CHAPTER 2

LITERATURE SURVEY

2.1 Introduction

A wide variety of ports related studies were conducted all over the world during the 20th century. Even before the beginning of the 20th century, maritime geography had a strong maritime component. During 1950s the studies were shifted towards the location and layout planning of seaports. The operational system studies were conducted from 1970 onwards. Ownership and strategy management studies mainly started in 1990s. Now a large research is going on to improve the system performance using management tools and mathematical models. Many Universities in Netherlands, Japan, United States, Singapore, China etc. are conducting studies aimed at improvement of the operational efficiency of container terminals during the last decades.

2.2 Classification of port related literatures

For the purpose of presentation and discussion, the literature related to ports is classified under six areas, viz. 1) Geography, locations of ports and hinterland and transportation studies, 2) Operation planning, operation management, and operational improvement studies other than container terminal, 3) Container Terminal/port related Studies, 4) Crude Oil Terminal related Studies and 5) Studies based on Indian Major ports and 6) Studies based on Cochin Port. The important studies in each class are discussed in the following paragraphs.

2.2.1 Literature related to Geography, Locations of Ports and Hinterland and Transportation studies

Maritime geography has attracted the interest of at least a few researchers since the beginning of the twentieth century. Russel Smith [1905] had published
a pioneering work in America on study of ocean commerce. Other significant contributions to the field of maritime geography were the studies by Sargant [1918] on the ocean trade routes of the British Empire, and on ports and hinterlands in 1938, and Seigfried’s [1940] study on the Suez and Panama canals.

Since early 1950s, the number and variety of port and ocean transportation studies have increased. The recent works of geographers and economists on overland transportation on industrial location, and on urban and regional development add to the theoretical and empirical base for the study of maritime transportation.

In the field of ocean transportation and port geography, the researchers contributions might be divided into two categories: empirical studies and theoretical or conceptual studies. There has been abundant research on the characteristics of single ports, or, in some cases, groups of competitive ports. These studies typically contain a brief history of the port, a description of the type and volume of cargoes moving through the port and of site and situation aspects, infrastructure and superstructure, and a definition of the hinterland. Among such studies are book of Walker on the Port of Buffalo [1939], Tavener [1950] on Southampton, Mayer [1957] on the Ports of Chicago and the St.Lawrence Seaway, Hance and Van Dongen [1958] on East African ports, and Bird [1963] on United Kingdom Ports. These studies provide an insight into historical dynamics of contemporary changes in the systems of ports.

A number of empirical studies have concentrated on the delineation of port hinterlands. Sargent's [1918] book is an early example. Then there are studies by Ullman [1943], Weigand [1956], Patton [1958], Draine [1963], Britton [1965], and Elliet [1969]. Most of these try to define the hinterland for one or two ports, based on an evaluation of the inland movement of cargoes. All of them emphasize the importance of hinterland analysis in the geography of ports. As Boerman [1952] has said: " No port structure can be understood when not seen together with its hinterland". Green's [1955] determination of the hinterland boundaries of New York and Boston in Southern New England, Patton's [1958]
analysis of general cargo hinterlands of four United States ports, and Kenyon’s [1970] research on the inter-port competition in the United States illustrate hinterland configuration on the eve of containerization, providing a useful basis for comparison with the contemporary picture. There is considerable emphasis, in the studies cited above, on complex and sometimes unique empirical cases; relatively little effort is made to conceptualize the phenomena of port regions, port rivalries or overlapping hinterlands.

The development of theory and of analytical frameworks for specific applications to port geography and ocean transportation has been very slow. This is a matter of recent concern in the literature. Robinson [1973] in his study indicates that traditional geographic studies of ports have failed to yield analytical methods suitable to the complexity of port systems; he concludes that there is “a desperate need for a more adequate framework for spatial analysis of ports.” As Mayor suggests, even the traditional geographic concepts, such as those involving port-hinterland relationships, the nature and location of transportation links, and the dichotomy between marine and inland transportation, require re-examination in the light of technological changes in maritime transportation.

Many of the theoretical themes introduced over the past decades have been “borrowed” either from other disciplines such as economics and management sciences or from other branches of geography. Cooley [1894] discussed general concepts of transportation costs, rates, and competition as early as 1896. This important study also analyzed hierarchies of transportation centers and trade routes, as well as the interaction of land and water transportation modes, which is very relevant in the recent development of intermodal transportation systems. Bird [1973] suggests that a comprehensive treatment of port city geography requires a welding of central place, gateway, and agglomeration concepts, which is the concept of classical central place theory. Nevertheless, the hexagonal grid of external place theory has been used by Bird to formulate a theoretical port hinterland. The model is based on Isard’s [1956] conception of a distorted hexagonal grid in the case of non-uniform distribution of population caused by transportation routes. This is an attempt to present a dynamic evolution of hinterlands from an initial stage of several ports.
equal in size and evenly spaced along a coastline, sharing among them a given hinterland) to a final stage in which the entire area falls into the economic hinterland of only one port. The model, however, focuses upon the space organization of hinterlands, and the causes of such organization remain mostly unrevealed.

The notion that ports must be viewed within the framework of a wider system is recognized in many studies. Weigend [1958] points out that close relationships exist between port and hinterland on the one hand and between port and foreland on the other. Robinson [1970] carries this point further and argues that the separation, in previous academic conceptualizations, of the foreland and hinterland into two packages represents a false dichotomy.

Transport development in underdeveloped countries, with particular focus on port evolution is modeled in the well known Taaffe, Morrill and Gould [1963] article, which illustrate port development and the concentration of port activities as related to the development of a general transportation system. Rimmer [1967], in a discussion of the evolution of Australian ports, extends the Taaffe, Morrill, and Gould model to include not only the landward transportation network but also the seaward connections. This study of transport expansion is twofold: First, they view port development in a dynamic context; second, they consider ports as part of wider transportation systems. The above concepts though very helpful in understanding overall ports performance have limited use in the operational performance research that is undertaken in this thesis.

2.2.2 Literature of Operation Planning, Operation Management, and Operational Improvement studies

Robinson [1970] treats port as an operational system in order to establish a modeling framework with in which linkages, spatial structure and port capacity can be analyzed. Other studies use simulation models to analyze the varied and complex interrelated systems with in which port operates. Recently good amount of research has been accumulated world wide on port planning and operation strategies for improving the efficiency and effectiveness of the ports. A report by
the UNCTAD Secretariat [1976], has described the importance of port performance indicators such as financial indicators and operational indicators. A number of performance indicators to assist port managements in the planning and controlling of port operations were discussed in this report. A method for the collection of the necessary information to permit the calculation of these indicators was explained with required set of interrelated files and registers. Another UNCTAD report [1993] has reviewed the strategies currently adopted by ports and the elements of strategic planning processes. They have done a comparative analysis of deregulation, commercialization and privatization of ports. It has also described various port problems and their causes.

The minimization of the total delay of ships is studied by Peterkofsky and Daganzo [1990]. Wan et.al [1992] have shown the application of information technology in the port of Singapore resulted in more efficiency and a higher performance. In Leeper [1988], has shown that, in order to achieve an improvement of productivity and reduction in investment costs, an advanced automated control technology is a necessary condition. Willekes et.al. [1995] have used computer simulation to select ship un-loaders for Indian ports. Park et.al [1987] have given an account of the use of a discrete event simulation model to simulate and study the future economic port capacity to meet the projected cargo demand. The first part of their model determines the effects caused by port capacity expansion. The second part evaluates the port economies due to changes in port capacity.

Edmond and Maggs [1978] have used queuing models to study and determine the number of berths that should be available at the quay. Imai et.al [1997] have looked into the problem of how to allocate berths to ships while optimizing the berth allocation. The introduction of a multi-objective approach is new in machine scheduling problems, according to Imai et.al [1997]. They developed a two objective non-linear integer program to identify the set of non-inferior berth allocations, which minimizes the dual objectives of overall staying time and dissatisfaction on order of berthing.
2.2.3 Literature of Container port related Studies

Literature review of container port related studies is mainly based on an article prepared and published by Iris.F.A et.al [2003]. The recent studies are discussed in this article in which the literature related to unloading and loading of the ship, transport of containers from ship to stack and vice versa, stacking of containers, inter-terminal transport and other modes of transport, and complete container terminal are separately discussed.

Harold M. Mayer [1975] argues that, because of increasing returns to scale, especially with the increased requirement for sophisticated capital intensive equipment for the handling of unitized general cargo, there is a tendency for port traffic to be concentrated at fewer but larger and more efficient ports. A study at the University of Wisconsin indicates that such a concentration will occur at "ports or other trans-shipment points in which traffic is consolidated for most efficient movement through highly capital intensive methods". Such ideas have been carried out to an extreme in a study predicts that "containers on the North Atlantic will mean an era of ship trading between one port on each side, with transshipment to all other ports and it seems likely that there will not be more than two major container ports on the east coast.

The European and International shipping Committees have also suggested the principle of concentration of container traffic in a limited number of terminal areas. A.L. Latham-Koenig [1970], in his evaluation of future trends and developments in the area of containerized transport in Europe concludes: "There will be an inexorable trend toward fewer main ports of call for container ships and more feeder services". As an example, he directs attention to the pattern of calls of the Sea-Land Company in Europe (Bremerhaven, Grangemouth, Felixstowe, Rotterdam), which indicates the probable shape of the future concentration of containerized shipping.

In a symposium at Bergen in 1973, E.Pollock, of the British Transport Dock Board, said that there is a limit to the number of ports that it would pay to link by direct services, not only because of ship size and availability of cargo, but most importantly because of turnaround time of ships in port.
In Shields [1984] a system is presented which can assist the stowage planning process of containers in the ship. The stowage problem was solved with the Monte-Carlo method. According to Wilson and Roach [2000], the container stowage problem is a problem, the size of which depends upon the capacity of the ships and the supply and demand of containers at each port. They proposed a suitable stowage plan using branch and bound algorithm and Tabu search method.

Later, many models were developed to improve the performance of container terminal operations using mathematical, financial and management tools due to the wide application of operations technologies and the advent of information technology. According to Agerschou et.al [1983], the use of containers has several advantages compared to conventional bulk namely less product packaging, less damaging and higher productivity. Daganzo [1989] discusses the static crane allocation problem in which a collection of ships is available at a berth to be handled at the start of the planning horizon and no other ships will arrive during this planning horizon. He developed a model using mixed integer program to minimize the total delay of the ships. The minimization of the total delay of ships is also studied by Peterkofsky and Daganzo [1990]. They found out an optimum departure schedule for the ships and a crane allocation scheme. Branch and Bound Algorithm was used to solve the crane-scheduling problem.

A number of research models were developed very recently in the area of transport of containers from ship to stack and vice versa. Baker [1998] proved that the use of straddle carriers instead of non-lifting trucks could mean improved QC productivity. According to his findings, multi-trailer system can be used to transport of multiple containers. In Steenken [1992], an optimization model was developed to determine the number of straddle carriers and their route. This problem is solved as a linear assignment problem. In Vis et.al [2001], a model and an algorithm are presented to determine the necessary number of AGVs at an automated container terminal. To solve the problem, a network formulation is given and a minimum flow, strongly polynomial time algorithm is developed. A complete review of the routing and scheduling of vehicles in general is given in
Bodin et al. [1993], Steenken [1992] and Steenken et al. [1993] describe the more specific problem of the routing of straddle carriers at the container terminal to minimize empty-travel distances by combining unloading and loading jobs. Routing and scheduling systems are tested and integrated into a radio data transmission system of a real terminal. They formulated the problem using linear assignment method and network problem methods to find the optimum solution. In Kim and Bae [1999] mixed integer linear programming formulations and a heuristic method are given for dispatching containers to AGVs such that the delay of the ship and the total travel time of the AGVs are minimized. In Chen et al. [1998], an effective dispatching rule is given that assigns AGVs to containers. They have developed a greedy algorithm to solve this problem. Bish et al. [2001] extended the analysis, by integrating both the problems of dispatching vehicles to containers with the location problem of containers. In other words, in this vehicle-scheduling-location problem, each container has to be assigned to a location in the stack and vehicles have to be dispatched to containers such that the total time to unload all containers from the ship is minimized. They proposed a heuristic method to solve this problem. In Van der Meer [2000], the control of guided vehicle based internal transport systems like container terminals is studied. Results are presented that show how different vehicle dispatching rules behave in different environments. In Evers and Koppers [1996], the traffic control of large numbers of AGVs is studied. A formal tool to describe traffic infrastructure and its control is developed by using four types of entities: node, track, area and semaphore (i.e. a non-negative integer variable which can be interpreted as free capacity). The tool is evaluated with simulation. It can be concluded that the technique is a powerful tool for modeling transportation infrastructure and its control that the performance and the capacity of the area increases.

Several studies were conducted in the area of operations of stacking of containers: storing on a chassis and stacking on the ground. The distribution of empty containers to ports is a related problem. It is, for example, studied in Crainic et al. [1993], Shen and Khoong [1995] and Cheung and Chen [1998]. Various storage strategies are described in Chen [1999]. He concluded that
higher stacking needs the improvement of all the other relevant conditions at the same time to reduce its possible adverse impact. Otherwise, large numbers of unproductive container movements are needed. Chung et al. [1988] developed and tested strategies that can reduce the unproductive movements of the stack crane during the loading process and as a result reduced the total container loading time. They propose the idea of using a buffer area, where a number of empty chassis are available to store export containers temporarily. A simulation model is developed to study the effect of this buffer area on the port’s operation.

De Castilho and Daganzo [1993] stated that for good configuration of the stack, methods are needed to estimate the number of moves to retrieve a container as a function of stack height and operation strategy. As a result, Holguin-Veras and Jara-Díaz [1999] developed a model to optimize the space allocation for containers in the stack.

Chen et al. [2000] developed a time-space network model to assist in assigning containers to storage locations in advance so as to minimize the total costs of operation. A test case and a real world case are solved with a branch and bound algorithm. In Kim and Kim [1999a] the storage space allocation problem is also studied, with decision variables stack height and allocation space. The objective of the problem is to minimize the number of reshuffles under the condition that the space requirements are met. Different arrival pattern of import containers such as: constant arrival rate, cyclic arrival pattern with the period of one week, and irregular arrival pattern. Linear program models are developed to solve these problems. The solution can be obtained by solving the dual problem and related sub problems by applying the sub gradient optimization technique. According to Cao and Uebe [1993] the repositioning of containers is closely related to the p-median transportation problem, namely the transportation problem of containers from rows to be emptied to p rows not to be emptied. In Taleb-Ibrahimi et al. [1993], results are obtained for long term and operational planning. They give a description of handling and storage strategies for export containers and quantify their performance according to the amount of space and number handling moves. Models are given that reflect the relationship between available handling efforts, storage space and traffic demand. In Kim et al. [2000],
the problem of determining storage locations for export containers with a certain weight is considered. A dynamic programming model is formulated to solve this problem. For making real time decision a decision tree is given. The performance of this decision tree is evaluated by comparing its solution to the solutions of the dynamic programming model.

In Kim and Kim [1998] it is discussed how the optimal number of straddle carriers can be determined for import containers. A model is developed to solve the trade off between the storage density, the accessibility, investment and service to outside trucks analytically. The sum of all costs is minimized with respect to the number of straddle carriers and amount of space. Kozan and Preston [1999] use genetic algorithm as a technique to schedule the retrieval of containers from the stack. The objective is to minimize the time ships spend at the berth for the unloading and loading operation. The authors suggest that research should be done into the use of other techniques, like neural networks or tabu search, to see if they are more efficient than genetic algorithms.

Another area of research is related to inter-transport and other modes of transport in container terminals. According to Van Horssen [1996], new concepts and technologies have to be developed to handle the large numbers of containers expected in the future. Furthermore, research has to be done to the various transport systems by which containers can be transported between the terminals. One of the systems, the multi-trailer system is studied in Kurstiens et.al [1996]. This method is based on a technique, which tries to minimize the number of empty trips. To obtain the minimum number of trucks needed an integer linear problem model is developed.

One way of transporting containers to other destinations is by rail. In Kozan [1997a] an analytically based computer simulation model is developed to describe the container progress at a rail container terminal. The simulation model is combined with heuristic rules to describe the progress of containers in the system. Bostel and Dejax [1998] observe the allocation of containers on trains. Different models and solution methods are given and tested using realistic data.
It can be concluded that the number of container moves and the use and quantity of equipment can be decreased.

Another way of transporting containers to other destination is on the road by trucks. In Ballis and Abacoumkin [1996] a simulation model is developed that can be used in the design and evaluation of terminal facilities at the landside. Five heuristics are incorporated in the model to investigate the performance of the system. The comparison between different studies indicates that a shorter truck service time is feasible but that this leads to an increase of traffic conflicts in the internal transport network.

In the above section, only problems for individual types of material handling equipment in container terminals are discussed. Within a container terminal it is obvious that in order to obtain an efficient terminal, it is also necessary to address all problems as a whole. For this purpose, several simulation models are developed at the end of the last century. In Gambardella et al. [1998], it is shown how operations research techniques can be used to generate resource allocation plans. Terminal managers to determine the best management strategies can use these plans. Ramani [1996] developed an interactive planning model to analyze container port operations and to support its logistics planning. It is assumed that all unloading operations are completed before loading operations are started. In the simulation model of Yun and Choi [1999], an object-oriented approach is used. Other simulation models for container terminals are developed in Merkuryev et al. [1998]. In Van Hee and Wijbrands [1988] a decision support system for the capacity planning of container terminals is developed. Several mathematical models, each describing parts of the complete process, are incorporated in this system. The system can support decisions at the strategic and tactical level. This decision support system is partially based on the system, for break bulk terminal, developed by Van Hee et al. [1988].

Analytical and simulation planning models for a complete terminal are compared by Kozan [1997b]. It is stated that containers arrive at the seaside in batches, namely on the ship, and not alone. Consequently, a batch-arrival multi
server queuing model is developed and compared with a simulation model. In Kozan [2000], the problem examined is of the minimization of handling and traveling times of import and export containers from the time the ship arrives at the port until the time they are leaving the terminal and vice versa. The complete trajectory that containers go through from the ship to road or rail terminals via storage areas is incorporated into a network model. The objective of this model is to minimize total throughput time. It is explained that this model can be used as decision tool in the context of investment appraisals of multimode container terminals.

2.2.4 Literature of Crude Oil Terminal related Studies

According to UNCTAD Review of Maritime Transport [2002], 36.5 percent of world sea trade is of crude oil petroleum and its products during the year 2001. About 80 percent of the crude oil and its products are transshipped through seaports. This data itself shows how important crude oil terminal operations are in ports. Many models have been developed for improving the crude oil terminal operations. World over operations management is moving from thumb rule based decision making to data fed model-based decision-making especially in the area of logistics. Several techniques were used for crude scheduling process. According to Coulbeck et.al. [1988], most approaches in crude oil tanker schedule for oil refinery rely either on simulation or on pipeline sequencing per se, but Hane et.al. [1995] points out that these do not take into account of manufacturing complication such as Crude Distillation Unit (CDU) runs, tankages etc.

Shah [1996] adopted a mathematical programming model and used it for crude oil scheduling. In this model, several constraints were taken into consideration such as: pipeline capacity constraints, storage tank capacity constraints, CDU capacity constraints etc. The objective of the study was to determine the ship discharge details, port and refinery tank allocation, pipeline schedule and CDU schedule so as to reduce the economic penalties of poor scheduling and to enable the exploitation of opportunities, e.g., unexpected
cheap cargoes on the high sea. The complex nature of the problem required a model that could effectively take into account, the queuing of tanker at sea, and the time for which a tanker would have to wait for the tide for movement to the berth, for optimization of the system. Deterministic event duration mathematical models fail to capture such complexity. Hence computer simulation model is most appropriate in such situations.

Hayuth et al. [1994] have described the development of simulation software for port operation with special emphasis on the considerations for choosing both the software and hardware; it also deals with coordination between terminals of more than one port. Kemthose et. al. [2001] developed a simulation based decision support system for selection of crude oil tanker schedule for an oil refinery. In their model, the tanker arrival schedule in equidistant intervals in time was considered and optimum number of tanker to be scheduled per month was obtained with in a tolerable limit of costs per metric ton for crude unloading.

2.2.5 Literature based on studies of Indian Ports

Literature has been found on studies of Indian Ports published very recently. Most of them are studies done by port executives and government agencies. Only a very few literature available are based on the studies done by academicians. At the same time, most of the studies are concentrated on projections volume of cargo handled in Indian ports. Also, it was noticed that most of the studies are based on a single port and only a few studies are based on two or three major ports in India.

Fotedar [1986] has discussed port development in India up to 2000. This is an empirical study conducted at major ports in India and projections of capacity and utilization and port traffic were done for 2000 A.D, based on past data from 1951-52 to 1985-86. Narain [1986] looked into inter-modal transport systems for the twenty first century. This study concentrated on container prospects in India and suggested strategies for development of containerization. Dayal [1986] also looked into the containerization perspective. Central Board of Excise and
Customs has published a report regarding the procedures and documentation problems relating to ports and customs in 1986.

In 1989, Planning Commission, Government of India published a report on "Perception planning for Transport Development". This report contains the status of major ports in India, projection of commodity wise capacity and traffic for 1989-’90 and traffic forecast for 2000 AD. It also discusses the port productivity of wet-bulk, iron ore other dry bulk, break bulk cargo and containerized cargo handling operations. The report has also looked into the financial issues of major ports in general. The report concluded highlighting the need for strengthening National Port Authority (NPA) for integrated planning and development of ports.

Nehria [1990] submitted a project report on "Development of Major ports in India during the 1980s," clearly stating the process of plan allocation in transport sector as a whole and comparing it with the plan allocation in port sector, and other transport sectors. This study also discusses the percentage utilization of all ports in 1984-85 and 1989-90. It is seen that the capacity utilization has improved in 1989-90, when compared with the capacity utilization in 1984-85.

The India Infrastructure Report- Policy imperative for growth and welfare, volume 3 [1997] discusses issues such as growth of Indian ports, major problems faced by Indian ports, traffic and capacity expansion projection for 2005-06, finances of the port sector, cost estimates for different types of cargoes, and strategies for addressing the problems. The report also emphasizes the need for private sector participation and corporatisation, commercialization and competitive market strategy, restructuring the labour force, computerized cargo clearances etc.

Ramakrishnan [1997] has looked into the overview of port developments in India. This study contains scenario off traffic, containerized cargo traffic, drawbacks and strategies and the measures desired in port sector. This study emphasizes the need of re-engineering concepts in the port sector. This study also emphasizes the need of bank finance, private participation and simultaneous developments of minor ports in India. A similar study was
conducted by Chakravarthy [1998], highlighting the importance of private participation, and private investment in state sector. The study also reviewed the progress of private participation in Indian Port sector. Ramakrishnan [1998] again discusses the potential, problems and strategies for port development in India. In this study, a comparison on traffic handled in Indian ports with international ports were made and it was seen that the total traffic handled through Indian ports is less than the traffic handled through a single port of Rotterdam, and Port of Singapore. Strategies were also recommended for improvements of Indian ports. Similar studies were done by Ghosh [1998], Swaminathan [1999], De [1999], Ramakrishnan [1999], and Veeramuthumoni [2000].

Sinha [1999] has reported the relevance of project evaluation techniques in India port sector. The focus of the study was to reduce waiting time of container ships, reduce stay time of container ships at berth and maximize revenue earnings. This paper suggests various models for project evaluation such as: 1) Goal programming, 2) Multiple Attribute Utility Analysis Theory (MAUT), and 3) Multi-objective Optimization Technique (MOOT). Putatunda [2000] has reported a conceptual marketing model and its implication for Indian ports. The study highlights the importance of port marketing and a conceptual framework. Bose [2001] presented a case study on cargo handling of Major Ports in India. This paper attempts to analyze the performance of major ports in India taking into account the absolute cargo handled by them during 1951-52 to 1992-93. A particular focus of the study is the Calcutta-Haldia Port, with a view to determining the reasons for its deteriorating performance. Ghosh and De [2001] have studied about Indian Ports in the context of globalization. This study is concerned with the economics of Indian ports as one important phenomenon in Indian economic geography, and its relationship with regional development under the free market economy. A port performance index with the help of Principal Component Analysis of eight individual port performance indicators shows that traffic intensity is the most significant determinant of performance. The study concludes that with increasing openness of economy and absence of an integrated policy toward export transport network, there is a decline in export intensity and rising domestic coastal traffic in Indian Ports.
2.2.6 Literature based on Studies of Cochin Port

Even though many empirical and theoretical and analytical models were developed and applied in port sector world wide, the uses and its applications of these models in the Indian port sector are very less. Only some empirical studies were conducted in one port or two ports together. Some of the relevant studies conducted in Cochin Port are mentioned here. The study by Pankajaksh [1963] was one of the systematic studies carried out on Cochin port. Agarwal and John [1968] while doing their labour productivity study of major ports in India have covered the port of Cochin from the period from 1954 to 1966. The National Council of Applied Economic Research (NCAER) [1969] conducted a comprehensive survey of Cochin port in 1969. The study concentrated on traffic survey with limited objectives like, to forecast the likely traffic growth through Cochin port. The study of Sahai [1986] on the ports of India also covered the history, emergence, developments, utilizations of facilities, and the prospects of Containerization of the port of Cochin. The study of Anilkumar [1988] was an attempt to examine the causes for declining trends in port activities. Mohankumar [1994] has conducted a customer survey to study the perceptions of the quality of services rendered by Rajiv Gandhi Container Terminal (RGCT) of Cochin port in 1993-'94. Narayanankutty [1996] has developed a model for Human Resource Accounting for Cochin port.

2.3 Conclusion

Literature survey has been done for seaport related studies by classifying the studies in six categories namely 1) Geography, locations of ports and hinterland and transportation studies, 2) Operation planning, operation management, and operational improvement studies other than container terminals, 3) Container port related Studies, 4) Crude Oil Terminal related Studies and 5) Studies based on Indian Major ports and 6) Studies based on Cochin Port. From the literature, it is seen that the latest studies have shifted towards container terminals and their improvement. This is because
containerization has great scope in future. Operation planning, operation management and operational improvement studies of container terminals are also discussed under the category of Container Port concentration studies.

From the review of literature, it is clear that operational problems in the port sector have come because of the rapid increase in demand and increased service level requirements of specialized modern ships. Inability to change processes and operations with times has also resulted in inability of ports to cope with the problems. A few research studies have been reported use of operation management tools like modeling, simulation and work-study methods to improve the operational performance of Indian ports, even though a good amount of such studies have seen reported worldwide. The work in this thesis is an attempt to fill this gap in the planning and operation studies of Indian major ports.