Chapter 4

Marine Fishing Fleet & Performances of Indian Maritime States

4.1 Introduction:

As we have discussed in earlier chapter that although India has a large coastline, enough marine resources, vast continental shelf area and also a number of inland fisheries, the contribution of fisheries towards India's GDP is negligible (around 1.2 percent at an average for the last ten years). We have already referred that many studies indicated that marine fisheries are not being exploited with fullest potential. It implies that the scopes of marine fishery production of maritime states are yet to be fully achieved. As we know that the Indian marine fishery is overpopulated with respect to both manpower and vessels employed, the reason of the gap between potential and actual may be due to under performance. With the objective of understanding the scope of improvement and identifying the areas of inefficiencies in marine fishery of the Indian maritime states we evaluated, compared and analyzed their performances on the basis of latest available data.

Any analysis only on the basis of production (harvest) data over the periods fails to reveal something meaningful. It shows that there is substantial and steady increase in production with frequent fluctuation. During the period 1985 to 2004, Indian marine fish production increased from 1.52 million tonnes to 2.58 million tonnes registering a peak of 2.69 million tonnes in 1997. But the total landing declined to about 2.3 million tonnes in 2001. However, next year in 2002, production has increased to 2.55 million tonnes again. Production of pelagic fish (oil sardines, lesser sardines, Bombay Ducks, mackerel, ribbonfish, carangids and seer fishes) resources increased from 7.7 lakh[10] tonnes in 1985 to 13.8 lakh tonnes in 2004 with a peak of 13.9 lakh tonnes in 2003. In Indian marine fish landing, pelagic fish landing fluctuates with high inter-annual variation. The landings of ribbon fishes and carangids have decreasing trend. Landings of demersal fish (elasmobranches, catfishes, perches, pomfrets, silver bellies, flat fishes, penaeid & non-penaeid prawns, crabs and cephalopods) range from 7.5 lakh tonnes in 1985 to 11.5 lakh tonnes in 2004 with a peak of 13.5 lakh tonnes in 1998. The landing of elasmobranches, catfishes, silver bellies soles croakers and non-penaeid prawns have shown declining trend (Marine Fishery Census 2005, CMFRI, Cochin).

Fish production (both marine & inland together) in the country has been showing an increasing trend and has reached a record level of 5.65 million tonnes in 1999-2000. The fish catches in the year 2000-01 and 2001-02 were about 5.95 million tonnes and 6.26 million

[10] 1 lakh = one hundred thousand

tonnes respectively (Report, Working Group, 2001). The marine fisheries sector in India has witnessed a phenomenal growth during the last five decades both quantitatively and qualitatively. The subsistence fisheries during the early 50's produced about 0.5 million tonnes annually. Currently, the total production is of the order of about 2.314 million tonnes. This production has the estimated value of about Rs. 10,400 crores[11] at the landing centre price and about Rs. 17,800 crores at the retail level (Srinath, 2003a). In 2002, the exports of marine fishery products earned about Rs. 5,300 crores foreign exchange (Srinath, 2003a). The increase in marine fish production is the result of improvements in the harvesting methods, increase in the fishing effort and extension of fishing zone into relatively deeper regions. Fleet size and operations underwent quantitative and qualitative changes.

In Indian Marine Fishery, imbalances in the exploitation across the zones and among the resources are pointed out by several experts as a result of unplanned phenomenal growth of number of vessels, crewmen and harvest. This prompted to promulgate fishing regularity measures by most of the maritime states through closure of fishing during certain seasons. This however failed to deter the increased effort over time and across regions. This possibly is the consequence of ever-increasing demand for marine food both from external and internal markets. Many also observed that inter-sectoral conflicts have increased due to competition in exploiting the common resources.

In spite of ever increasing effort and reported overexploitation for few species, Indian fishery has not achieved the target potential. The achievement of the total fish production (marine & inland together) was much below the target of 7.04 million tones set for the Ninth plan (1997 to 2002) at an estimated growth rate of 5.64 percent per annum. In spite of increasing trend of total fish production many claim that the slower growth than expected in the marine fish production during this period is the reason of this gap between target and actual. The details of potential marine catch as reported by the government appointed Working Group and the actual harvest levels are shown in **table-4.1.** While comparing with the actual marine catch we find that 51.68 percent of demersal and 30.58 percent of pelagic resources are remained unexploited.

[11] 1 crore= 10 million

Table- 4.1: Potential of fishery resources in the Indian EEZ at different depths in million tonnes

Depth range(m) / Fish type	0-50	50-200	> 200	Total		
				Estimated Potential	Actual[12]	percentage of under achievement
Demersal	1.28	0.625	0.028	1.933	0.934	51.68
Pelagic	1.00	0.742	0.246	1.988	1.38	30.58
Total	2.28	1.367	0.374	3.921	2.314	40.98
percent total	58.1	34.9	7.0	100.0		

Source: DAHD, (1995); CMFRI (2005)

Comparing the actual marine fish production with the estimated potential, we find that 40.98 percent of potential has not been achieved.

Clearly, there are two contradictory positions. On the one hand there are views that resources are over exploited because of excessive efforts and, on the other, actuals are reported as less than the maximum sustainable yield (MSY). The situation clearly indicates that further probe of the matter is necessary. Since the actual harvest is less than the estimated potential and there are reports of overexploitation, we could understand that both can not be true simultaneously. Only plausible explanation may be that there are some zones or species those are left unexploited, while some species or zones are overexploited.

This suggests that the production function like analysis for Indian marine output with respect to input employed during a period of time would not be able to identify those zones which are either overexploited or underexploited. Instead, Data Envelopment Analysis may identify a zone where excess inputs are employed with respect to output relative to other zones. It, therefore, can point out the irrational or inefficient distribution of inputs like vessels or manpower/ crewmen in different maritime zones.

[12] Actual data are of the year 2005 published by CMFRI, India. However, marine fish production was maximum in 1995 (2.71 million tones) which constitutes 69 percent of the total potential.

4.2 Maritime States and Marine Fishing Fleet:

According to the Seventh Schedule, Article 246 of the Constitution of India, fisheries within the territorial waters of India (i.e. up to 12 nautical miles or depth upto 50 mtrs) are under the jurisdiction of the Provincial (State) Government and fishing and fisheries beyond territorial waters within the EEZ are under the jurisdiction of the Central Government. Thus, statutorily Indian marine resources are under the management and control of the state (provincial) as well as central government. There are ten maritime states in India[13]. These maritime states are: West Bengal (WB), Orissa (OR), Andhra Pradesh (AP), Tamil Nadu (TN), Pondicheri (PC), Kerala (KR), Karnataka (KT), Maharastra (MR), Gujarat (GR) and GOA.

As we have already stated in chapter-II that fishing vessels used in Indian Marine Fishing sector are not of same types. Indian marine researchers categorized[14] those into three distinct groups. (CMFRI, 1980; Sathiadas et al., 1995):

1. Non-mechanized (artisanal) group using country craft with traditional gears
2. a) Mechanized group using traditional crafts with outboard motors (OBM)
   b) Mechanized group using inboard motors (IBM):
3. Deep sea fishing Vessels

Among these general groups stated above, non-mechanized vessels with gears of traditional design are concentrated in the shallow inshore coastal waters in depth range up to 50m and mechanized as well as deep-sea vessels exploit the resources of deeper off shore waters (Chandy, 1970a; Jhingran, 1991). In table - 4.2 we furnish the distribution of these different types of vessels among different maritime states in 2003 and 2005.

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[13] Three union territories could not be considered due to non-availability of all relevant data. Please refer to discussion in 4.3.

[14] Each of these categories (mechanized, motorized and non mechanized) has several subdivisions and numerous local names, specific to the respective states (Chandy, 1970b; BOBP, 1982, 1983b, 1984; CMFRI, 1988; BOBP, 1990; Thirumilu et al., 1994; Chennubhotla et al., 1999; Pillai et al., 2000

Table – 4.2: Present fleet strength of Indian Maritime states

Vessel Type	Mechanized		Motorized		Non-Mechanized		Total	
YEAR	2003	2005	2003	2005	2003	2005	2003	2005
WB	3362	6829	270	1776	4850	10041	8482	18646
OR	1276	3577	2640	4719	10993	15444	14909	23740
AP	8642	2541	4164	14112	53853	24386	66659	41039
TN	9892	7711	8592	22478	42537	24231	61021	54420
PC	560	627	505	2306	7802	1524	8867	4457
KR	4206	5504	12913	14151	40786	9522	57905	29177
KT	2866	4373	3452	3705	22744	7577	29062	15655
GOA	1092	1087	1100	932	2194	532	4386	2551
MR	8879	13053	286	3382	10256	7073	19421	23508
GR	11372	13047	5391	7376	14613	3729	31376	24152
TOTAL	52147	58349	39313	74937	210628	104059	302088	237345

Source: CMFRI, 2005, DAHD

Table 4.2 reveals that except in West Bengal and Orissa, number of non-mechanized crafts have declined drastically from 2003 to 2005. On the other hand, except GOA, the reverse trend is observed in case of number of motorized boats which has significantly increased from 2003 to 2005. However in GOA, the numbers of both categories of crafts declined. Possible reasons of such reverse trends in number of non-mechanized and motorized boats may be many:

a) The one of the important reasons is that the 2004 Tsunami in Indian Ocean caused extensive damages in southern regions of India affecting a total of 2260 km coastline. The worst affected regions were the maritime states Tamil Nadu and the states with damage of lesser degree were Pondichery, Andhra Pradesh and Kerala (Report, UNDMT, 2005). The estimated numbers of damaged and lost vessels due to Tsunami in 2004 are given below.

Effect of Tsunami 2004

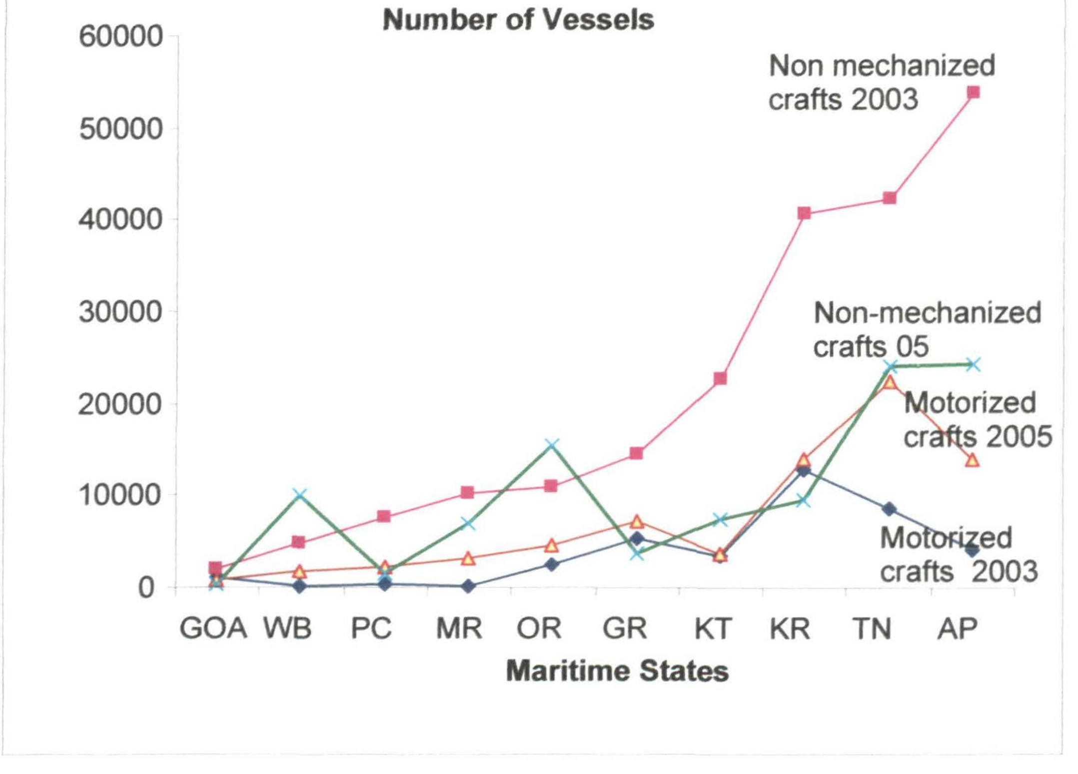
MARITIME STATE	FISHING VESSELS DAMAGED	FISHING VESSELS LOST
TN	43953	10000
PON	6678	
AP	108270	1362
KR	2324	2519

b) Another possible reason is that the changeover from non-mechanized to motorized is very simple and remunerative. A non-mechanized boat can be registered as motorized as soon as a motor is added to the boat. As a declared policy the government provides subsidy to a fisherman for fitting motor with the fishing boat. Hence, the fishermen consider the change as remunerative. It always plays as a cause of motivation to changeover (Yadava, 2005)

c) All maritime states are affected by the problem of over-crowding. This is very acute specifically in case of non-mechanized country boats. Initial cost, being very small, could not prevent entry. Large number of entry thus makes the fishing activities of a non-mechanized boat non-remunerative. As a consequence of this, many boats discontinue marine fishing activities as they do not sustain the economic loss of operation. Fluctuation in number of non-mechanized boats in year to year is, therefore, not very unusual.

However, this general phenomenon has not been observed in West Bengal and Orissa. We find that the number of both types of boats has increased to a large extent for these maritime states from the year 2003 to 2005. To understand visually we present this graphically in Fig- 4.1

Figure-4.1: Number of motorized and non-mechanized fleets in different maritime states in 2003 and 2005



4.3 Methodology and Data Source:

We apply DEA considering each maritime state as an independent Decision Making Unit (DMU). In chapter 2, we have mentioned that there are 13 maritime states including union territories. However the marine fishing activities of three union territories, namely, Lakshdweep, Andaman & Nicobar Islands and Daman & Diu are so insignificant with respect to major maritime states that the official publications most often do not mention data related tose three union territories specifically. Because of this non-uniform practice of reporting data, we compelled to consider only ten maritime states excluding these three union territories. With regards to application of DEA in evaluating efficiency of Indian maritime states, it could have been better if we could consider those three also as DMU. The policy notifications and regulations of each state influence the marine fishery within the jurisdiction of the respective states. While the central regulations influences each state equally, state regulation which is binding on the particular state only, determines fleet size, vessel and gear type, cost of human resources and intensity of the harvesting activity of fishing fleet within the specific region of the said state.

As we discussed earlier that each maritime state of India has different kinds of fishing vessels which can be characterized by multi-input, multi-output production technology, as they combine several inputs to produce a variety of outputs (fish species) during a fishing trip. However, measuring the performances of the maritime states with respect to their efficiency of fishing vessels poses several problems not typically found in other industries. Apart from unpredictable weather conditions, the quantity of catch is heavily dependent on vessel's breakdown, mechanical faults and other adverse situations. Moreover, spatial and temporal variability in fish stocks can lead to different output mixes and quantities for similarly configured vessels. Certain species may not be present at a specific location during the harvesting of a particular vessel whereas a vessel which has similar physical dimensions and horsepower fishing at the same location a week later, or in a slightly different location, may harvest a different species mix and quantity. Because of these reasons we wanted to measure the performances of the maritime states in two different years. We have taken the data for two years with a gap of one year, i.e. 2003 and 2005 and evaluate the performance of those years. Then by comparing the corresponding results we have tried to check whether the inefficient states of 2003 have taken note of their reasons for inefficiencies and acted accordingly to improve their performance in the year 2005 or not.

4.3.1 Determinants of Maritime States' Harvest Output

Maritime states harvest output in absolute quantum has varied widely from state to state. However, this is not unexpected as the states themselves are of various types with respect to varying number and types of fishing vessels, access to geographically determined sea-location and marine resources, availability of human resources, man-made facilities and infrastructure etc. We, therefore, conceive that the amount of harvest (output) of a maritime state depends on such factors which, in some cases, do not change over time and remain fixed as a given endowment specific state. According to the nature and type of these determinants, these could be grouped into three distinct categories (Ghosh & Ray, 2008):

I) **Types of fishing vessels:** We group all crafts into a single category as fishing vessels (**category-I**) in our model. We have already mentioned that there are different types of vessels. Each of these types of fishing vessels has different trawling nature and capacity. They also have different requirement of crew members and on-board facilities.

II) **Access to geographical location, natural and man-made facilities:** Accessibility to geographical or natural factors like continental shelf or coastline differs with respect to area and length in different states. These factors along with available man-made facilities like availability of landing centres near the fishing villages also influence the level of productivity of maritime states. These factors may, therefore, be considered as a separate category of inputs (**category-II**). Under this category, few determinants vary from state to state but remain as a fixed endowment for a particular state and few may vary over time.

III) **Types of human resources involved:** Human resources involved in marine fishing activities are not of identical expertise with respect to skill and time spent on marine activities. According to census classification (DAHD, 2006), any fisherman who spends more than 30 percent but less than 90 percent time in fishing activity is called part-time fisherman, whereas any fisherman who spends less than 30 percent time in fishing activity is called occasional fisherman. We consider this as a separate category of inputs and classify as **category-III.**

It is, therefore, clear that under each category there are several distinct determinants. Each determinant is, therefore, identified as X_{ij} where i stands for category and j stands for determinant number in that particular category.

Category-I represents types of fishing vessels, encompasses the following:

X_{11}: number of mechanized crafts,

X_{12}: number of motorized crafts

X_{13}: number of non-motorized crafts

Category-II comprises with the following variables:

X_{21}: length of coastline in kilometers,

X_{22}: area of continental shelf in square kilometers,

X_{23}: number of fish landing centres and

X_{24}: number of fishing villages

Category-III, types of human resource, is important for marine fishing as productivity depends on skill and experience of crewmen. This category includes:

X_{31}: full time fishermen,

X_{32}: part-time fishermen and

X_{33}: occasional fishermen.

Here, of course, one is faced with a problem of choice and data constraint. There are some logically possible factors which we could not include either due to the fact that data are not available or can not be quantified. We are, therefore, left with the choice of considering only those which are available, quantifiable or having close proximity to available one.

Secondly, the most important and crucial data constraint that we face with relation to determining the efficiency of maritime states by DEA is the restriction on number of input variable with respect to number of DMUs. Total number of maritime states being only ten, our number of DMUs is ten only and, hence, restricts the number of inputs variables. Generally speaking, if the number of DMUs (n) is less than the combined number of inputs and outputs $(m + s)$, a large portion of the DMUs will be identified as efficient and efficiency discrimination among DMUs is questionable due to an inadequate number of degrees of freedom. Hence, it is desirable that n exceed $m + s$ by several times. A rough rule of thumb in the envelopment model is to choose n (= the number of DMUs) equal to or greater than *max*

$\{m * s, 3 * (m + s)\}$ [15]. 's' being 1 [since we have single output (harvest)], it implies that $3 * (m+1)$ must be less than 10 (number of maritime states is DMUs) .Thus, the number of input variables that we could consider is only two.

In order to overcome methodological restriction and making our study meaningful we resolve to observe the following methodological approach:

Initially, we take up the analysis of regression of harvest output on each variable under different categories. Gradually, we will introduce more explanatory variables to identify the set of determinants which provides relatively better explanation. This process will help us to identify the two most important determinants of harvest and subsequently we will consider those as input variables in DEA analysis..

Our contention in this chapter, however, is neither to identify causal relationship that influencing harvest output, nor to estimate an exact functional relationship between output and inputs. Our objective is only to discuss such inputs which are linearly independent to each other and, at the same time, having relatively greater influencing ability. Great nicety of this approach is that, if we could estimate a regression equation, free from multi-co-linearity, with respect to any two of those variables, then those two input variables must be linearly independent. Thus, if there are more than one such set of variables, we could consider the best set. This will satisfy our objective.

As discussed in section 3.3, BCC output oriented model in the dual form of DEA is chosen for the purpose of comparison. Harvest levels of fish production of the year 2003 and 2005 of each maritime state are considered as output (Y). But the level of output depends upon factors those are grouped under a) types of fishing vessels, b) access to geographical location, natural and man-made facilities and c) types of human resources involved. In India, fishing profession is a caste occupation and skippers as well as crew people acquire their skills over generation. Difference in skill of different fisher-folk is, therefore, not very significant. Hence, we exclude the human factor as input. Thus the remaining two sets of key contributing resources are inputs in our mathematical formulation of DEA.

[15] The rule is n >= max {m∗s, 3∗(m+s)}, where n = number of DMUs, m = number of inputs and s=number of outputs. (**Cooper, Seiford, Tone, 2004, page-252.**)

We have altogether 7 variables under two categories. The number of DMU being ten, we could not employ all 7 variables together as inputs to avoid the problems involving degrees of freedom. Moreover, it seems that many of these variables may have the interdependence between themselves. We wanted to verify the independency of inputs for avoiding spurious effects. In order to evaluate the performance of Indian maritime states with respect to as many factors as possible, we decide to obtain efficiency of them category wise. Even then, as we have grouped more than two factors in a category, we could not include all those factors as input variables in our DEA for that category. Our option is, therefore, restricted to selecting only two variables from the set of potential variables for category-I and category-II. Hence, it is necessary to select any two variables whose joint contribution in output is relatively higher than any other group of two variables of that category and, at the same time, as explanatory variables those two would not form spurious relationship with the dependent variable. Best way to do this is to estimate variables stepwise through Ordinary least square (OLS) analysis (Ghosh &Ray, 2008, 2009). For this we adopt a somewhat revised version of Frisch's Confluence Analysis method (Koutsoyiannis, A. 1977).

4.3.2. Data

The dataset used for Category-I & II are obtained from "Marine Fishery Census, 2003" & "Marine Fishery Census, 2005" published by Central Marine Fisheries Research Institute (CMFRI), India. For the production (output) data we have used publication from Fisheries Resource Assessment Division (FRAD) of CMFRI, 2003 & 2005.

4.4 Selecting Input Variables:

As suggested by revised version of Frisch's Confluence Analysis, for every category, we regress dependent variable on each of the explanatory variables separately. We then examine the results of these elementary regressions on the basis of a priori and statistical criteria. We select most plausible regression and introduce remaining variables gradually to examine their effects on coefficients, on their standard errors and on the overall R^2. Additional variable is classified as useful, superfluous and detrimental if,

I. The new variable improves R^2 without being cause of any individual coefficients unacceptable on a priori considerations, the variable is retained as a useful explanatory variable,

II. The new variable neither improves the value of R^2 nor affects considerably the values of the individual coefficient, the variable is rejected as superfluous,

III. The new variable affects considerably the coefficients, either the sign or the value, then it is considered as detrimental. If individual coefficients, being affected by the introduction of a new variable, become unacceptable on both priori and theoretical consideration, it would imply the existence of multi-co linearity. In other words, it implies that the variables are not independently influencing the dependent variable.

4.5 Selecting Input Determinant Considering All Variables Under Two Different Categories Together:

We consider all seven variables as defined earlier, under two distinct categories except the category 'human resources involved' and tried to find two inputs which influences the output most significantly. We regress output (harvest) as dependent variable against each of those seven variables one at a time to obtain regression co-efficient and R^2 values. We find four variables having significant R^2 values. Those variables are mechanized crafts (X_{11}), motorized crafts (X_{12}), length of coastline (X_{21}) and continental shelf (X_{22}). Thus we run the Frisch's Confluence Analysis considering the above mentioned variables.

We then obtained the multiple regression equation for the year 2003 as

$$Y = f(X_{ij}) \text{ for } i = 1, 2 \ \& \ j = 1, 2$$ [16]

and results are shown in Table-4.3[17].

[16] If not stated otherwise, in this chapter, i stands for category and j stands for determinant number in that particular category.

[17] Results of the combination which produce either detrimental or spurious relationship are not shown in any of the Frisch's' Confluence analysis table

Table-4.3: Regression Co-efficient and R^2 for Frisch's Confluence Analysis for the year 2003

VARIABLES	X_{11}	X_{12}	X_{21}	X_{22}	R^2
X_{11}	29.635 (13.152)				0.388
X_{12}		34.164 (11.393)			0.529
X_{21}			232.516 (112.637)		0.348
X_{22}				2039.408 (980.609)	0.351
X_{12}, X_{21}		27.236 (12.264)	130.678 (103.002)		0.617
X_{12}, X_{22}		**31.008 (8.416)**		**1736.647 (616.980)**	**0.779**
X_{11}, X_{22}	19.465 (21.016)			969.121 (1521.282)	0.422
X_{11}, X_{21}	24.087 (34.060)		50.494 (282.459)		0.391

Source: Computed from the data used. Figures in the parenthesis indicate standard error (SE) of estimates

First, associated R^2 – value being the highest, we fix the variable X_{12} and introduce the variable X_{21} as an additional explanatory variable. We see that the value of R^2 improves from 0.529 to 0.617 and the coefficients also appear significant. But when X_{22} is combined with X_{12} it gives a far better result. The value of R^2 improves further to 0.779 and the coefficients are not affected adversely. However, when we introduce variables either X_{21}or X_{22} with the variable X_{11}, results are not that promising. All other combinations appear to be not plausible. Hence for the year 2003 the most plausible determinants of outputs are Number of motorized crafts (X_{12}) and Continental shelf in square kilometers (X_{22}).

For the year 2005, we follow the same procedure to obtain regression co-efficient and values of R^2 for Frisch Confluence Analysis. Results are shown in Table-4.4 below. We find that the identical combination of X_{12} and X_{22} gives the best possible and plausible result with the coefficients without violating any conditions of Frisch Confluence Analysis. The highest value of R^2 is 0.544 as shown in the table. Hence for the year 2005, we may consider that the most plausible determinants of outputs are Number of motorized crafts (X_{12}), Continental shelf in sq. km. (X_{22}).

Table-4.4: Regression Co-efficient and R^2 for Frisch's Confluence Analysis for the year 2005

VARIABLES	X_{11}	X_{12}	X_{21}	X_{22}	R^2
X_{11}	23.414 (9.735)				0.420
X_{12}		11.072 (6.936)			0.242
X_{21}			195.758 (93.328)		0.355
X_{22}				1667.920 (815.449)	0.343
X_{11}, X_{21}	16.311 (13.381)		96.792 (121.670)		0.468
X_{11}, X_{22}	20.704 (21.308)			244.468 (1678.018)	0.421
X_{12}, X_{21}		5.052 (8.114)	153.625 (118.364)		0.389
X_{12}, X_{22}		**10.124 (5.766)**		**1570.287 (728.475)**	**0.544**

Source: Computed from the data used. Figures in the parenthesis indicate SE of estimates

4.6 Application of DEA:

As we discussed earlier, we are constrained to consider only two variables. We have obtained two most contributory factors from all explanatory variables under two different categories in previous section. The performance of maritime states now is evaluated with the application of DEA in the subsection below.

We now find the efficiency of the maritime states (DMUs) and resource allocation applying **BBC-O**[18] model of DEA. As we have discussed in chapter 3 the problem takes the following form:

$$\begin{aligned} & \max \quad \eta \\ & \text{subject to} \\ & X\lambda \le x_0 \\ & \eta y_0 - Y\lambda \le 0 \\ & e\lambda = 1 \\ & \lambda \ge 0 \end{aligned}$$

Where, η is the efficiency score, **X**= input vectors specified as above, **Y**= fish production of each maritime state of the corresponding year 2003 or 2005, $\mathbf{x}_0$ = virtual input combination, $\mathbf{y}_0$= virtual output.

[18] We use DEA-Solver (Microsoft excel add-in)

4.6.1 DEA and Comparative Performance of Maritime States in 2003 & 2005

Thus, we find that for the measurement of efficiency of Indian maritime states through DEA, both in the year of 2003 and 2005, the inputs appear to be most plausible are

X_{12}: number of motorized crafts

X_{22}: area of continental shelf in square kilometers

The following Tables 4.5 & 4.6 show the results of DEA when number of motorized crafts (X_{12}) and area of continental shelf (X_{22}) are considered for the years 2003 & 2005 respectively. The corresponding tables showing the optimum weights of inputs and output along with efficient frontier shown as bar graph is given in appendix-2 (for year 2003) and appendix-3 (for year 2005).

Table-4.5: Results of DEA of considering motorized crafts (X_{12}) & continental shelf (X_{22}) as inputs for 2003

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS MOTORIZED CRAFT	EXCESS CONTINENTAL SHELF	PEER STATE(S)
WB	1	1	193643	0	0	0	WB
OR	0.24	10	285089	314.03	0	0	WB, KR, MR
AP	0.55	9	346713	80.57	0	0	WB, KR, MR
TN	0.71	7	497062	39.95	0	0	WB, KR, MR
PC	1	1	14968	0	0	0	PC
KR	1	1	623293	0	0	0	KR
KT	0.59	8	311573	69.26	0	0	WB, KR, MR
GOA	0.77	6	125153	30.52	0	0	WB, KR, PC
MR	1	1	415094	0	0	0	MR
GR	0.89	5	499267	12.42	0	101.11	KR, MR

Source: Computed by the author

If we compare the performances of the maritime states for the year 2003 & 2005, we can see that all the states improved their performances with the exceptions of AP and TN. The states which were efficient in 2003 were WB, PC, KR &MR. They remained efficient in 2005 also. The states GOA & GR were inefficient in 2003 but became efficient in 2005. Comparing the results shown in tables 4.5 & 4.6 we observe that, all other inefficient states except AP & TN have improved their efficiency score in 2005. The states OR & KT improved their efficiency score with respect to motorized crafts (X_{12}) and area of continental shelf (X_{22}). OR has gone up from 0.24 to 0.363 and KT is up from 0.59 to 0.89. For OR the improvement required in harvest decreased from 314.03 percent to 175.46 percent. Thus it improved its performance and bettered its rank from 10 in 2003 to 9 in 2005. Similarly, for KT the improvement required in harvest decreased from 69.23 percent to 12.99 percent. Thus, it also improved its performance and bettered its rank from 8 in 2003 to 7 in 2005.

Table-4.6: Results of DEA of considering motorized crafts (X_{12}) & continental shelf (X_{22}) as inputs for 2005

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS MOTORIZED CRAFT	EXCESS CONTINENTAL SHELF	PEER STATE(S)
WB	1	1	197420	0	0	0	WB
OR	0.363	9	279596.4	175.46	0	0	WB, KR, GJ
AP	0.361	10	441917.4	167.75	2087	0	PC, KR
TN	0.56	8	536220	79.96	8327	1	KR
PC	1	1	10820	0	0	0	PC
KR	1	1	536220	0	0	0	KR
KT	0.89	7	253145.8	12.99	0	0	WB, KR, GJ
GOA	1	1	81600	0	0	0	GOA
MR	1	1	282380	0	0	0	MR
GR	1	1	421870	0	0	0	GJ

Source: Computed by the author

Comparing the results, we can see that the opposite has happened for the states AP & TN. For AP the improvement required in production of marine fish (harvest) increased from 80.57 percent in 2003 to 167.75 percent in 2005. Thus, it worsened its performance and lowered its rank from 9 in 2003 to 10 in 2005. Similarly, for TN the improvement required in harvest increased from 39.95 percent to 79.96 percent. Thus, it also deteriorated its performance and lowered its rank from 7 in 2003 to 8 in 2005. Though AP and TN appeared as inefficient maritime states in 2003, there were no excess motorized crafts at that time. But in 2005, performance of AP & TN had resulted in excess motorized crafts to the extent of 2087 and 8327 respectively and that also contributed in worsening of their relative rank.

The state GR has bettered its utilization of continental shelf. It could not use its resource of continental shelf fully in the year 2003 and thus became inefficient. But it rectified that in 2005 and started to utilize its resources better and became efficient in 2005. GR had a score of 0.89 in 2003 and held the relative rank 5. It became efficient in 2005 in spite of increase in fleet size by 1985. Peer states of GR were KR & MR in 2003. On the other hand, peer state of GOA were WB, KR & PC and its overall rank was 6, having score 0.77. Subsequently in 2005, GOA reduced its number of motorized crafts and became efficient.

So all these above results and discussions prove that there is much scope of improvement in production for the maritime states as well as relocation of fishing resources are necessary.

4.7 Rationale of Category Wise Analysis:

It is to be noted that we are constrained to consider only two variables as inputs. As a result, however, many important input variables have eventually been excluded for this methodological restriction. The better insight of the problem could have been revealed if we could observe the effect on performance with respect to other variables as well, which we could not do unless we increase the number of DMUs from ten. Since there is no way to increase the number of DMUs, the only way to observe the effect of other inputs, is to select variables category-wise so that we could incorporate other variables in our analysis. Then, performance of marine states using DEA may be compared to have an overall and critical understanding of the marine fishery sector. Thus we select input variables category wise following the same method.

4.7.1 Selecting Input Variables in Each Category:

For the years 2003 & 2005, we first obtained the regression equation for category-I

$$Y = f(X_{1j}) \text{ for } j = 1, 2, 3$$

and subsequently introduced other explanatory variables gradually in accordance with the variables appeared as useful, detrimental or superfluous. Final results of Frisch's Confluence Analysis of Category-I for 2003 is given in Table 4.7.

In the year 2003, from the estimated equation $Y = \lambda + \lambda_{1j} X_{1j}$ for $j = 1, 2, 3$ we find that for $j = 2$, the goodness of fit is the highest ($R^2 = 0.529$) [λ_{12}, however appears to be insignificant by S.E. test [$s(\lambda_{12}) < \lambda_{12}/2$)]. Other variables with descending order of their R^2 values are X_{11} ($R^2 = 0.388$) and X_{13} ($R^2 = 0.177$). Introducing X_{11} with X_{12}, R^2 improves to 0.694 and also coefficients do not change adversely and thus X_{11} may be accepted as a useful explanatory variable. X_{12} however joining with X_{13} does not improve the co-efficient value or R^2 and hence, X_{13} may be considered as superfluous.

None of the combination comes out as plausible. Hence, most likely, if we are constrained to consider only any two variables as determinants of the marine fishery output under Category-I for 2003; those are number of motorized crafts (**X_{12}**) and number of mechanized crafts (**X_{11}**).

Table-4.7: Regression Co-efficient and R^2 for Frisch's Confluence Analysis of category-I for the year 2003

VARIABLES	X_{11}	X_{12}	X_{13}	R^2
X_{11}	29.635 (13.152)			0.388
X_{12}		34.164 (11.393)		0.529
X_{13}			4.471 (3.411)	0.177
X_{12}, X_{11}	**20.452 (10.532)**	**27.506 (10.532)**		**0.694**
X_{11}, X_{13}	26.024 (15.752)		1.688 (3.522)	0.408

Source: Computed from the data used. Figures in the parenthesis indicate SE of estimates

We then assess the contribution of same set of variables of Category-I in determining the output for the year 2005. Comparing the elementary regression for each variable we find that R^2 value for X_{11} appears to be highest (R^2 = 0.420) and coefficients λ_{11} appears insignificant with S.E. test or t – test [$s(\lambda_{11}) < \lambda_{11}/2$) or $t^* > t_{0.025}$]. Other variable in accordance to their R^2 value are X_{12} (R^2=0.242) and X_{13} (R^2 = 0.007). Introducing X_{12} with X_{11}, we find that R^2 improves to 0.587 and coefficients appear as significant. At the same time, X_{13} jointly with X_{11} fails to appear as very promising, sine R^2 = 0.429 is well below R^2 = 0.587. It is noteworthy that as coefficients do not change adversely, all variables together may explain the output to a greater extent. But as we are constrained to consider only two variables as determinants of output, we obtain the same two variables (**X_{12}**) number of motorized crafts and (**X_{11}**) number of mechanized crafts in 2005 also. Final results of Frisch's Confluence Analysis of Category-I for 2005 is given in table 4.8.

Table-4.8: Regression Co-efficient and R^2 for Frisch's Confluence Analysis of category-I for the year 2005

VARIABLES	X_{11}	X_{12}	X_{13}	R^2
X_{11}	23.414 (9.735)			0.420
X_{12}		11.072 (6.936)		0.242
X_{13}			1.568 (6.620)	0.007
X_{11}, X_{12}	**21.421 (8.864)**	**9.286 (5.525)**		**0.587**
X_{11}, X_{13}	23.481 (10.326)		1.801 (5.386)	0.429

Source: Computed from the data used. Figures in the parenthesis indicate SE of estimates

Similarly, for category-II also we obtain the regression equation for the year 2003 as

$$Y = f(X_{2j}) \text{ for } j = 1, 2, 3, 4.$$

We arrange the variables in descending order of their R^2 values. We find that for the variable $\mathbf{X_{22}}$ (area of continental shelf in square kilometers), the value is the highest (R^2=0.351) and the co-efficient (λ) appears to be insignificant with S.E. test or t – test.

Introducing other variables one by one with X_{22} we obtained that jointly with X_{23}, the value of R^2 (0.389) is the highest and coefficients neither change adversely nor do those appear as insignificant. In this case X_{22} combined with X_{23} give the most plausible result and their joint effect explains most of the output. Another combination of X_{22} with X_{21} was plausible but with less value of R^2 (0.384). We decided to keep the previous combination of determinants for category-II.

None of the combination comes out as plausible. Hence, as previously, we are constrained to consider only any two variables as determinants of the marine fishery output under Category-II for 2003; those are ($\mathbf{X_{22}}$) area of continental shelf in square kilometers and ($\mathbf{X_{23}}$) number of fish landing centres. Final results of Frich's Confluence Analysis of Category-II for 2003 are given in Table 4.9.

Table-4.9: **Regression Co-efficients and R^2 for Frisch's Confluence Analysis of category-II for the year 2003**

VARIABLES	X_{21}	X_{22}	X_{23}	X_{24}	R^2
X_{21}	232.516 (112.637)				0.348
X_{22}		2039.408 (980.609)			0.351
X_{23}			238.753 (323.728)		0.064
X_{24}				286.824 (250.862)	0.140
X_{22}, X_{21}	125.183 (202.881)	1146.595 (1770.867)			0.384
X_{22}, X_{23}		**1972.226 (1022.603)**	**184.449 (281.075)**		**0.389**

Source: Computed from the data used. Figures in the parenthesis indicate SE of estimates

Next we try to find the contribution of same set of variables of Category-II in determining the output for the year 2005. Comparing the elementary regression for each variable we find that R^2 value for X_{21} appears to be maximum ($R^2 = 0.355$) and coefficients λ_{21} appears insignificant with S.E. test or t – test [s (λ_{21}) < $\lambda_{21}/2$) or t* >t0.025]. Other variable in accordance to their R^2 value are X_{22} (R^2=0.343), X_{23} (R^2 = 0.195) and X24 (R^2=0.012). Introducing X_{22} with X_{21}, we find that R^2 improves to 0.384 and coefficients appear as significant. At the same time, X_{23} jointly with X_{21} and X_{22} with X_{24} also appear as promising; with R^2 values are 0.362 & 0.344 respectively. But out of all the possibilities the most promising combination obtained as X_{22} and X_{23} whose R^2 value is as high as 0.459 which is far better than all other combinations and coefficients neither change adversely nor those appear as insignificant As earlier we have explained that as coefficient do not change adversely all variable together may explain the output to a greater extent but as we are constrained to consider only two variables as determinants of output, we obtain the same two variables (**X_{22}**) area of continental shelf in square kilometers and (**X_{23}**) number of fish landing centres in 2005 also. Final results of Frich's Confluence Analysis of Category-II for 2005 are given in table 4.10.

Table-4.10: Regression Co-efficient and R^2 for Frisch's Confluence Analysis of category-II for the year 2005

VARIABLES	X_{21}	X_{22}	X_{23}	X_{24}	R^2
X_{21}	195.758 (93.328)				0.355
X_{22}		1667.920 (815.440)			0.343
X_{23}			649.275 (466.905)		0.195
X_{24}				80.490 (262.024)	0.012
X_{21}, X_{22}	115.548 (169.086)	850.096 (1464.459)			0.384
X_{21}, X_{23}	172.651 (127.186)		165.274 (569.517)		0.362
X_{22}, X_{23}		**1488.028 (804.987)**	**508.587 (416.187)**		**0.459**
X_{22}, X_{24}		1655.856 (878.412)		24.455 (230.062)	0.344

Source: Computed from the data used. Figures in the parenthesis indicate SE of estimates

Hence after all these above discussions we come to the conclusion that output and inputs for determining the efficiency of maritime states under two different categories and for the two different years are as follows (table-4.11).

Table-4.11: Input Output Combination for DEA as Determined by Frisch's Confluence Analysis

Year	Input Type	Output	Inputs
2003	**Types of fishing fleet and gears (Category I)**	**Production**	Number of mechanized crafts, Number of motorized crafts
	Access to geographical location, natural and man-made facilities (Category II)	**Production**	Continental shelf in sq. kms, Number of fish landing centres
2005	**Types of fishing fleet and gears (Category I)**	**Production**	Number of mechanized crafts, Number of motorized crafts
	Access to geographical location, natural and man-made facilities (Category II)	**Production**	Continental shelf in sq. kms, Number of fish landing centres

4.8 Application of DEA under each Category:

In order to make provisions for many important variables other than those two considered under sub-section 4.4, we obtained set of most plausible explanatory variables in each category in previous sub-section (4.6.1). We have analyzed and discussed the relative performances of maritime states category wise in the following sub-section.

4.8.1 DEA and Comparative Performance of Maritime States in 2003 & 2005 Category wise:

Again we find the efficiency of the maritime states (DMUs) and resource allocation applying **BBC-O** model in accordance to each category. For category-I, the results for the years 2003 and 2005 are given in tables - 4.12 and 4.13 respectively. The corresponding tables showing the optimum weights of inputs and output along with efficient frontier shown as bar graph is given in appendix-4 (Category-I, 2003) and appendix-5 (Category-I, 2005).

Table-4.12: Results of DEA of considering inputs in category-I, (mechanized crafts (X_{11}) and motorized crafts (X_{12}) as inputs) for the year 2003

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS MECHANIZED CRAFTS	EXCESS MOTORIZED CRAFTS	PEER STATE(S)
WB	1	1	193643	0	0	0	WB
OR	0.52	9	132484.6	92.41	0	0	PC, KR, GOA
AP	0.4	10	479036	149.49	1199	0	KR, MR
TN	0.64	8	552046.6	55.43	4087	0	KR, MR
PC	1	1	14968	0	0	0	PC
KR	1	1	623293	0	0	0	KR
KT	0.7	7	263405.1	43.1	0	0	WB , KR
GOA	1	1	95890	0	0	0	GOA
MR	1	1	415094	0	0	0	MR
GR	0.89	6	499267.3	12.42	4382	0	KR , MR

Source: Computed by the author

When we consider the inputs of category-I, namely mechanized crafts (X_{11}) and motorized crafts (X_{12}), we see that 5 states WB, PC, KR, GOA and MR appeared efficient in 2003. In 2005 the number of efficient states increased to 7 with the addition of KT & GR.

Comparing the tables 4.12 and 4.13 we see that the state AP has improved its score from 0.4 in 2003 to 0.69 in 2005 and also improved its rank from 10 to 8 subsequently. It had excess mechanized crafts of 1199 in 2003. It brought down that number to nil in 2005. But number of excess motorized crafts had increased for this state from zero in 2003 to 8829 in 2005. Also improvement required in production had declined from 149.49 percent in 2003 to 44.82 percent in 2005. Hence all these effects were reflected in its performance through improvement of score and rank. But for OR it is exactly the reverse. In fact OR's rank & score both deteriorated from 9 to 10 and from 0.52 to 0.42 respectively. Although OR caught more marine fish in 2005 than in 2003 but its overall input utilization has deteriorated. Although it did not have any excess crafts in both the years but the improvement in production amplified from 92.41 percent in 2003 to 132.78 percent in 2005. Hence the cumulative effect is its rank lowered from 9 to 10. in 2003 its peer states were PC, KR, GOA. But in 2005 they were KR, KT & GOA. The state MR was peer state for 4 states in 2003 but in 2005 it remained peer state only for itself.

Table - 4.13: Results of DEA of considering inputs in category-I (mechanized crafts (X_{11}) and motorized crafts (X_{12}) as inputs) for the year 2005

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS MECHANIZED CRAFTS	EXCESS MOTORIZED CRAFTS	PEER STATE(S)
WB	1	1	197420	0	0	0	WB
OR	0.43	10	236272.3	132.78	0	0	KR , KT, GOA
AP	0.69	8	231253	44.82	0	8829	KR , GOA
TN	0.56	9	536220	79.96	2207	8327	KR
PC	1	1	10820	0	0	0	PC
KR	1	1	536220	0	0	0	KR
KT	1	1	224040	0	0	0	KT
GOA	1	1	81600	0	0	0	GOA
MR	1	1	282380	0	0	0	MR
GR	1	1	421870	0	0	0	GR

Source: Computed by the author

As we have already observed, the result reveals that maritime states' performance with respect to mechanized crafts (X_{11}) and motorized crafts (X_{12}) the number of efficient state increases from five in 2003 to seven in 2005. The state KT & GR have improved their efficiency score in 2005. Reasons of improvement are different for KT and GR. Whereas KR became efficient due to increase in its fish production, GR acquired efficient state status by reducing the excess number of mechanized crafts by 4382 in 2005. KT has bettered its marine fish production from 184075 tonnes to 224040 tonnes. In case of the state TN, we observe reduction in efficiency score from 0.64 to 0.56. However, further analysis reveals that though the state was able to reduce the excess mechanized crafts in 2005 but the increase of the number of motorized crafts deterred it to become efficient. . It had excess mechanized crafts of 4087 in 2003. It brought down that number to 2207 in 2005. But number of excess motorized crafts had increased for this state from zero in 2003 to 8327 in 2005. Also improvement required in production had increased from 55.43 percent in 2003 to 79.96 percent in 2005. Hence all these effects were reflected in its performance through fall of score and rank. The catch as well as the performance of the state TN has gone down from 2 003 to 2005 and that is why rank dropped from 8 to 9. in 2003 the peer states of TN were KR & MR but in 2005 it was only KR.

The results for the years 2003 and 2005 for category-II are shown in table-4.14 and 4.15 respectively. The corresponding tables showing the optimum weights of inputs and output along with efficient frontier shown as bar graph is given in appendix-6 (Category-II, 2003) and appendix-7 (Category-II, 2005).

Table-4.14: Results of DEA of considering inputs in category-II, (continental shelf (X_{22}) and number of landing centres (X_{23}) as inputs) for 2003

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS		PEER STATE(S)
					CONTINENTAL SHELF	LANDING CENTRE	
WB	0.73	5	264537.2	36.61	0	506	PC, KR
OR	0.29	10	239007.2	247.11	0	0	PC, KR, KT
AP	0.37	9	514106.5	167.75	0	318	PC, KR
TN	0.57	8	623293	75.49	1	136	KR
PC	1	1	14968	0	0	0	PC
KR	1	1	623293	0	0	0	KR
KT	1	1	184075	0	0	0	KT
GOA	0.62	7	155350.7	62.01	0	14	PC, KR
MR	0.78	4	529652.6	27.6	74.77	0	KR, KT
GR	0.71	6	623293	40.35	144	60	KR

Source: Computed by the author

Comparing the tables 4.14 & 4.15 where efficiency of maritime states were evaluated with respect to continental shelf (X_{22}) and number of landing centres (X_{23}) as inputs for category-II results reveal that the number of efficient states have increased from 3 to 4. In 2003 efficient states were PC, KR and KT. In 2005 the efficient set changed to WB, PC, KR & GR. But interestingly the state KT which was efficient in 2003 became inefficient in 2005. Its score reduced from 1 in 2003 to 0.72 in 2005 and rank plunged from 1 to 6. This was because in 2005 it needed to improve its production by 37.95 percent. Its peer states in 2005 are WB, KR & GR who produced better results by utilzation of resources. However, GR and WB, by improving their performance, become efficient in 2005. The state WB has improved its rank from 5 in 2003 to 1 in 2005. It also elevated its score from 0.73 to 1. It reduced the production impovement requirement from 36.61 percent to nil and reduced inputs by getting rid of the excess landing centres by 506 numbers and thus, became efficient. In 2003 the peer states of WB were PC & KR. Similarly, the state GR started to utilize its resources better in 2005. The state GR has improved its rank from 6 in 2003 to 1 in 2005. It also elevated its score from 0.71 to 1. It reduced the production impovement requirement from 40.35 percent to nil and reduced inputs by getting rid of the excess landing centres by 60 numbers. In 2005 GR utilized its continental shelf optimally to achieve better harvest and thus, became efficient. In 2003 the peer states of GR was KR.

Table-4.15: Results of DEA of considering inputs in category-II, (continental shelf (X_{22}) and number of landing centres (X_{23}) as inputs) for 2005

STATE	SCORE	RANK	PRODUCTION PROJECTION	PERCENT IMPROVEMENT	EXCESS CONTINENTAL SHELF	EXCESS LANDING CENTRE	PEER STATE(S)
WB	1	1	197420	0	0	0	WB
OR	0.44	9	231378.7	127.96	0	0	WB, KR, GJ
AP	0.36	10	441917.4	176.75	0	120	PC, KR
TN	0.56	8	536220	79.96	1	174	KR
PC	1	1	10820	0	0	0	PC
KR	1	1	536220	0	0	0	KR
KT	0.72	6	309061.9	37.95	0	0	WB, KR, GJ
GOA	0.87	5	93753.33	14.89	1.89	0	WB, PC
MR	0.59	7	482163.6	70.75	3.93	0	KR, GJ
GR	1	1	421870	0	0	0	GJ

Source: Computed by the author

Although the state GOA could not became efficient but it improved its score and rank and bettered its performance in 2005. GOA has improved its rank from 7 in 2003 to 5in 2005. It also improved its score from 0.62 to 0.87. It reduced the production improvement requirement from 62.01 percent to 14.89 percent. In 2003 it was using its resource of continental shelf effectively an efficient but had 14 excess landing centres. In 2005 it reduced the number of excess landing centre to zero but could not use the continental shelf properly. Thus, in spite of all its improvements it remained inefficient. In 2003 its peer states were PC & KR, but in 2005 the peer set changed to WB & PC.

The performance of MR deteriorated in 2005 in comparison to 2003. Its rank declined from 4 in 2003 to 7 in 2005. Its score fell from 0.78 to 0.59. Although it started to utilize its continental shelf in better manner in 2005 but its production improvement requirement increased from 27.6 percent in 2003 to 70.75 percent in 2005. Thus, its performance dwindled and remained inefficient. In 2003 the peer states of MR were KR & KT but in 2005 they were KR & GR. States OR, AP & TN hold the last three positions for both the years. In 2003, OR, AP & TN ranked 10th, 9th & 8th respectively and production improvement required were 247.11 percent, 167.75 percent & 75.49 percent respectively. In 2003 AP & TN had 318 and 136 excess fish landing centres. In 2005 OR, AP & TN ranked 9th 10th and 8th respectively and production improvement required were 127.96 percent, 176.75 percent & 79.96 percent respectively. AP & TN had reduced their excess fish landing centres by 120 & 174 respectively. OR had PC, KR & KT as peer states in 2003 which was changed in 2005 as WB, KR & GR.

4.9 Conclusion:

The results obtained in this chapter ascertain our hypotheses that the resources are not fully exploited by few maritime states and, at the same time, there are excess inputs employed in some other zones. Application of DEA to measure the performances of maritime states of India exposes that there are enough scope for improvements in productivity. When we consider all the inputs together, we find that the most effective combination of inputs are the motorized crafts and the continental shelf. However, we also find that these inputs could have been utilized in a better way by the states like OR, AP,TN, KT, GOA & GR to improve their production. As these states are under utilizing their capacity with respect to potential harvest, it could be said that there are certain zones in Indian EEZ where potential harvest is not fully exploited. With relation to production in 2003 the states GOA and GR have improved their harvest in 2005 and thus they have come up to the efficient frontier in that year. But, in case of AP & TN they neither lay off the excess motorized crafts as inputs nor they improve the production in 2005. On the contrary, these states without taking note of the reasons of their under performance in previous year, have tried to enhance the effort level by increasing the number of crafts with further deteriorations as a consequence.

Category wise analysis for the years 2003 and 2005 reveals the fact OR, AP, TN, KT and GR are states performing below the efficient frontier with respect to use of crafts and gears. However, KT & GR improved in 2005 to become efficient. We have shown that number of motorized crafts of AP & TN increase substantially from 2003 to 2005. DEA analysis explains that they have employed excess motorized crafts to the extent of 8829 and 8327 respectively.

DEA analysis of category-II, where we have considered geographical and natural resources as well as man made facilities, also exposes similar results. The outcome substantiates the fact that the performance of few maritime states could not justify the number of landing centers and the availability of the size of continental shelf fully.

So far the Indian Marine Fishery is concerned, the policy-making unit is the maritime state. We try to identify the relative position of different maritime states with respect to utilization of inputs. We find that there are few zones under the management of states, where inputs are employed in excess of requirement. Where mechanized crafts and motorized crafts are employed more than requirement, the over harvesting seems to be the logical consequence. Study indicates that certain states are trying to reduce their inputs in order to achieve the optimum fishery harvest. Most of the states are aware of the input utilization but some other states tried indiscriminately increase their fishing inputs to achieve better result without any success. This low productivity of some maritime states seems to indicate the cause of not achieving the potential level of harvest. It, therefore, follows that for Indian Maritime states, the further enhancement of effort by increasing the size of fishing fleet is not the desirable option in order to achieve the optimum level of output.