessels sailing along the Yangtze River network, which includes its numerous tributaries. They had a combined total capacity of 39.65 million dwt, giving an average size of just 314 wt per vessel.

If those vessels that sail along the river's tributaries – where water levels are generally lower than in the Yangtze trunk-line – are excluded, the average size rises to 750 dwt. But even this is still much smaller than the vessels that sail on the Mississippi, for example, where the average is more than 1,300 dwt. Only China Yangtze National Shipping Corp, China's largest inland shipping line, has a fleet of a similar size; its vessels have an average size of 1,360 dwt. Vessels as large as 8,000 dwt are now plying the upper reaches of the river.

In 2000, the Ministry of Communications began rolling out a long-term programme to standardize all vessels on rivers across China. With regard to the Yangtze, circulars categorically banned oar-carrying motorboats, vessels made out of cement and wood, and any newly built or renovated but non-standard vessel of any kind from entering the upper river from 1 October 2003. Earlier, in 2001, the ministry issued a new regulation governing the age of vessels allowed on inland rivers, effectively withdrawing old vessels from service on a compulsory basis. Given the huge amount of money needed for compensation

under the compulsory scheme, old vessels are being withdrawn at a slow pace. However, the average age of vessels is coming down significantly as a result of the many new vessels being built according to the standards promoted by the government; indeed, a shipbuilding spree is underway among the many yards that line the river. Except for passenger craft, vessels are becoming larger and more specialized in a standardized fashion, as the government has planned. RoRo vessels, known locally as *gunzhuang-chuan,* come in many different sizes and most are privately owned. They can be accommodated in most of the cities and towns that line the river.

Because of China's lack of experience in the chemical tanker sector and the need to meet high standards of safety, the ministry has opened up coastal chemical transport to Sino-foreign joint ventures on condition that the Chinese partner takes the majority stake in the company. Hubei Tian En Petroleum Gas Transportation Co, formed in 1996, was the first Sino-foreign joint shipping venture operating in Chinese domestic waters. It specialises in carrying LPG, butane, propane and other petrochemical products.

The most significant change on the river has occurred in container shipping. Since containers began to be moved on the Yangtze in 1976, the trade has been growing at a double-digit pace. In 2007, container throughput at the Yangtze's 24 major ports stood at 5.54 million TEU (twenty foot equivalent unit containers), an increase of nearly 38 per cent year-on-year. In 2008, the total is expected to increase 36 per cent to 7.5 million TEU. Vessels of 140 TEU capacity are currently the mainstay of container operations on the Yangtze. However, new models carrying 196 TEU and 256 TEU have been built, indicating a likely growth in the average size of vessel in future. With all the dredging efforts taking place, particularly along the lower reaches, the government also wants to promote vessels that are capable of sailing both on the river and at sea. Among the ports close to Shanghai, Nanjing is particularly keen to accommodate both river- and ocean-going vessels. Regular services have already started on a direct route between Nanjing and Shanghai Yangshan Bonded Terminals, using vessels with a capacity of 200–300 TEU.

The environment

Greater use of the Yangtze as a mode of transport, however, is likely to exacerbate pollution levels in the river. In the international context, concentrations of pollution in the Yangtze trunk-line are broadly in line with other large rivers elsewhere in the world according to a study conducted by the Swiss Federal Institute of Aquatic Sciences and Technology (Eawag) in late 2006. The team conducted a thorough chemical analysis of water quality between the Three Gorges Dam and Shanghai, collecting 20 water and sediment samples and analysing about 260 chemical parameters; this made it the most comprehensive study ever performed on the river.

The Eawag analysis of this 1,700-kilometre stretch found high pollution loads but varying degrees of concentration according to location and type of element and organic compound. Since the water discharge of the Yangtze is much larger than most other major cargo-carrying rivers such as the Rhine, it can accommodate much larger pollution loads to result in similar concentration levels. Generally, concentration levels are lower in downstream locations due to dilution, although the effects are much less pronounced in the tributaries and connecting lakes. Concentrations of nitrogen have approximately doubled over the past 20 years and are twice as high at the mouth of the river as they are at the Three Gorges Dam, reflecting an increasing use of mineral fertilisers in agriculture. Officials plan to establish a riverside greenbelt nearly one kilometre wide to reduce fertilizer runoff and other pollutants from entering the river.

In other aspects, the Yangtze came out relatively well from the Eawag study. For example, heavy metal concentrations in the Yangtze are currently about two to eight times lower than those in the Rhine 30 years ago, when pollution levels on that river peaked. EU guidelines on maximum levels for a number of heavy metals are all higher than the concentrations found in the Yangtze, suggesting that even today pollution levels are still significantly lower than in many European rivers. However, there are no grounds for complacency. With factories, hydroelectric schemes, individual households and farmers all contributing to worsening pollution levels, it is an extremely complex problem to solve. Industry would appear to be the single biggest culprit. Huge volumes of water are siphoned off for factories and then released, heavily polluted, back into the river.

Many environmentalists and ecologically minded local government officials in China have worked hard to highlight the pollution problems facing the Yangtze and have supported initiatives designed to improve the situation. This is a challenging task in a country where industrial growth is a political imperative. Rising public discontent, however, may come to their aid. Awareness of issues such as polluted drinking water, declining fish stocks and low water levels, has been quite high in recent years. More and more local residents are starting to campaign about the deterioration in water quality levels, as part of a national trend. In the first five months of 2007, the State Environmental Protection Administration (SEPA) received 1,814 petitions calling for a better environment, an increase of 8 per cent year-on-year.

The biggest challenge is to change the mindset of the many officials who tend to downplay the scale of the problem, believing that the sheer size of the Yangtze and its capacity for self-cleaning will always enable it to cope with pollution, according to Professor Yuan of the Chinese University of Geosciences. Central and local governments have

Box 2 The objectives of national water resources policy

I. To ensure the availability of water as it's needed – and at an appropriate quality for its respective uses for both present and future generations

II. To ensure the rational and integrated use of water resources, including their use for waterway transport, with a view to sustainable development

III. To ensure the protection of water resources against natural events and against any possible adverse effects of integrated use

pledged to address the problem of pollution on the Yangtze and on other major inland waterways. According to a report from Xinhua on 27 September 2007, Beijing has set a timetable to improve the Yangtze's worsening water quality, vowing to restore an ecological balance to the river by 2050. By 2010, up to 70 per cent of polluted water dumped into the Yangtze will be treated before being discharged, while the river's health would be 'significantly improved' by 2020, the news agency reported. The timetable was agreed by environmentalists and government officials from 14 provinces and major cities along the river.

Some critics argue that announcing new initiatives is the easy, natural response to environmental crises; implementing an effective and sustainable clean-up campaign is much harder to achieve. Securing the full support of local governments can be particularly difficult, since they are invariably judged on their economic performance; central government orders that might compromise economic activity are not always welcome at the local level. According to Zhou Shengxian, head of SEPA, plant bosses who violate state guidelines are often protected by local officials, whose primary concern is the creation of jobs. Zhou says many plants even build secret pipes to discharge untreated waste.

In China it is hard for environmentally concerned officials and individuals to make a difference, or even to get their voices heard. The absence of an independent legal system, along with the restrictions that are placed on the media and non-governmental organizations, mean that discussion of important environmental issues is often suppressed. Campaigners say it is important for Chinese officials to recognize that the cost implications of a badly damaged environment are potentially much greater than the benefits resulting from a growing economy.

6.6. Tietê-Paraná waterway

The Rio Tietê was the initial 'path' taken by explorers towards the countryside of São Paulo during the first 100 years of the colonization period, when adventurers left the plateau to search for gold and other precious stones. Today the Tietê-Paraná valley lies in the Brazilian State of São Paulo. Although the watershed is only 8 per cent of Brazil's land mass, it has a population of 50 million and generates over half of Brazil's gross domestic product. The region is a dynamic growth area with a tremendous demand for infrastructural development.

The government of Brazil has embraced the concept of integrated water resources management (IWRM) and adopted a national water resources policy (see text box). Inland water transport is an important part of this policy.

The Tietê-Paraná waterway and its planned extension down the Paraná and Paraguay rivers to Buenos Aires in Argentina will form an efficient bulk-cargo highway through the heart of Mercosul. Mercosul, or the Southern Common Market is a regional trade agreement between Brazil, Argentina, Paraguay, and Uruguay. The Tietê-Paraná waterway is to be the backbone of a regional intermodal transport system that will allow agricultural produce from areas in the centre-west of Brazil, eastern Bolivia, northern Argentina, and Uruguay to reach Atlantic ports cheaply and efficiently, thus increasing the international competitiveness of these countries.

The Tietê River was first developed for hydroelectric power, without navigation in mind. The hydroelectric dams did not originally have locks that would enable the passage of ships and other waterborne vessels. However, over the past 50 years, the government of the State of São Paulo has progressively built locks on the hydroelectric dams of the Tietê and Paraná rivers, allowing ships to overcome the water level differences created by hydroelectric development. The São Paulo government has also dredged channels to improve navigation conditions and marked the navigation channels with buoys for the entire length of the waterway. This water transport system now extends for 2,400 kilometres and is part of an intermodal network, connected to highway and rail systems. It provides a critical connection between agricultural production areas and marine ports (Agência Nacional de Transportes Aquaviários –ANTAQ, 2008).

Once a system of locks is built at the Itaipu Dam on the Paraná River at the Brazil-Argentina border, the waterway will be navigable from the State of São Paulo to Buenos Aires.

The terminals of the Tietê-Paraná waterway were established in the 1970s as integral elements of multimodal routes and belong both to logistical operators as well as to shipping companies. They tend to be specialized, varying from simple docks for loading sugar cane or limestone to installations with advanced technology for moving grains, bran and vegetable oils to large, raw-material processing companies.

The volume of cargo transported on the Tietê-Paraná waterway is growing rapidly, having more than quadrupled over the 12-year period from 1995 to 2007, from about one million tonnes to 4.7 million tonnes. From 2006 to 2007 alone, there was

Figure 5 **The Danube River basin**

an increase of 19 per cent in tonnage moved on the waterway. Major products moved include soya beans, corn, sugar cane, and gravel (Hydrotransport Department, 2008).

There is still much room for growth, because the Tietê-Paraná waterway has the potential to move 20 million tonnes of cargo annually. Current transport represents about 20 per cent of this potential capacity.

Brazil's northern and central-west region contains a vast area, similar in size to the Midwest breadbasket of the United States Much of this area is *cerrado* (savannah) and dry forest, which receives seasonal rainfall. Expansion of agriculture into this area has long been considered a possibility, but development was long delayed by a number of problems. Agronomists and soil scientists have learned to overcome soil infertility by the addition of lime and fertilizers, and plant breeders have developed varieties of soya beans and other crops that are suited to the tropical environment. The last hurdle, the lack of economical transport is being overcome by a variety of infrastructure initiatives. Development of the Tietê-Paraná waterway has played a large role in this agricultural expansion by providing an energy-efficient and environmentally friendly way to transport products to markets.

In Brazil, moving freight on waterways costs 20 per cent less than on the highways. It also costs less to develop waterways. The average investment per kilometre required by the waterways system is US$34,000, as compared with $1.4 million for railroads and US$440,000 for major roads.

ANTAQ is proposing that new hydroelectric dams be built with navigation locks. This would increase the project costs by 5 per cent, but adding them later increases project costs by 30 per cent.

The entire Brazilian inland waterway system moves approximately 45 million tonnes of cargo per year. However, this could increase to 160 million tonnes if waterways were fully utilized (Botelho de Oliva, 2008).

Brazil is reaching out and collaborating with other nations to improve its inland water transport system. A series of Bi-lateral (Brazil/United States) Inland Waterways Navigation Conferences has begun, with the first one in Brazilia in 2007, and the second in the Mississippi River region of the United States in July 2008.

Within Brazil, a seminar was held in 2007 on the Tietê-Paraná waterway, and ANTAQ recommended that the five states involved in the waterway, São

Figure 6 **The Sava River Confluence**

Paulo, Parana, Minas Gerais, Mato Grosso do Sul and Goias form a group and set a common work agenda. This would facilitate taking the agenda for discussion in political and corporate forums and helping to implement waterway-transport expansion projects. So in this case, navigation, and inland water transport in particular, is precipitating inter-governmental co-operation

6.7 Danube River – a link between West and East

The Danube is Europe's second-longest river after the Volga, with a drainage area of almost 801,500 square kilometres. It originates in the Black Forest in Germany, and after traversing 2,845 kilometres, passing through Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova, and Ukraine, it ends its journey in the Black Sea. Along with the countries that are directly located on the banks of the Danube, a number of other countries are in the Danube River basin (Figure 5). With so many countries in its watershed, the Danube is the most international river basin in the world. The European Commission recognizes the Danube as the 'single most important non-oceanic body of water in Europe,' and as a 'future central axis for the European Union'. It is the only river in the world connecting four capitals: Vienna (Austria), Bratislava (Slovakia), Budapest (Hungary), and Belgrade (Serbia). Each of these cities has very long history and is closely connected to the river.

The Danube River is navigable for 85 per cent of its length (2,411 kilometres), from the city of Kelheim in Bavaria in southeast Germany, to Sulina, Rominia's easternmost point. In the city of Kelheim, the Danube is linked to the Rhine-Main-Danube canal. Since the completion of the canal in 1992, the river has been part of a trans-European waterway from Rotterdam on the North Sea to Sulina on the Black Sea (3,500 kilometres). The Danube is well known as *Corridor VII,* the only river along ten transport corridors in Europe.

Another important canal on the Danube River is the 64-kilometre-long Danube-Black Sea canal, between Cernavodă and Constanța in Romania. It was finished in 1984, and it shortens the distance from western Europe to the Black Sea by 400 kilometres. The canal was designed to transport sea-going vessels.

The Danube is divided into three sections:

1. The upper Danube – km 2,845 – km 1,791 (Kelheim to Gönyü)
2. The middle Danube – km 1,790 – km 931 (Gönyü to Iron Gate)
3. The lower Danube – km 930 – km 0 (Iron Gate to Sulina)

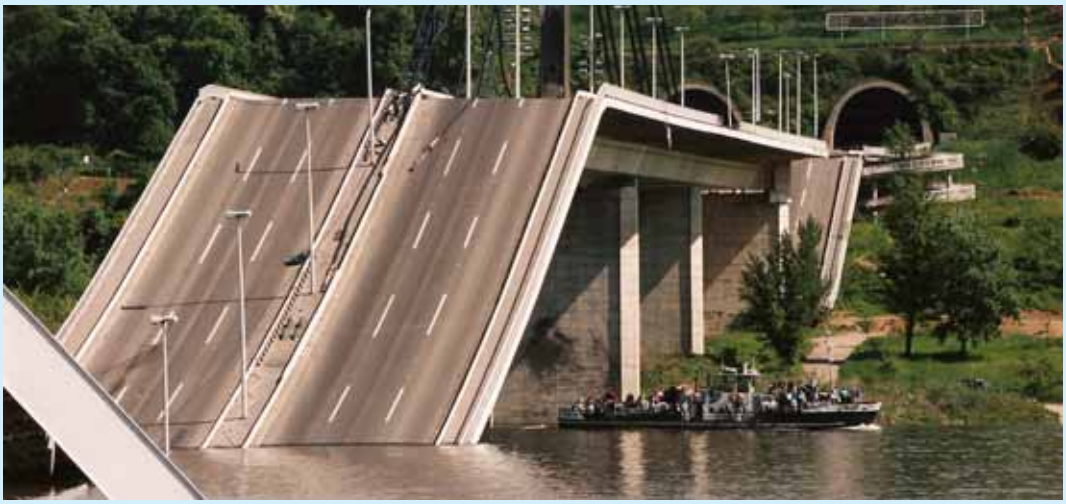
Each section has very distinct geomorphological characteristics. The upper Danube is characterized by high-flow velocities, narrow widths, shallower waters, and smaller vessels, while the lower Danube is a wide and deep river with lower-flow velocities and large sea-going vessels.

The Danube has a number of tributaries and the largest are: the Inn, the Drava, the Sava, the Tisza, and the Prut (Figure 6). Almost 60 tributaries are at least partially navigable.

The size and type of the vessels navigating the Danube depend on the characteristics of the river at its various points. There are two major classifications used to define the types of vessel used on the inland waterways and the fairway dimensions they require.

The European classification that defines the type and the size of the vessels used on the navigable rivers

Figure 7 **Destroyed bridge on the Danube River**



and canals, depending on its characteristics, is the 1996 *European Agreement on Main Inland Waterways of International Importance (AGN),* introduced by the United Nations Economic Commission for Europe (UNECE). It defines waterways and ports of international importance as *'E waterways'* and *'E ports'*. According to this classification, the Danube, upstream from Belgrade, is defined as category *VIb* and *VIc,* while downstream from Belgrade it's category *VII*.

Dimensions of the Danube River fairway are defined according to the Danube Commission recommendations (Via Donau 2007). The river is divided into sectors, depending on the available widths and depths. For example, on the sector through Serbia, available fairway depth for the free-flowing river should be 2.5 metres, and in the sections influenced by the reservoir, that depth should be 3.5 metres.

The Danube Commission is a governing body consisting of the countries that are located on the banks of the Danube River (Danube Commission 2008). It is regulated through the Convention regarding the Regime of Navigation on the Danube signed in Belgrade on 18 August 1948. Known as the Belgrade Convention, it aims to provide free navigation on the Danube in accordance with the interests and sovereign rights of the contracting parties of the Convention, aiming to strengthen the economic and cultural relations among themselves and with other nations.

According to the Convention, the 11 Member States: Austria, Bulgaria, Croatia, Germany, Hungary, Moldova, Serbia, Slovakia, Romania, Russia, and Ukraine are required to take measures to maintain their sections of the Danube in a navigable

Figure 8 **The Iron gate gorge**

condition for river-going vessels and, on the appropriate sections, for sea-going vessels and to carry out the works necessary for the maintenance and improvement of navigation conditions.

The Danube Commission was established to supervise the implementation of the 1948 Convention and to fulfill various other tasks with the aim of ensuring adequate conditions for shipping on the Danube. It goes, historically speaking, back to the Paris Conferences of 1856 and 1921, which established for the first time an international regime to safeguard free navigation on the Danube.

Up to now, the great potential of the Danube River for the development of inland waterborne transport has not been realized equally in all of the riparian countries. The main reasons why are the tremendous diversities between countries (unbalanced socio-economic power, different quantitative and qualitative characteristics of domicile and transboundary waters, different vulnerability of waters and ecosystems, etc.), and the fact that not all of the ten countries are EU members. In addition, a big set-back in the development of inland navigation, specially, on the middle and the lower sections of the Danube was caused by the introduction of sanctions against the former Federal Republic of Yugoslavia and by the bombing of Novi Sad in 1999 which resulted in the destruction of a number of bridges across the Danube. International transport on the river was then virtually stopped, and national river transport was carried out in restricted and dangerous conditions, Figure 7.

After the clearance of the debris caused by the destruction of the bridges and the removal of the temporary pontoon bridge in Novi Sad in 2005, waterborne transport on the Danube slowly started to recover.

The main task of all countries in the Danube basin is now to follow and implement international conventions, the EU Water Framework Directive, and other treaties which have the same goal – the protection and sustainable use of the Danube and its tributaries in the future. For these reasons, the International Commission for the Protection of the Danube River (ICPDR) was established in 1998. Figure 8 shows the Iron Gate gorge.

The ICPDR is an international organization consisting of 13 member states (Germany, Austria, Czech Republic, Slovakia, Slovenia, Hungary, Croatia, Bosnia and Herzegovina, Serbia, Bulgaria, Romania, Moldova, Ukraine) and the European Union. The goal is to ensure sustainable and equitable water management, including conservation, as well as the improvement and rational use of waters for the benefit of the Danube River basin countries and their people. It is mandated to implement the Danube River Protection Convention (DRPC), the major legal instrument for co-operation and transboundary water management in the Danube River Basin, as well as the Water Framework Directive of the EU. It is the institution that's legally responsible for further integrated river basin management (International Commission for the Protection of the Danube River 2008).

One of the most important documents that was presented in recent years, in the field of navigation and environmental protection is the Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin. The process to develop the joint statement has been initiated by the ICPDR, the Danube Commission and the International Sava River Basin Commission. The main purposes of this document are to protect the riverine environment and to define the necessary processes and conditions for conducting and developing sustainable inland navigation (safe and easy navigation; the organization of traffic; the maintenance, improvement and building of new vessels; the maintenance of existing infrastructures; the construction of new infrastructures, and the maintenance and improvement of existing waterways).

The further development of waterborne transport on the Danube and its tributaries, and the economic growth of riparian countries, all depend on the various action plans being fully implemented for integrated river basin management at all levels.

6.8. Ganges River –the multi-functional role of urban waterways: Kolkata, a case study

Introduction

In India, the prospect of rapid industrial growth has brought into focus the urgent task of planned urbanization at an unprecedented scale. In the next 20 to 25 years, about 60 million families will settle in newly urbanized areas. The cost of this urbanization must be low so that it is sustainable. It must also be low in energy consumption, low in carbon emissions, as well as eco-friendly and environmentally far superior to the present metropolitan cities and smaller towns.

Management of water is a crucial factor in new urbanization. Water resources must be used most prudently and the supply and disposal of very large volumes of water must be planned properly with environmental goals in view. In this context, it is necessary to examine the possible roles of the water bodies – the rivers, canals, lakes, ponds and wetlands in and around the areas proposed for urbanization.

This paper proposes a multifunctional role for the canals in such areas with reference to Kolkata (formerly Calcutta), a mega city of 14 million inhabitants on the River Ganges approximately 130 kilometres upstream from the Bay of Bengal.

The multi-functional role of the canals.

In an urban setting where the land is mostly built up, any body of water presents a pleasant contrast. A canal is a linear body of water with flowing water. To the urban designers, it offers many opportunities. The canal banks can be landscaped with greenery,

walkways, kiosks and resting places under trees. The canals can make way for the delightful intrusion of nature into the core of the city. It can also offer opportunities for boating, sailing, sightseeing and anchoring yachts. In extreme cold, a canal can convert itself to an idyllic ice skating rink. For a canal in a fully developed urban area in a high-income country with advanced infrastructural facilities, nature and leisure will perhaps be the best role.

But in the setting of an underdeveloped urban area that's undergoing rapid development both in terms of expansion and qualitative transformation, a planner cannot neglect the tremendous scope of using waterways for various other purposes. For a city, supplying and disposing of very large volumes of water are primary requirements. Canals can be used for both these functions.

Many industries need large quantities of water and many river banks have been spoilt to satisfy industrial need. The canals can lure them away to a planned location leaving the river banks for better uses. The supply of water for firefighting can be taken up by the canals, saving the cost of laying expensive hydrants. Lifting ground water indiscriminately for piped water supply without recharging has been proved to be disastrous. Where a river or lake is the principal source, canals can carry water to the planned locations of waterworks. It saves the cost of lifting water as well as the geo-morphological balance. In this way, the cost of water supply should also be reduced substantially, if proper planning is in place. Braithwaite observed that 'it is so expensive to construct new water pipes and storm water sewers that the canal is a valuable capital asset which should be used as much as possible' (Braithwaite 1976).

Canals are readily recognized as useful tools for disposing of water. In any city, most of the precipitation and approximately 80 per cent of the supplied water need to be disposed of. Rainwater harvesting is now compulsory for large-scale developments and all other developments are encouraged to do likewise. In spite of these steps, the rainfall that cannot be harvested, along with the sewage, makes up a very big quantity of water. In the Kolkata area, canals are traditionally the final point of outfall for the drainage system and these canals could carry out the same job in planned, new urban areas. Canals offer a much cheaper substitute than gigantic drainage pipes. It is not only the drainage but also the holding and storing of the water that makes the canals far more useful. Where the drainage depends on canals that have become blocked as a result of faulty planning, silting up and continuous large scale misuse, the streets have to bear the brunt during the heavy downpours. This is a lesson that is learned the hard way in Kolkata.

Canals are also natural barriers to movement. One has to cross over by a bridge or pass under in a tunnel. This gives a feeling of separation and is a tool for enclosures. In a large city, where developments tend to merge together, the canals can be used for the separation of neighborhoods, municipal boroughs, and land-use zones.

Perhaps the most useful task that can be taken over by such a water network is the transport of freight, and to a lesser degree, of passengers. It is well known that water transport is cheaper. A litre of fuel used on the waterways can transport four times the tonnage that can be carried by road over the same distance – albeit at a slower speed. Obviously, more time taken means higher costs as it involves human labour. But even so, the sum still works out in favour of water transport in India where labour costs are low.

It should also be pointed out that in order to achieve the high speed offered by road transport, considerable capital outlay is necessary to ensure smooth traffic flow – otherwise congestion is caused, which reduces the advantage that roadways have over the canals. With motorized boats and properly designed vessels, the speed on waterways can be competitive. The one advantage roadways will always have over waterways is the door-to-door transport that only road haulage can offer.

Nevertheless, in this present era when carbon emission is threatening the earth and when the consumption of energy in every form has become a central issue for sustainable development, one just cannot afford to neglect this energy-saving form of transport when planning new urban centres.

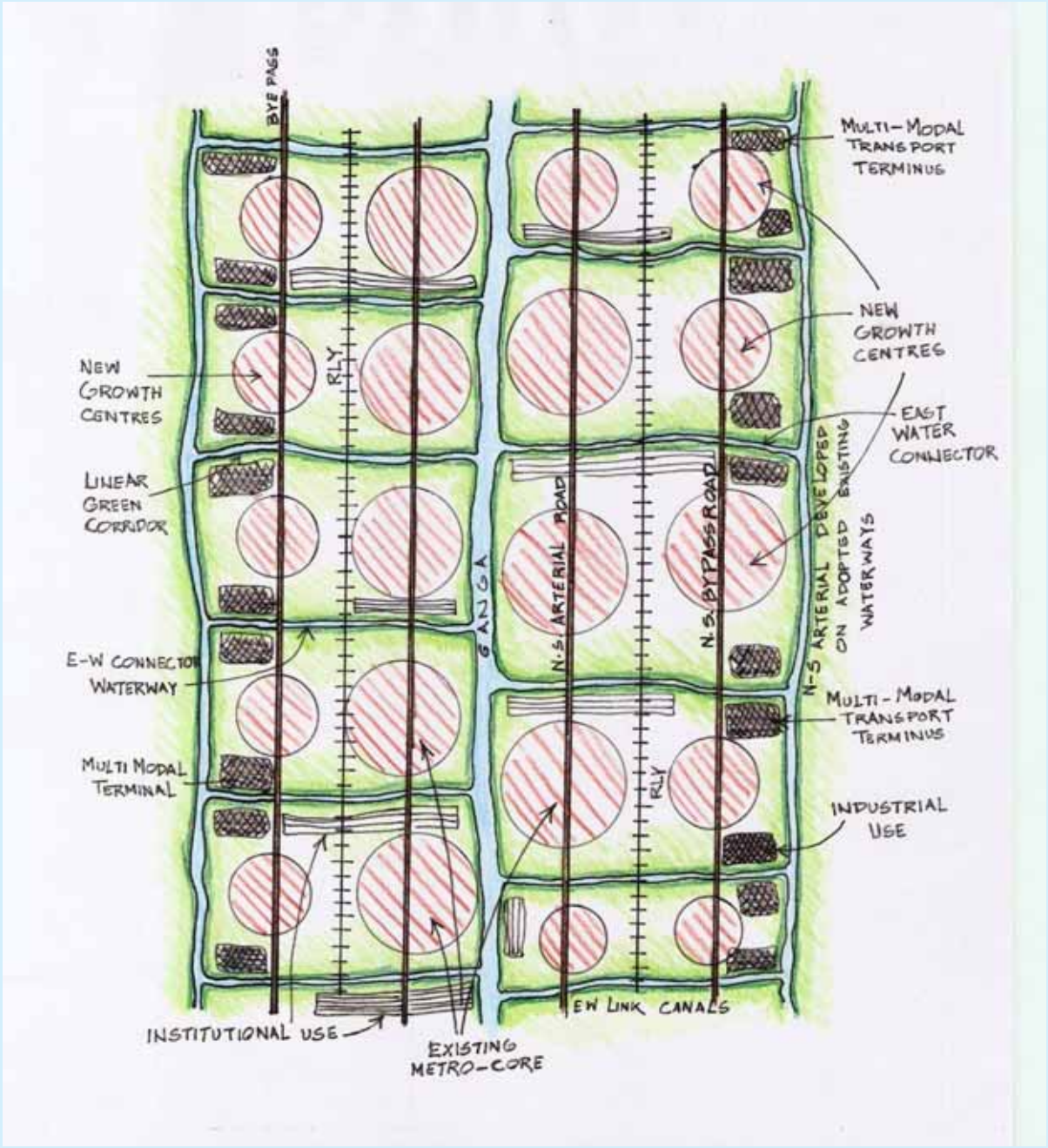
The role of waterways as a transport network

Once it is accepted that waterways offer an opportunity to transport people and goods at a lower cost, consuming less energy, emitting less carbon, and contributing to a better environment, it becomes imperative to examine analytically the specific functions that can be assigned to waterways. A 'modal split' is required to assign the most suitable form of traffic to a network of waterways. The relatively low speed of waterway transport rules out passenger transport in a general way. Here we need to calculate not only the high costs of labour needed to operate it, but also the time (and therefore the cost) of each and every passenger.

In certain cases, for instance, in a ferry crossing over a river or a bay, the time involved may be actually less than that needed for a journey by car or bus using congested bridges and roads. A ferry service is also suitable for leisure-time travel, for tourism and for entertainment.

Water transport in urban areas is particularly suitable for movement of freight, especially freight that is voluminous and bulky. Cargoes that are carried by waterways, traditionally comprise agricultural products, construction materials and mineral products, including industrial raw materials. A modernization of the system would mean that industrial products could also be transported on the waterways.

Figure 9 **Schematic diagram for proposed waterways, Kolkata**



A waterway network must therefore be designed to carry goods as well as performing other functions such as the supply, storage and drainage of water, within an overall policy framework for environmental improvement.

Designing the waterways

If waterways are proposed to carry goods, it is first of all necessary to find out where these goods originate and where they are required to go – see Figure 9, Schematic Diagram for Proposed Waterway Networks. It is important that these origins and destinations are linked directly by the waterways in order to ensure commercial success and economic viability.

For traditional freight on waterways, these origins and destinations are mainly ports, railway yards, truck terminals, wholesale markets and industrial centres. The newly developing areas, where large-scale construction is going on, are also desirable destinations. In any given case, the existing waterways should be examined to find out what links are required in the context of an overall transport plan.

It is also important to identify the possible nodal points where inter-modal transfers can be arranged. These multi-modal transport interchanges should be connected and served by railways, arterial roads and canals. These should also have enough space to contain warehouses and vast open air storage areas including a zone for containers.

Containers, incidentally, open up vast possibilities for inland water transport. Tug-boats moved by motorized pilot vessels should carry the containers one-at-a-time or in a convoy. The concept of floating containers also holds much potential. An Inland Container Depot (ICD) has already been proposed by Kolkata port authorities. This system is likely to attract the kind of freight – a wide range of sophisticated industrial products – which so far has remained beyond the scope of water transport in India.

This brings up the crucial question of standardization of vessels and terminal facilities as well as the design requirements of the canals themselves. Inland water transport has suffered a big loss due to non-standardization. All kinds of vessels, ranging from country boats (some still manually operated and some rather crudely fitted with engines) to an assortment of barges, steamers, launches and even hovercrafts and catamarans, can be seen operating in the Ganges alongside Kolkata. The costs of transfer as well as the turn-around times needed are unnecessarily high, offsetting a large part of the benefit of water transport.

The design of the vessels will obviously depend on the design of the canals – and vice versa. Six types of vessel were identified for such standardization. Two of these were chosen for priority research and development. The first type was a modernized country boat and the second was a flotilla designed to carry dry and bulk cargo as well as containers (Misra 1997). A study shows that a draught of at least two metres is necessary to make the canals navigable enough to support a water transport system. (Chakraborty and Roy 1997) So these should be dug at least to a level of two-and-a-half metres below the lowest low-water level in the Ganges. The width of the existing canals cannot be increased but these are usually ten metres or more, which would be an acceptable width for the new ones. There should be a minimum number of lock gates but these are unavoidable at the meeting points with the river where tide makes a considerable difference in the water level. The bridges, similarly, should leave enough clearance for the boats to pass under.

Designing waterways for Kolkata Metropolitan District

The Kolkata Metropolitan District (KMD) is stretched along both sides of the Ganges, covering more than 80 kilometres of the river bank. Interestingly, it is water transport that has been the determining factor for the metropolitan growth. Historically, European merchants established their bases along this river bank to take advantage of the water transport for their trades. Portuguese, French, Dutch and Danes –all had their bases on the western bank. Only the English merchants had a base in the eastern side in three villages with a flourishing cotton yarn trade. This grew gradually to become the Kolkata Metropolitan District.

Over the centuries, this resulted in a very interesting urban formation – basically linear with urban centres strung along the river bank in the form of a necklace with Kolkata as the dominant pendant. This is a very desirable form as it combines the advantages of small towns with those of a metropolis. Later, the roads and railways strengthened this 'String of Beads' urban formation and recently the underground railways have followed suit.

Any proposed network of waterways should be planned in harmony with this layout and with a view to strengthening this unique, organic urban form, which is derived largely from the great waterway of the River Ganges, and forms the spine of the urban structure. The river needs to be dredged as well as maintained and equipped with jetties. The necessary infrastructure should also be built for both passenger and cargo traffic. The river is suitable both for ferries crossing its breadth as well as for long-distance, high-speed passenger transport along its length. These already exist but much improvement is desirable. The river, which stretches basically in a north-south direction, should have a number of east-west branches running between two municipal areas. These branches should, in turn, be connected by a long arterial waterway stretching north-south at the edge of the Kolkata Metropolitan District. It is necessary to identify the steps that need to be taken to make the waterways suitable for the transport of passengers and freight. Sites for excavating new canals, mainly links, also need to be identified. This is a theoretical framework which can suit the multiple

functions of the waterways including drainage, the supply of water for industrial and civic purposes, the formation of the core of linear parkways, acting upon the micro-climate, and most importantly, the transportation of goods and passengers.

It is important to note that this part of the Ganges has been declared to be National Waterway No. 1, and a national waterway can work just like a national highway if it is connected with a regional and sub-regional network of waterways. Kolkata urban waterways would be a part of such network. It should also be mentioned that such waterways connected directly with the Holy Ganges may save a lot of travelling for the many people who perform their religious rituals on the bank of the Ganges.

The existing Kolkata scenario

KMD (Kolkata Metropolitan District) is well endowed with a large network of waterways – most of which are natural. The total length is approximately 1,840 kilometres. This includes 47 kilometres of excavated canals. The central spine of this network is the River Ganges. At the north end of KMD, the river used to branch into three channels with a western branch called the Saraswati and an eastern branch called the Yamuna. In the past, the Saraswati was a mighty course which met with the central stream far south near the present southern end of KMD. The eastern branch was joined by a few tributaries and joined with the Vidyadhari, which connected with the Sundarban system and provided a very popular trade route. A number of canals, both natural and man made, collectively called 'The Circular and the Eastern Canals' are still used as the main outfalls of the city – but their use as trade routes has almost ceased.

Unfortunately, both the Saraswati and the Yamuna have turned into dry channels over the years making way for agriculture and settlements in many stretches. The eastern branch, the Yamuna, can hardly be traced today at all. But there is another water course which almost follows the eastern limit of KMD known as 'Nowai khal' ('khal' meaning 'canal') This canal continues to survive and on its way south is joined by the Bagzola canal, which flows close through the new township of Rajarhat, and the Kristopur canal, which runs along the northern and eastern boundary of the new town of Bidhan Nagar. Bidhan Nagar was developed in the early 1960s by reclaiming an area of the salt lake that runs along the eastern fringes of the city. Further south there is the great wetlands which are a RAMSAR site (The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands). These wetlands support a unique eco-system with sewage-fed fisheries and agriculture. The Bhangar Khal is at the south of these wetlands. It has a healthy flow of dirty water ultimately meeting the Vidyadhari system, which is also joined by the Nowai Khal.

There is an old channel of the Ganges, which was excavated and renovated in 1777 by a British Army major, William Tolly, who collected tolls from the boats. He excavated a new branch of the old channel to meet with the Vidyadhari River, which was a very popular trade route from the Sunderbans. On the western bank, there are a number of east-west channels connecting with the Ganges. Apart from the saraswati, mentioned earlier, there is also the Kunti River flowing in a north-south direction.

It is interesting to note that the origins and development of Kolkata are intricately linked with the excavation of the canals. The first thing that the English did on purchasing three villages from the Nawab in the 18th century, was to excavate a canal along the eastern boundary to protect against possible invasions. This canal was filled up long ago to form one of the city's major arterial roads. This has also created undesirable precedents as there is a strong lobby for filling up the canals and building wide roads there to clear the stench and the squalor and to permanently solve the ongoing problem of canal maintenance. This would be similar to cutting off an artery to solve the problem of cholesterol blocking the blood circulation.

The proposed plan

The schematic plan is based on the two north-south arterial waterways, one on each bank, running close to the KMD boundary and a number of east-west canals with the River Ganges as the central spine. The proposed system effectively connects the most likely origins and destinations of freight. The Howrah, Sealdah and Chitpore Railway Stations, the Khidderpore docks, the industrial areas of Budge Budge, Howrah, Bantala, Uluberia etc. and the new development areas of Rajarhat, Kalyani, Barasat, Baruipur and Dankuni – all will be directly linked by this waterway network. The arterial roads and the railways will have several meeting points with the waterways network – a few of which can be selected to develop the multi-modal transport interchanges.

For storage of water to feed the system, it is proposed to use the horseshoe lakes of Mathura Bil and Kulia Bil on the eastern bank and a new lake still to be excavated near the Kana Damodar system on the western bank.

The entire system will involve an enormous amount of dredging and removal of silt mixed with accumulated garbage. Excavating the 1,800-kilometre-long system up to a depth of two-and-a-half metres, as well as some new excavation will involve five million cubic metres of dredging – not including the works for the development of the canal banks, the reconstruction of a number of bridges and the construction of many new bridges, lock systems and roads. The excavated earth will however, be in great demand for filling up lowland and raising levels for new townships, highways and industries. It is also a very coveted raw material for the manufacture of bricks.

The problem of the re-housing of displaced people is not discussed here as funds for housing should be used for that purpose. But it is an essential task and

the success of the entire project depends on how efficiently this could be done.

A detailed estimate of the cost of restoring Tolly's Nullah (which connects the river Hooghly with the east Kolkata wetland) was prepared by Chakraborty and Roy. Without the cost of re housing, it worked out to be approximately $9.5 million (Chakraborty and Roy 1997).This was for a stretch of just 28 kilometres. For 1,800 kilometres, taking into consideration a lower cost for rural stretches, it would have been $500 million. At today's prices, this would be in the region of $1 billion.

It is a huge cost but considering the huge benefits, the project must be implemented, because the alternative scenario is even more expensive, more detrimental to the environment and in the long run, disastrous. We must also take into consideration the huge potential of this scheme for creating employment opportunities.

Conclusion

The West Bengali Government's Department of the Environment, assisted by the United Kingdom Overseas Development Administration (ODA) published a report prepared by CEMSAP (Calcutta Environmental Management Strategy and Action plan). While the emphasis was on the environmental aspects, it observed that 'the existing canal system could, at least partly, be well utilized as Inland waterway transport and could be gainfully utilized for the cheaper transport of goods as well as passengers' (CEMSAP, 1997). The restoration of the canal has at last been taken up, partly financed by the Asian Development Bank.

The idea of using waterways in a planned manner for water supply, drainage, transport and the improvement of the environment is applicable to all emerging urban areas. Even developed countries have already revitalized the waterways and transferred a substantial part of the cargo to their waterways. Kolkata is uniquely rich in natural waterways. Water transport has traditionally been a part of the cultural and socio-economic life of the people in that part of the world. Planned development of the waterways would give the city a unique feature – a much-sought-after new dimension to its urban fabric and an eco-friendly environment in addition to all the socio- economic benefits discussed here.

7. Conclusions

In preparing this report it has become obvious that the historical benefits of inland navigation still hold good in the 21st century. The greater globalization of the world and the increasing interdependence on trade requires closer political and legal co-operation between countries especially in the field of transport and communications.

River navigation has in the past provided links between countries during war and peace, and has provided them with the means to overcome major political and cultural differences, whether in their commercial use or even nowadays in their recreational use.

It is apparent that to meet several of the Millennium Development Goals, namely to help development and to provide environmental sustainability, the use of Inland Waterborne Transport (IWT) can provide the way forward. However it does require a consensus approach to the development and improvement of navigation and it is essential that participants understand the benefits that the development of navigation can bring, not only in terms of transport but also the opportunities it brings to reduce flooding, provide reservoirs, create employment and further investment, and to either generate or regenerate development and growth so that Millennium Development Goals can be met. It should also be noted that river navigation is an in-stream or non-consumptive water use, which does not diminish the flows that are needed for other purposes.

In this day and age, the use of information technology and electronic communications can create improvements in the marking of channels, the availability of information relating to water levels and tides and the closer co-operation of all stakeholders, to provide a much higher capacity system while reducing any potential environmental impact.

Greater knowledge, and the increasing transfer of professional expertise in the field of design, management and operation means that where problems were created in the past, it is now possible to use and develop waterways in a far less environmentally intrusive manner than is the case for other forms of transport and to even undo previous environmentally damaging works.

Water is essential to the human body; it is also the life blood of trade and communication. If we are to improve the wellbeing of many people throughout the world, we must protect and conserve our water supplies. IWT must be part of the process of achieving this and of meeting the Millennium Development Goals. It can do this in a manner that is not only environmentally sustainable, but also brings many other hard and soft benefits to the associated communities and stakeholders. It can provide the stimulus to overcome economic downturns and bring diverse cultures together to achieve common benefits.

For centuries navigation has made a major difference to the improvement of life. From the recent studies contained within this report, it is evident that this is still the case.

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World Water Assessment Programme side publications, March 2009

During the consultation process for the third edition of the World Water Development Report, a general consensus emerged as to the need to make the forthcoming report more concise, while highlighting major future challenges associated with water availability in terms of quantity and quality.

This series of side publications has been developed to ensure that all issues and debates that might not benefit from sufficient coverage within the report would find space for publication.

The 17 side publications released on the occasion of the World Water Forum in Istanbul in March, 2009, in conjunction with *World Water Development Report 3: Water in a Changing World*, represent the first of what will become an ongoing series of scientific papers, insight reports and dialogue papers that will continue to provide more in-depth or focused information on water–related topics and issues.

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by Keith Kennedy, Slobodan Simonovic, Alberto Tejada-Guibert, Miguel de França Doria and José Luis Martin for UNESCO-IHP

Institutional Capacity Development in Transboundary Water Management
by Ruth Vollmer, Reza Ardakanian, Matt Hare, Jan Leentvaar, Charlotte van der Schaaf and Lars Wirkus for UNW-DPC

Global Trends in Water-Related Disasters: An Insight for Policymakers
by Yoganath Adikari and Junichi Yoshitani at the Public Works Research Institute, Tsukuba, Japan, for the International Center for Water Hazard and Risk Management (ICHARM), under the auspices of UNESCO.

Inland Waterborne Transport: Connecting Countries
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