Muhammad Rabiul Islam
Md. Mashiur Rahaman
Nastia Degiuli

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INVESTIGATION OF THE CAUSES OF MARITIME ACCIDENTS IN THE INLAND WATERWAYS OF BANGLADESH

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Review paper

Summary

Water transport is the proven cheapest and safest mode of transportation but it is the agent of catastrophe in Bangladesh. The overall scenario of Bangladesh inland water transport has been studied. The form of occurrences of maritime accidents in the inland waterways of Bangladesh may be categorized based on mode of failure. Data analysis of major accidents shows that prevention of passenger vessels' accident will drastically reduce the number of casualties in Bangladesh Inland Waterways where the two repeatedly reported causes of accidents are overloading and inclement weather. Literature review shows that analyses were carried out mostly to investigate the mechanism of capsizing due to violation of "The Inland Shipping Laws and Rules". To enlighten the roles of professionals like Naval Architects and Law Enforcing Agencies, the reasons behind the accidents in Bangladesh Inland Waterways have been simplified and the nature of actions required for preventing the accidents have been identified from practical point of view. The effect of consideration of overloading condition and higher wind pressure in design has been studied and found that it will have adverse effect on the socio-economical condition of Bangladesh. Role of proper design and construction has been identified by dividing the accidental phenomenon into two phases, capsizing and sinking of vessels.

Key words: inland waterways; maritime accidents; Bangladesh; overloading; inclement weather

1. Introduction

Bangladesh is a riverine country. The river network of Bangladesh as the most important transport artery in the country's communication sector plays a vital role in national life. Almost all big cities, towns and commercial centers of the country grew up on the banks of its rivers. Figure 1 shows the river network of Bangladesh. Until now waterways is the principal mode of transporting goods and passengers in the southern region of the country. In the rest of the country where the places are inaccessible by land transport like roads and rail, water transport acts as the gateway to communication.

Fig. 1 River network of Bangladesh

Since independence in 1971 movements of goods and passengers from the districts of the southern region of Bangladesh have increased and water transport is the only mode of transport to the capital city, Dhaka. Inter-district and intra-district movements within the southern districts of Barisal, Bhola, Patuakhali, Jhalokathi, Borguna, Pirozpur and their sub-districts are by water transport. These districts and sub-districts of southern Bangladesh are connected to the capital city, Dhaka with water transport although very few places are now accessible by all-weather road transport.

There is single decker; double-decker and triple-decker motor launches that ply on different destinations daily. Moto launches travelling to near destinations around the capital city are smaller in size and they make more than one return trip throughout the day. Large motor launches going to distant locations have specific time schedules. Also, mechanized country boats and steel bodied small-mechanized boats have dramatically changed the pattern of inland water transportation system. These boats use engines, which are normally intended for agricultural use. The numbers of such boats are unknown, but believed to be in tens of thousands. There are two types of such vessels i.e.:

a. old fashioned wooden country boats with propulsion fitted,
b. large dingy boats of simple hard chine flat bottom steel or wooden body construction.

The government has exempted these boats from the requirements of the Inland Waterways Act. There have been numerous accidents involving such vessels. Until now, Inland Maritime

Administration Authority of Bangladesh has found no means of regulating these boats and minimize accidents.

With the increase in population and the growing economy of the country, the waterways are getting congested despite the fact that the inland waterways are not expanding. Figure 2 shows the number of vessels registered for transporting various types of goods and passengers in the inland waters of Bangladesh [1]. Therefore, problems relating to maritime safety are emerging with new dimensions every day. In Bangladesh, maritime safety has become a severe issue when a number of passenger launch accidents killed several thousands of people within the past few years. In response to such emergencies, the government took minimum remedial measures. Therefore, accidents in inland waterways of Bangladesh are very common. Also, the extent of damages and losses of property are tremendously expensive which severely puts substantial amount of burden on the national economy. There yet remain numerous deficiencies on maritime safety and the scope for improvements in this aspect is a contemporary demand.

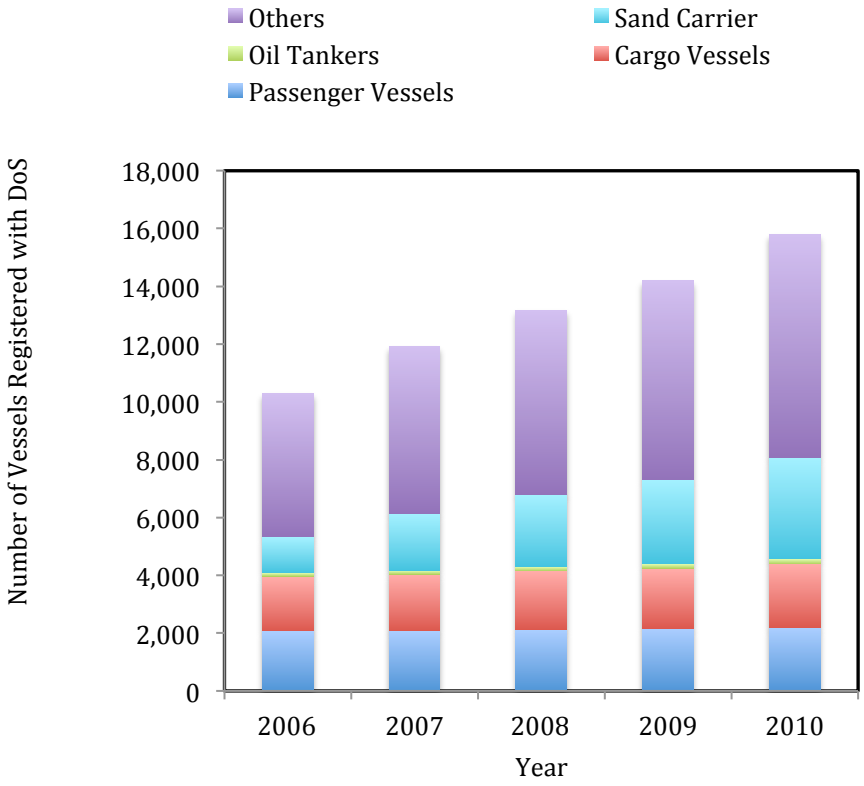

Fig. 2 Number of different types of vessels registered in Department of Shipping (DOS), Bangladesh for inland waterways.

Present investigation deals with the reasons behind the accidents particularly the passenger vessels in Inland Waterways of Bangladesh and identification of the measure that are needed for preventing the accidents.

2. Characteristics of inland waterways

Bangladesh with 24000 km waterways has a navigable network varying from 5968 km during the monsoon to 3865 km during the dry season. According to the traffic and economic importance, the inland waterways have been classified into four classes of routes [2]. In these routes various navigational aids are provided to make night-navigation possible.

Class I: Arterial/trunk routes maintain at a depth of 3.6 m throughout the year. Length of Class I route is 683 km or equivalent to only 11 per cent of the total network and links the two main seaports of Bangladesh Chittagong and Mongla and the inland ports of Dhaka, Barisal and Khulna.

Class II: Secondary routes maintain at a depth of at least 1.8 m throughout the year. This class of route comprises kilometres of secondary route or equivalent to only 17 per cent of the total river network and is kept open for passenger launches and cargo barges.

Class III: These are feeder routes of regional importance. The mean depth of the route is 90 cm, which is equivalent to 32 per cent of the total network, and having a length of 1885 km.

Class IV: Seasonal routes of less than 90 cm depth. Its total length of 2400 km is equivalent to 40 per cent of the total network.

Minimum vertical and horizontal clearance of these river routes are described in Table 1.

Table 1 Minimum vertical and horizontal clearance of Inland routes of Bangladesh

Name of Route	Minimum Vertical Clearance	Minimum Horizontal Clearance
Class- I	18.30 m	76.22 m
Class- II	12.20 m	76.22 m
Class -III	7.62 m	30.48 m
Class -IV	5.00 m	20.00 m

3. Regulatory framework of inland navigation

There are two authorities responsible for the management of water transport sector of Bangladesh:

- Department of Shipping (DOS) and
- Bangladesh Inland Water Transport Authority (BIWTA).

Department of Shipping (DOS) is responsible for:

- Administer the Merchant Shipping Ordinance 1983, and the Inland Shipping Ordinance 1976.
- Administer the national and international standards of shipping to the inland and seagoing ships through survey and inspection.
- Administer the standards for the seafarers by conducting examination and certification for various grades of examination for inland and international shipping.
- Monitor after survey conditions of the vessels and take appropriate steps to check any unlawful practices and ensure safe operation of watercraft across the country.
- Administer the Bangladesh Flag Vessels (Protection) Ordinance 1982 and the rules made there under.

As per Section 15 of the Ordinance E. P. Ordinance No. LXXV of 1958; amendment Ordinance No. LV of 1977, the Bangladesh Inland Water Transport Authority (BIWTA) performs the following principal statutory functions of development, maintenance and

regulatory nature:

- Carry out river conservancy works including river training works for navigational purposes and for provision of aids to navigation including marks, buoys, lights and semaphore signals.
- Disseminate navigational and meteorological information including publication of river charts.
- Provided pilotage and hydrographic survey services.
- Draw up programmers of dredging requirements and priorities for efficient maintenance of existing navigable waterways and for resuscitation of dead or dying rivers, channels, or canals, including development of new channels and canals for navigation.
- Fixation of maximum and minimum fares and freight rates for Inland Water Transport on behalf of the Government.
- Approve timetables for passenger launch services.
- Act as the Competent Authority of Bangladesh for the protocol on Inland Water Transit and Trade, looking after the use of waterways of Bangladesh on behalf of the Govt. of Bangladesh for the purpose of trade and transit between Bangladesh and India as provided in the Protocol.

4. Accidents in inland water ways

In present study, accidents data are collected from various sources such as Daily Newspapers, reports of Department of Shipping (DOS) and Bangladesh Inland Water Transport Authority (BIWTA). Statistics of death toll in waterways shows a large number of fishermen die each year due to sailing in bad weather. That toll has also been excluded from the data presented in year-to-year comparison plot.

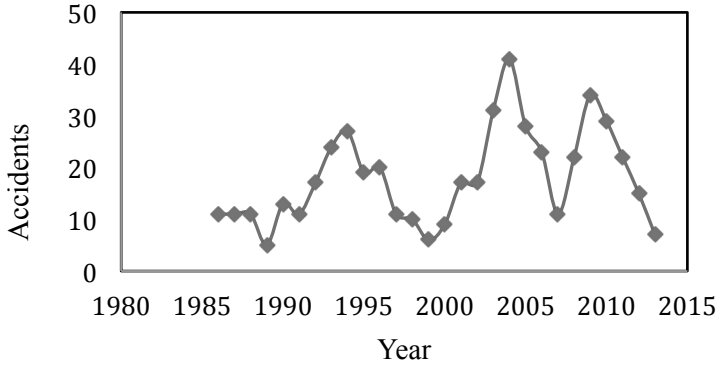

Fig. 3 Year wise inland maritime accidents in Bangladesh [3]

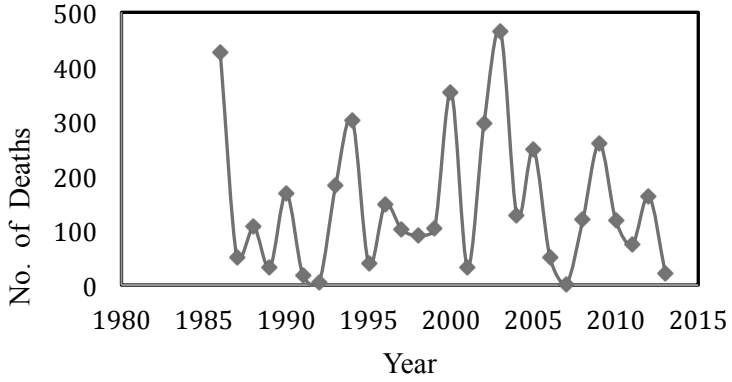

Fig. 4 Year wise death tolls due to inland maritime accidents in Bangladesh [3]

In Figures 3 and 4, the column height is comparatively greater in the year of 1986, 1994, 2000, 2002, 2003, 2005 and 2009. The reasons behind the relatively higher death number in those four years are the major accidents shown in Table 2. Here accident level has been defined on the basis of no. of death toll. Table 2 shows that the types of all the vessels suffered the major accidents are passenger carriers.

In year 2014, two serious passenger vessels named M.L. Pinak-6 and M.V. Miraz-4sank in the inland waterways of Bangladesh, which causes death tolls of 47 and 56 passengers respectively.

Table 2 Accident data of the year 1986, 1994, 2000, 2002, 2003, 2005 and 2009

Year	Total death	Vessel (Type)	Reported Cause
1986	426	--	--
1994	303	M.V. Dinar – 2 (passenger)	Turbulence water & over loading
2000	353	M.V. Salauddin -2 (passenger)	Northwester
2002	297	--	--
2003	464	M.V. Mitali-3 (passenger)	Northwester
		M.V. Nasrin-1 (passenger)	Turbulence water & over loading
2005	248	M.V. Moharaj (passenger)	Northwester
2009	260	--	--

After every launch accident, which often takes a heavy toll of human life, the government immediately exhibits promptness, forming multiple high-level probe committees, promising punishment for the responsible persons behind the accident. It has been reported that over the last four decades more than 800 investigation committees have been formed to investigate over 500 inland waterway incidents. But no probe committee comes with the exact reasons behind the accidents. It is because of:

- Inclusion of official or officials from Department of Shipping (DoS), government regulatory body for registration of inland waterways crafts or, Bangladesh Inland Water Transport Authority (BIWTA), government regulatory body for maintenance of inland waterways who are involved in a vessel's registration or, survey and fitness checking or, inspecting the launch before the journey at the ghat, was included as a member in the investigation committee of that particular vessel's incident.
- Non-inclusion of experts particularly in the field of naval architecture; as a result the engineering or, technical elements behind any launch accident always remain out of focus.

Therefore, it is reasonable to emphasize on accidents of passenger vessels, as prevention of these accidents will drastically reduce the number of casualties in Bangladesh inland waterways accidents.

5. Analysis of causes of accidents

For simplifying the causes of accidents in the inland waterways of Bangladesh, the most common form of occurrences are divided into two groups based on the mode of failure as structural failure and stability failure as shown in Figure 5.

When accident occurs due to collision, grounding or fatigue, structure of vessel fails and when accident occurs due to overloading or inclement weather, vessel loses its stability in some manner. Structural failure always leads to stability failure, but stability may fail without the failure of structure.

Fig. 5 Mode of failure and form of occurrence of accidents in waterways

Accidents may occur with different combinations of all the form of occurrences. The most common combined form in Bangladesh is overloading with inclement weather as shown in Figure 6. After accomplishing some voyage, it cannot be said that accident has occurred due to only faulty design or construction. Faulty design or construction acts as catalyst of accidents increasing the level of catastrophe.

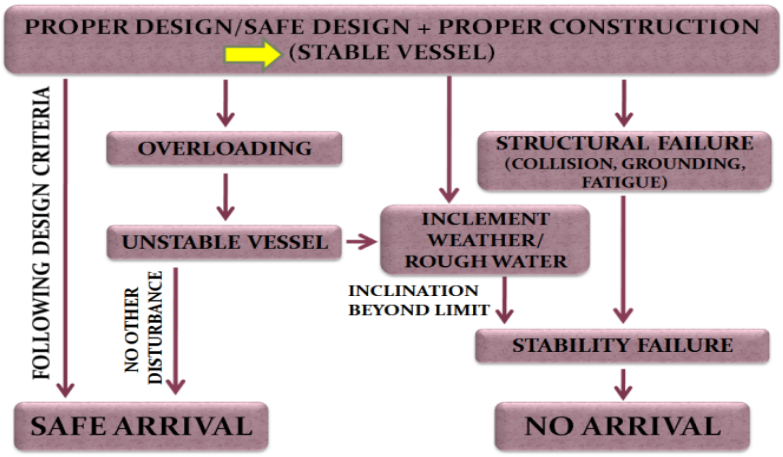

Fig. 6 Combination of form of occurrences

In Bangladesh, most of the time passenger vessels ply with overloading which makes them unstable. If they do not suffer any disturbance they can finish voyage safely and no one cares about that. It is rare that overloading in single form acts as the cause of accidents. Commonly storm, strong current, water turbulence combines with overloading. On the other hand inclement weather can act as a single form of occurrence of accidents.

Analysis of accident data indicates two major repeatedly reported causes of accidents in Bangladesh inland waterways mostly in combined form namely overloading and inclement weather.

5.1 Overloading

A safe design constructs a stable vessel. But in overloading condition, vessel does not remain safe making the vessel unstable. If an unstable vessel inclines up to a certain angle (flooding angle), it will not be able to return to its upright condition rather it will incline more resulting loss of stability and finally it will capsize. On the other hand, if inclination does not take place it may finish its voyage. That is why in all the cases of overloading, accidents do not take places. Inclination up to the flooding angle indicates presence of another form of occurrence like inclement weather or water turbulence.

In designing any vessel, usually four loading conditions are considered and it is to be confirmed that the vessel satisfies all the stability criteria at those conditions, namely:

1) Full Load Departure Condition,
2) Full Load Arrival Condition,
3) Departure Condition without Load,
4) Arrival Condition without Load.

Investigating the mechanism of capsizing due to overloading, Iqbal et. al. [5] proposed to consider the departure and arrival conditions for some level of overloading in addition with the stated four conditions. Consideration of overloading condition in design means keeping a margin of safety up to a certain limit. In case of the existing traditional design of Bangladesh inland passenger vessels, the ratio of lateral area above the load water line (exposed to wind) to the underwater part is large and the down flooding angle is less due to opening of engine room. Due to this, the stability criteria are satisfied minimally i.e., there remains no margin for safety.

In this circumstances, if for instance 150% loading condition is to considered, in design 100% loading condition in which the stability criteria is satisfied marginally will simply converge to 150% loading condition and the previous 67% (more or less) loading will then be considered as 100% loading condition. So it is rational to say that the practical impact of considering overloading condition up to any level in design it will be: "*If all other parameter remains unchanged, declaration of the passenger capacity in registration certificate will be decreased by some amount depending on how much overloading has been considered in design and due to less amount of passenger capacity declaration, the vessel owners legal earning will decrease all through the year"*. On the other hand overloading has no relation with capacity declaration or the registration certificate. In fact overloading is not a problem to solve; it is a matter to prevent – by any means, at any cost. As per Iqbal et al [6] "Overloading is not a pure Naval Architecture problem".

5.2 Inclement Weather

In case of inclement weather, strong wind creates pressure on lateral area of superstructure or lateral area of the vessel exposed to weather, which tends to incline the vessel in Figure 8. For inclining, the vessel has to overcome the resistance of water exerted on the underwater volume. Strong current due to inclement weather tends to roll the ship. It is clear that ratio of underwater volume to lateral area of superstructure plays a vital role in the stability of passenger vessels. That is why less superstructure and large underwater volume makes the sand carriers highly stable in full load condition as wind gets very less area to

create pressure and on contrary the water resistance against the inclination of vessel is very high.

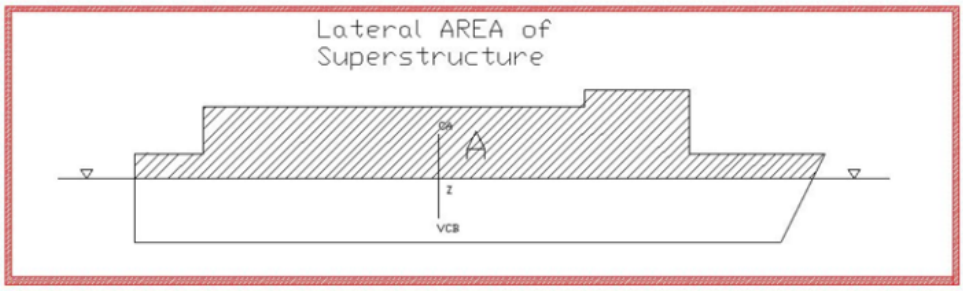

Fig. 8 Lateral area of superstructure

Equating the moment due to wind pressure and moment due to water resistance, a lever has been defined as wind lever. Passenger Vessels Stability under Wind Pressure largely depends on this wind lever:

$$\text{The Wind Lever } lw_1 = \frac{PAZ}{D}$$

where:

P - wind Pressure that determines the vessels limit of sustainability under strong wind.
A - lateral area of superstructure,

Z - distance between vertical center of buoyancy and centroid of the lateral area,

D - displacement.

As per Weather Criterion of the Inland Shipping Stability Rules, 2001 of Bangladesh [4], maximum allowable/permissible wind pressure is equal to 0.0322 t/m^2.

Designers' requirement is to keep the value of wind lever as low as possible. As per The Inland Shipping Stability Rules, 2001 passenger vessels are not permitted to ply at a wind speed more than 10 m/s and on the basis of this wind speed the wind pressure has been defined as 0.0322 t/m^2. Several Accidents have been occurred due to inclement weather when the wind pressure was more than the defined value (0.0322 t/m^2). Greater wind pressure at the time of accident means greater wind speed at which the vessel was not supposed to sail. Preventing vessels from sailing at a wind speed greater than the design wind speed is not a pure Naval Architecture problem.

Iqbal et al [4] has proposed to consider greater wind pressure in design so that a vessel can sustain when that higher pressure will be created by the stormy wind. Statistical analysis shows, passenger vessels of length around 40 m suffered accidents due to Inclement Weather/Northwester. For accommodating (for ensuring the same level of stability) higher wind pressure (P) in design of passenger vessels having specific length in order to ensure sustainability at the higher wind pressure a designer can increase displacement by increasing breadth**.** As for example ferry for vehicle transportation usually has a larger breadth, which makes it highly stable. If breadth of a vessel increases, water resistance also increases, which in turn increases fuel consumption along with the necessity of twin screw that is double engine. Naturally vessel owners always try to avoid this situation.

Another way of increasing the displacement of a vessel is to increase draught. But this dimension cannot be increased due to shallow water depth in the river routes.

The only way left for accommodating higher wind pressure to a designer that is to a naval architect is to decrease volume of superstructure which will decrease the value of A and Z in the equation of wind lever. The passenger vessel owners always have a tendency to modify their vessels by increasing the superstructure volume whether the design permits or not. That is, their tendency is to make their vessel more economical. The reason behind is either design criteria (wind pressure of 0.0322 t/m^2) is such that it does not produce economical vessel from the owners point of view or the profit the vessel owners want to make is undue profit.

On the other hand, the greater wind pressure is the criteria of extreme case and all the vessels will not suffer that pressure very frequently.

The passenger vessel owners can be offered only two available options:

- keeping superstructure volume less,
- stop doing business in stormy weather.

If the first one is applied in design, the owners earning will reduce all through the year whether the vessel faces any stormy weather or not. So there is a high possibility that the vessel owners will choose the second option.

For that obviously they have to know the weather forecast well before the incident and there must be some authority to ensure that the vessel owners are doing what they are saying. Reducing the superstructure volume and rescheduling passengers fare accordingly may not be a feasible solution considering the socio economic condition of mass people.

So the only feasible solution for preventing accidents in stormy weather is that the passenger vessels, which were designed based on the weather criterion of The Inland Shipping Stability Rules, 2001 must have to be stopped from sailing at a wind speed more than 10 m/s.

5.3 Role of proper design and construction

For a clear understanding of the role of proper design and construction, an accidental phenomenon can be divided into two phases:

- Phase- I: Capsizing,
- Phase- II: Sinking.

A vessel, which is properly constructed based on, a proper design may capsize if design criteria are not followed. On the other hand, prevention of capsizing of vessels will automatically prevent the sinking of vessels.

When a vessel is capsized due to accident, it is the design and construction, which is solely responsible for sinking or quick sinking of the vessel. The role of proper design and construction is to save the lives of ill-fated passengers by at least delaying the sinking of the vessel. Without the ease of access, only provision of sufficient lifesaving appliances in design and construction cannot ensure the survival of passengers till the moment of the arrival of rescue party. Not only a proper design but also an improved design is required for preventing the sinking of capsized vessels. Research in this area is yet to be done.

6. Conclusions and recommendations

Prevention of passenger vessels' accident will drastically reduce the number of casualties in Bangladesh Inland Waterways. Accidental causes should be analyzed from two different viewpoints, causes of capsizing and causes of sinking. Following the design criteria

strictly can prevent capsizing of vessels, which will automatically prevent the sinking of vessels. For preventing sinking of a capsized vessel not only proper designs but also improved designs are essential. It is the "Law Enforcing Agencies" who can stop the periodical accidents in Bangladesh waterways at once by preventing the violation of "The Inland Shipping Laws and Rules".

As safe design does not remain safe if design conditions are not followed, only two recommendations can be made for preventing the capsizing of vessels in accidents:

a) Prevention of overloading is the only practical solution other than consideration of overloading in design;
b) Prevention of sailing in inclement weather (more than 10 m/s wind speed as per present law of Bangladesh Inland Shipping) is the feasible solution other than consideration of inclement weather in design due to socio-economical aspect.

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Muhammad Rabiul Islam
Naval Architecture & Marine Engineering Department
Military Institute of Science and Technology
Dhaka, Bangladesh

Md. Mashiur Rahaman
Department of Naval Architecture & Marine Engineering
Bangladesh University of Engineering & Technology
Dhaka-1000, Bangladesh
mashiurrahaman@name.buet.ac.bd

Nastia Degiuli
Faculty of Mechanical Engineering and Naval Architecture
University of Zagreb
Ivana Lucica 5, 10000 Zagreb
Croatia