The Prospects of Dredging and Indigenization of Dredger Design

Eswara Arun Kishore *, **and Ramesh US** *

*Indian Maritime University, Visakhapatnam, India

Submitted to Dredge India INAvation 2015 conference at Mumbai, India

The scope for dredging in India is potentially vast, looking at the prospects of development and maintenance of existing major ports, building new ports, offshore resources exploration, demand from navy and more interestingly the projects envisaged for national waterways. The capital dredging demand during 2012-2017 is about 639 million m^3 and that of maintenance dredging during the same period is about 521 million m^3. This requires the employment of substantial number of dredgers of varying capacities. The minor sector dredging demand of about 100 million m^3, during the said period, offers additional opportunity for dredging. The modal shift of cargo to inland and coastal waterways offers bright prospects for a sustainable economic prosperity. The government encouragement for "Make in India" has brought in a lot of economic interest as well. This is an excellent period to target for indigenization of dredger manufacture. Locally manufactured dredgers not only reduce costs of dredging but also encourage business climate. Further, it will enable India to produce globally competitive world class dredgers. The present paper is written in this context of presenting our study[1] encompassing the scope for dredging activity, identifying suitable types and capacities of dredgers for employment in India. The paper also touches upon the present shipbuilding infrastructure, dredger equipment manufacturers and a road map for indigenization. The paper concludes with forecasting future dredging demands, scope for native dredgers manufacture, identifying a particular target range for indigenization.

Keywords: India | Dredging demand | Indigenization | Dredger design

Abbreviations: GBS, Gross Budgetary Shortfall; IEBR, Internal and Extra Budgetary Resources; MEIS, Merchandise Exports from India Scheme; SEIS, Service Exports from India Scheme; CAG, Comptroller and Auditor General of India; TSHD, Trailing Suction Hopper Dredger; CSD, Cutter Suction Dredger; HSD, Hydraulic Suction Dredger; FTP, Foreign Trade Policy; IRNSS, Indian Regional Navigation Satellite System; HSL, Hindustan Shipyard Limited; MDL, Mazagaon Dock Limited; HDPEL, Hooghly Dock and Port Engineering Limited; GRSE, Garden Reach Shipbuilders and Engineers; SRU, Ship Repair Unit

Introduction

Dredging industry in India is picking up with a lot of positive forecasts in demand for dredging. The new Foreign Trade Policy 2015 - 2020 by the Govt. of India sets out MEIS and SEIS incentives to encourage export of manufactured goods and services from India. Among the listed businesses, maritime industry can also claim the rewards of 5% of FOB or foreign exchange realized by way of leasing assets, undertaking foreign projects or by selling ships and equipment made in India. Businesses can also gain privileged status (star rating) and get facilitated for their trade transactions in order to reduce their transaction costs and time.

The dredging demands are estimated by the individual ports and are sent as proposals to the planning commission. New port establishment proposals can be taken up by central or the state governments. Planning commission analyzes these inputs and allocates funds in phases during each financial year. The planned proposals cover dredging to maintain the drafts at the ports, referred to as maintenance dredging and dredging proposals to enhance cargo turnovers, by way of creating additional berths or deepening the ports to accommodate larger vessels, referred to as capital dredging. However, the targets achieved fall significantly below the projected demand. This is mainly due to the delay or failure in implementation stage, financial and environmental constraints, lack of engineering studies to assess the quantum and type of dredging to be performed, and poor response from bidders to undertake the work.

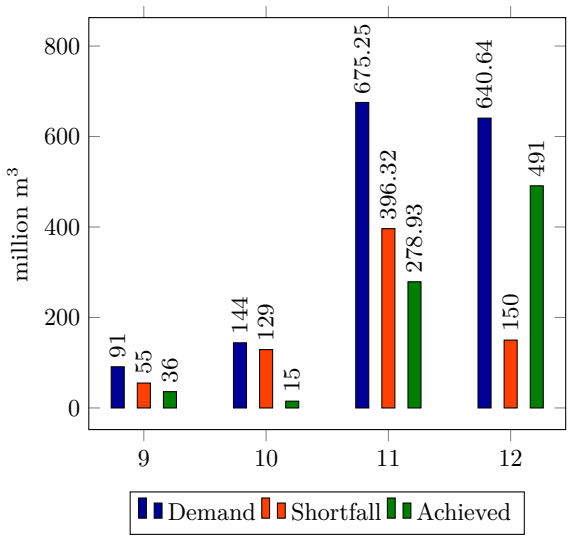

Fig. 1. Capital Dredging Scenario from $9^{th} \sim 12^{th}$ Five year plan

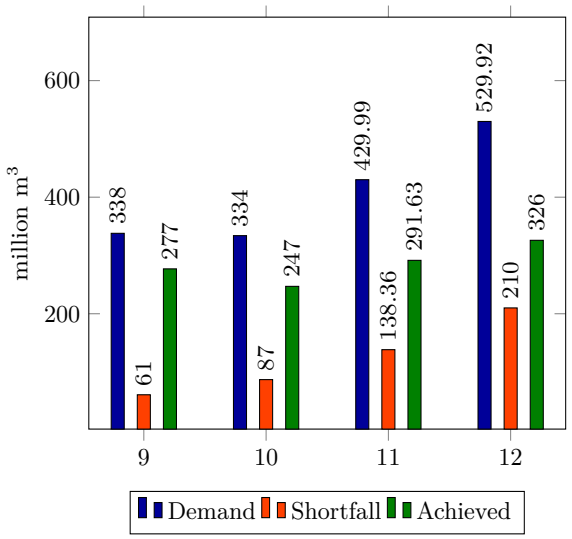

Fig. 2. Maintenance Dredging Scenario $9^{th} \sim 12^{th}$ Five year plan

[1] Ministry of Shipping, Govt. of India has funded the study project at IMU - Visakhapatnam to develop indigenous designs for dredgers manufacture.

The graphs in Figs.1 and 2 show the data for capital dredging and maintenance dredging activities for the period of 1997 to 2017 [IIR [2]] and [Planning Commision [5]]. The difference in the demand and achieved output is shown as the shortfall in dredging. It should be noted that the achieved targets will increase for the 12^{th} year plan upto the end of its period.

Predicting a practical dredger demand involves some data analysis. Table 1 shows the share of various reasons estimated in percentage of forecasted demand leading to the shortfall. The under performance refers to a poor performance of a dredging contract covering various aspects such as performance of the equipment, personnel involved and project planning. CAG has pointed out that some dredging contracts have lessened the penalty clause and that has resulted in a complacent attitude of the contractor. Over estimation in the maintenance dredging refers to the situation where a port operational requirement is met, after attaining a part of the production estimated for the dredging project. But, this aspect was contradicted in a report [CAG [1]], which said that most of the Indian ports have failed to maintain their designed operational drafts and in some instances, the drafts in the entrance channel fell below the available draft at the berth. Inspite of the various deficiencies, the dredging industry has attained a parabolic growth over the period 1997 - 2015 as indicated by the green bars in the Figs.1 and 2. From the past data between 2000 to 2015, using regression, total achieved quantities (capital + maintenance) can be predicted by equation 1 and its growth rate is found to be decreasing according to equation 2.

$$\text{achieved}_{\mathbf{total}} = -34.23 \times \mathrm{t}^2 + 411.2 \times \mathrm{t} - 114.97 \qquad [\mathbf{1}]$$

$$\text{growth rate}_{\mathbf{achieved}} = -68.46 \times \mathrm{t} + 411.2 \qquad [\mathbf{2}]$$

Where, the time step *'t'* can be approximated to a step function, whose value is

$\mathbf{t} = 1$ between 2000 to 2005
$\mathbf{t} = 2$ between 2005 to 2010
$\mathbf{t} = 3$ between 2010 to 2015

The achieved quantities present a more realistic dredging demand in India. The inland water transportation projects planned for NW4 and NW5 have also increased demand for capital dredging. The work on NW4 is scheduled to begin soon and has a projected dredging requirement of 12.8 million m^3 and is estimated to cost about 200 ₹/m^3 [Wapcos [7]]. NW5 development plan has a requirement of 54.84 million m^3 of capital dredging [nrsc isro [4]]. The increasing demand has attracted foreign players into Indian markets and in some cases Indian contractors have leased foreign dredgers exploiting bilateral trade agreements to cut down royalty expenses[2]. These provisions negate scope for indigenization of dredgers and equipment.

Table 1. Shortfall in dredging and causes, Years 2007-2012

Reason	Shortfall (% demand)
Capital Dredging	
Lack of Funds (GBS/IEBR)	6.8
Under performance	4.5
Disputes	8.4
Project approval delays	9.7
Unknown	31.7
Maintenance Dredging	
Under performance	13.2
Disputes	4.4
Failed project	3.2
Over estimation	9.8
Unknown	6.1

Dredging Projects

Dredging is an important activity for the development of port facilities that boosts maritime industry. Dredgers are a specialized earth moving equipment that work in water and rely on two basic principles for excavation - namely dislodge the sea bed material and discharge the turbid waters or employ devices to dig into and grab sea bed material. The former are usually referred to as hydraulic dredgers and the later as mechanical dredgers. Suitability of a dredger in a project mainly depends on soil types, distance to discharge area, drafts available, dimensional restrictions, environmental constraints, traffic among others. Each of the types of dredgers have their own advantages and disadvantages. But, often only one or two dredgers are a best fit for a project.

Indian ports fund their own dredging demand that results in high port charges for ships, with the exception of Kolkata port which is funded by the central government. The costs of dredging are usually quantified in terms of ₹/m^3 of dredge spoil. For example, in the year 2010, the dredging contract executed in Visakhapatnam is priced at 161 ₹/m^3, Cochin is priced at 135 ₹/m^3 and Mumbai is about 250 ₹/m^3. It is important to note that the quantity (mass) of the dredged material depends on the density of the dredge spoil that is discharged by a centrifugal pump in hydraulic dredgers or by buckets or grabs in mechanical dredgers. It is usual to have 20% solids and 80% water by volume in the discharges from hydraulic dredgers; mechanical dredgers can achieve production upto 60% solids. The fuel costs depend on the mass transport and profits can be maximized by a close control on the precision of the excavation and density of spoil transported. The costs involved in a dredging project are complex to analyze and usually, no two dredging projects can be compared. It is well known that rock dredging is quite expensive than a fine sand dredging. There are three main dredging contracts followed in India namely, unit rated, daily rated and daily rated with depth guaranteed clauses. Dredging project costs can be summarized as:

1. Mobilization costs - These are specified as a fixed lumpsum in dredging projects and cover the costs involved in the mobilizing of men, materials and equipment to the project site. The rule of thumb is that lower the dredge volumes, the higher is the cost per m^3.

Table 2. % Share of components in total expenses in a Indian dredging scenario

Component	% Share
Wages	17
Repairs & Maintenance	9
Fuels & Lubricants	54
Spares & Stores	8
Other expenditure	12

[2] Madras High Court in 2014 ruled that the money received as hire (bareboat) by the foreign company by way of leasing dredger and equipment was governed by the provisions of Double Taxation Avoidance Agreement (tax treaty) between India and other countries such as between Netherlands and India or Singapore and India etc,. Such income is not taxable in India.

© Institution of Naval Architects, India

2. Daily costs - The costs that cover wages, fuel, lubes, maintenance, repair, overhead and any lease or interests payable for hired equipment or services and capital.
3. Day's estimated dredge production - When the dredge production is more, the unit costs work out less i.e. Daily cost/Dredge production during the day.
4. Production variation - The variation in the estimated production and the actual dredged quantity.
5. Any rework costs - Example of a rework includes interruption of the dredging activity by a storm or a flood, resulting in sediment deposition in the dredged areas and that requires a rework.
6. Delays - Due to various permits and procedures such as customs clearance for a certain equipment being imported. Other examples include underperformance of men and equipment, acts of God etc.,
7. Equipment damage - Machinery or the pipe lines are prone to damage due to the nature of operation or a human error.
8. Third party claims - Hindrance to traffic or damage to habitat and environment, damage of third party assets.
9. De-mobilizing costs - The costs involved in arranging for transportation of men, materials and equipment from the project site after completion of the works. These costs are specified as a lumpsum in a dredge project and are around 50% of the mobilizing costs.
10. In India, dredge contracts specify that the mobilizing and de-mobilizing costs should be within 15% of the total project costs.

Table 2 lists the % share of various components in the total expenses. A profit of about 22% of the total earnings can be realized in the current market conditions.

The objective of dredging is to achieve and maintain a certain draft at the ports. But, the survey quantifies the volume of the sea bed to be excavated to attain the required draft. Hence a lot of care must be exercised during the planning stage of the project by a thorough hydrographic survey, to meet the objective. The exact quantities and type of soils are determined during the phase and forms the basis for selection of dredger(s) for the project. A capital dredge survey is often more elaborate than maintenance dredging, as dredge companies are aware of the data from previous contracts. The charges for the surveys are worked out per m^2 of the survey area and are contracted to specialized agencies, which is likely to be around ₹0.05 $\sim$ ₹0.10 per m^2.

Indian standard IS:4651 (Part V) - 1980 - Code for practice for planning and design of ports and harbors - layout and functional requirements offers valuable guidance to dredging projects in India. Other useful references in this regard are the naval facilities engineering command design manual DM26.1 and technical guidance to dredge depth criteria code 15C issued in 1997 and British standards BS 6349-5:1991 Part 5: Code of practice for dredging and land reclamation.

Table 3. Recommended work days estimation for Indian dredgers, Planning commission

Age of Dredgers	No. of working days
0 - 5 years	300
5 - 10 years	280
10 - 15 years	270
15 - 20 years	265
20 + years	260

Fleet utilization and Productivity

The productivity of a dredger can be calculated using the equipment specific data, rate of discharge or excavation and location specific inputs. For a large fleet of dredgers often, a utilization factor is defined as a percentage of the total work days or total capacity feasible to achieve to estimate the fleet efficiency. The Indian dredger pool has a mix of some new and very old dredgers with varying degrees of issues. They are specialized equipment that work in arduous conditions with high degrees of wear, corrosion and damage. A dredger cannot be available for all the days in a year and a yard stick to determine their availability is recommended by planning commission based on its age. It is illustrated in Table 3. Barring few exceptions, large companies are able to achieve above 80% days or upto 90% capacity utilization.

Client's requirements

Indian ports periodically outsource a large share of their maintenance and complete capital dredging requirements to contractors, selected on a few parameters or least quote by a

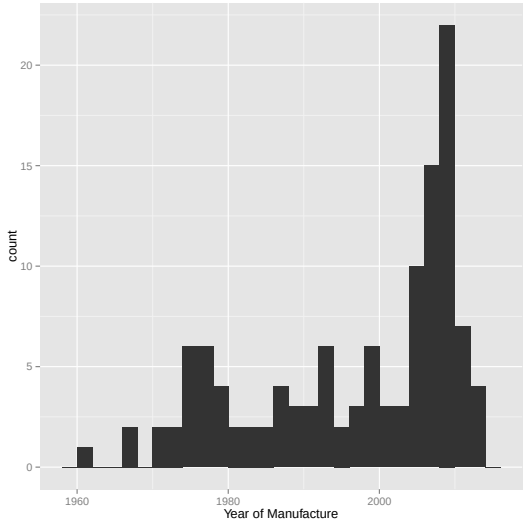

Fig. 3. Histogram of Indian Dredger fleet by year of manufacture

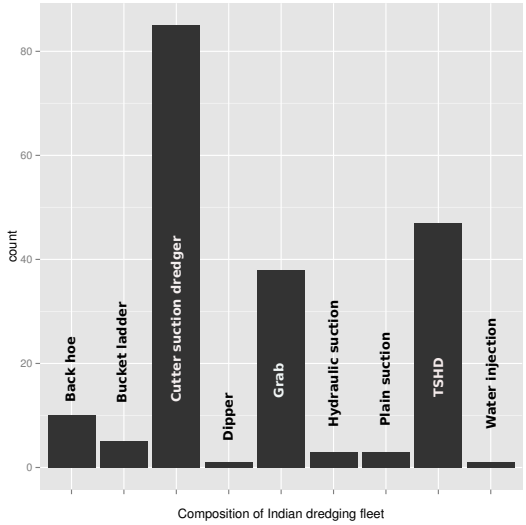

Fig. 4. Histogram of Indian Dredger fleet by type

open tendering process. Indian ports have a small capacity of dredging crafts totaling about 29.73 million m^3 in 2012. Capital dredging at a few locations such as Visakhapatnam and Dahej required rock dredging with a Back hoe dredger or employing other suitable methods such as use of explosives and a CSD. The ports usually specify -

1. A minimum averaged previous three year turn over, which is usually around 30% $\sim$ 35% of the total worth of the tender.
2. The type and capacity of dredger(s) required. For most of the maintenance dredging contracts analyzed, ports have specified a TSHD requirement exceeding 3000 m^3 hopper capacity. It is observed that this capacity falls in between 20% $\sim$ 30% of the estimated averaged dredge volume per day.
3. A relevant and sufficient experience in carrying out the activity. The bidder is expected to have carried out a minimum specified dredging in the last seven years either in a large single contract or in two or three smaller contracts. The ports seem to be following a thumb rule of 30%, 20%, 15% or 60%, 40%, 30% or a 80%, 50%, 40% of the estimated tender cost for these requirements.
4. Expected time frame for the completion of the works.

It is found that for most of these open tenders, a startup company may not have the financials or the capacity specified. However, there is a possibility that a few companies together can qualify as a consortium. A new player is at a definite disadvantage and has to render services to a mature contractor, who will lead the consortium.

Indian dredger fleet

A summary of Indian dreger fleet is illustrated using histograms [R Core Team [6]] in Figs.3 and 4. The two most popular types namely CSD and TSHD are summarized in Figs.5 and 6. These figures convey vital information about the most available dredgers and their capacities.

Indian shipyards

Indian shipyards are capable of handling vessels upto 250m in length. Table.4 lists out the various shipyards and their dredger construction experience. DGS of India exercises control on the ship repair yards in India by way of registration and licensing as a SRU. Only approved SRUs are entitled to avail custom duty and other concessions for undertaking ship repairs. Currently there are 35 SRUs of which, 7 SRUs are given permanent approvals. Other SRUs are approved for a limited period.

The shipbuilding yards have to compete with global competition and require governmental subsidy to sustain. Presently, shipyards have to pay various duties, taxes and levies amounting to 37.6% increase in ship production costs [Planning Commision [5]]. It is proposed to declare all the existing shipyards as SEZs and bring in fiscal and administrative reforms into the sector in the current five year plan.

Tebma shipyard has delivered a new grab hopper dredger of 300 m^3 hopper size, to the Indian navy with 90% of made in India products in May 2015. The parts that were imported include reverse reduction gear box, oily bilge separator, hydraulic and sea water pipe fittings and all navigational electronic equipment such as radar, echo sounder, compass, speed log, AIS etc.,.

Table 4. Indian shipyard's dredger building experience

Shipyard	Dredgers built (No.s)
HSL	Grab (2)
GRSE	TSHD (3)
MDL	TSHD (1) and CSD (6)
HDPEL	HSD (3)
Chowgule	Grab (2)
Tebma	CSD (17) and Grab (1)

Conclusions

Fig.3 and the growth rate shown in Eq.2 points towards a missed opportunity for indigenization of dredger manufacture. The best time to target would have been in the mid 1990's as more dredgers were added to the Indian fleet after the year 2000. Even so, it is now strongly suggested to augment the process of indigenization of dredgers and equipment.

It is often wise to consider to replicate established designs and those that have more takers in maritime industry, where the financial compulsions hold the ship builders against new adventures. The present Indian market scenario is illustrated

Table 5. Statistical summary of the Indian dredger fleet (all types)

Statistic	Units	Mean	St. Dev.	Min	Max
Dredge depth	m	18.70	6.85	6.0	41.0
Hopper	m^3	1416	2443	200	9248
Draft	m	3.49	2.32	0.70	9.21
Year		1996	13.7	1961	2013
Pump power	kW	1537	1146	138	5200
Cutter power	kW	424	534	33.0	2940
Suction Dia	m	0.6	0.2	0.30	1.0
Delivery Dia	m	0.6	0.2	0.30	1.0

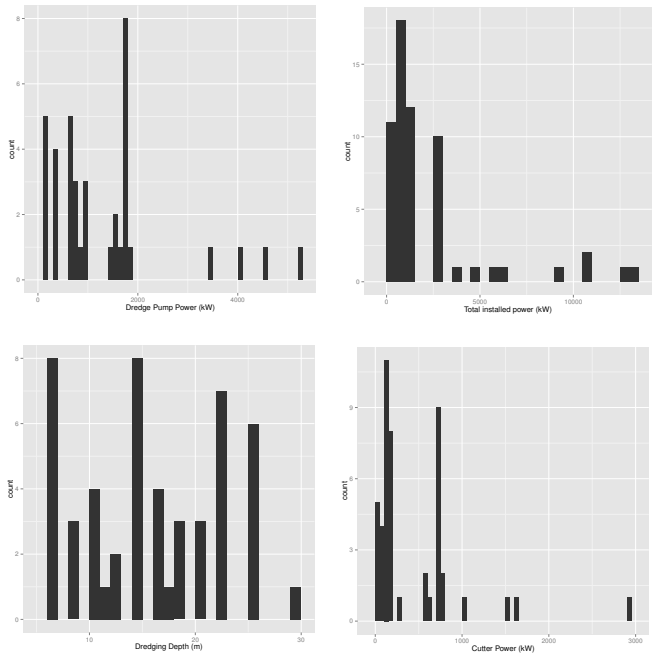

Fig. 5. Snapshot of Indian CSD fleet

© Institution of Naval Architects, India

from a statistical view point as shown in Figs.3, 4, 5 and 6. Table 5 summarizes the key statistics [Marek [3]]. The Indian industry can work towards achieving completely made in India dredgers. Our suggestions are enumerated here.

1. CSD,TSHD and Grab together form 88% of the dredger fleet in India. Tebma shipyard has constructed a grab hopper dredger using upto 90% of Indian made products. Grab dredgers can be built in India but, key powering, navigational and automation components have to be made in India.
2. Some of the components in a CSD and TSHD are made in India, like dredge pump and cutter teeth. However, most of the hydraulic system components and high voltage electrical machinery and systems are either made by foreign companies in India or directly procured from overseas markets.
3. Indian firms should target producing the spares and systems to the existing fleet. Manufacturers can initially target the most common dredger types to begin with, in association with the shipyards.
4. Indian shipyards should provide ship repair facilities and compete with the nearest neighbours. They can also earn the FTP incentives as offered under the new policy to encourage export of services i.e. they should undertake repairs of foreign ships.
5. Indian research facilities should develop key control equipment like the swell compensators, drag head and dredging monitoring equipment to name a few components. The metallurgy for these components should also be identified and enhanced based on cost benefit analysis. The manufacturing industry should accommodate and encourage Indian research.
6. The Indian IT industry should develop and build advanced monitoring systems for dredging operations.
7. ISRO has developed a geospatial portal that can benefit dredging projects in the planning stage - `http://bhuvan.nrsc.gov.in/bhuvan_links.php`. ISRO is likely to start the IRNSS services in a year and has released a "interface control document" to the public to enable development of products for precise position fixing and related services. It is strongly suggested for the maritime industry to develop navigational, survey and monitoring equipment for the dredging operations and migrate from GPS to IRNSS based devices. The document can be downloaded from `http://irnss.isro.gov.in/`.

ACKNOWLEDGMENTS. Thanks to Ministry of Shipping, Govt. of India for funding the study, Mr. Kalluru Mallikarjun for data collection. Professor RP Gokarn (a visiting faculty at IMU - Visakhapatnam) for his encouragement and support. Professor S.C Misra (Ex-Director IMU-Visakhapatnam) who is instrumental in initiating the study project at SMDR (School of Maritime Design & Research, IMU-Visakhapatnam). Thanks to the opensource community for providing high quality packages that are used in creating this paper, especially - pnas.org, R (statistical programming language), LaTeX,TiKZ & pgf and Inkscape. We thank Fedora-Linux and Trisquel-GNULinux for making the software platforms freely available to us.

References

1. CAG (2009-2010). Civil performance audits report no.3 of 2009-10 - marine operations. Report No.3 chapter no.2(http://www.saiindia.gov.in):16.
2. IIR (2013). *Dredging in India - Sector Analysis, Project Profiles and Market Outlook*. India Infrastructure Publishing Pvt. Ltd., B-17, Qutab Institutional Area, New Delhi-110016.
3. Marek, H. (2014). stargazer: Latex code and ascii text for well-formatted regression and summary statistics tables. *R package version 5.1.*, (http://CRAN.R-project.org/package=stargazer).
4. nrsc isro (2008). National waterways-4. (http://india-wris.nrsc.gov.in).
5. Planning Commision (2009-2015). *Report of the working group - port sector*. Planning commission, Govt. of India, Yojana Bhawan, Sansad Marg, New Delhi - 110001.
6. R Core Team (2015). *R: A Language and Environment for Statistical Computing*. Vienna, Austria.
7. Wapcos (Dec-2014). Development of waterway stretch between pedaganjam to ennore south of north buckingham canal in national waterway - 4. Project feasibility report(http://www.environmentclearance.nic.in):29.

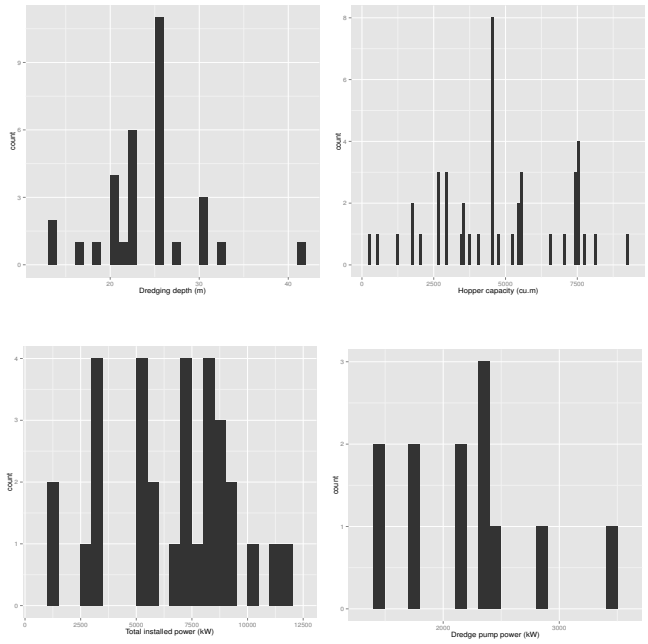

Fig. 6. Snapshot of Indian TSHD fleet