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Development of Traditional Indonesian Boatyards: The Simulation of Collaborative Working with a Large Shipbuilding Facility

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Abstract

As Indonesia determines to increase its marine fishery production, the development of traditional boatyards has to be included in the agenda as it will give the local fishing communities a better chance to compete with large capital intensive fishing companies. It will also spread job opportunities evenly throughout the country instead of concentrating fishing vessel construction in a few large shipyards located primarily on the highly populated island of Java. However developing every single boatyard in Indonesia would not only be prohibitively expensive, but it would also create social tensions as the introduced technology would not be immediately accepted by the rural societies whose own traditions are still culturally significant. Both these problems can be reduced by developing a collaborative scheme between traditional boatyards and a larger shipyard. The shipyard, with modern facilities, can develop work packages containing knock down components which are then assembled in the traditional boatyards. The work packages are planned and designed so that every component can be assembled with relatively simple tools. Radical changes can be avoided as new techniques can be introduced gradually, responding to the boatyard's own requirements and aspirations. While this manufacturing procedure is conceptually straightforward its efficient implementation is in practice complicated by the fact that each traditional boatyard has unique characteristics in terms of labour resources, technological capability, and transportation links. By developing a computer model to simulate the interaction between the main shipyard and small traditional boatyards work packages can be designed that ensure that activities at all manufacturing locations are efficient.

Keywords: traditional boatyards, collaborative production, work package, simulation

1 Introduction

Indonesia has vast fishery resources offering a great potential for development. To utilise this natural resource for the welfare of the people fishery development in Indonesia is aimed at increasing the fishery sector's contribution to an efficient and strong agricultural sector. This will ensure the availability of both animal protein for the population and raw materials for processing industries. It will also support regional development by providing additional employment opportunities and increasing the income of individual fishermen(Murdjio 1995).

The potential maximum sustainable yield of Indonesian marine fish resources is estimated to be around 6.7 million metric tonnes annually. Of this 4.4 million metric tonnes could come from territorial waters and 2.3 million metric tonnes from the Indonesian Exclusive Economic Zone, IEEZ(Pragnyono 1997). One study indicated that less than a quarter of this potential was being exploited in the early nineties(Jay 1996), even though marine fisheries production has grown steadily in the past two decades. Recorded yields indicate that in the ten years to 1994 production climbed from 1,712,804 tonnes to 3,056,100 tonnes, a rate of 5.97 per cent per year. These figures suggest that only 45.8 per cent of the total potential maximum sustainable yield was being exploited(Murdjio 1995, Jay 1996).

In Indonesia there are at least 7000 coastal villages that rely on inshore fishing, the majority of which can be characterised by poverty, underdevelopment, and a low level of education(Djohani 1996). These villages can be grouped into 11 geographical areas, based on the traditional community associations and their specific fishing practices:

1. Western coast of Sumatra
2. Southern coast of Java
3. Strait of Malacca
4. Eastern coast of Sumatra
5. Northern coast of Java
6. Bali and East Nusa Tenggara
7. Southern and Western coasts of Kalimantan
8. Eastern coast of Kalimantan
9. Southern coast of Sulawesi
10. Northern coast of Sulawesi

About 90 per cent of the fishermen pursue traditional artisanal fishing using simple equipment, such as hook and line, seines, traps and various forms of lift nets. Almost half of the total catch is obtained in this way. The remaining 10 per cent of the fishermen are company based using modern technology that requires substantial capital investment. The use of low level technology restricts most of the fishermen to shallow coastal waters, resulting in over fishing in some areas. The official estimates suggest that about 73 per cent of the total production is caught in just 43 per cent of Indonesian waters.

To improve the quality of life for this population clearly has to be a development priority. Introducing more advanced technology into the traditional boatyards in Indonesia could help them to build better boats, and produce them more efficiently. This in turn will increase the standard of living of these communities, and help prevent the over fishing in the coastal regions.

Currently, Indonesia has around 2,700 ocean going fishing boats ranging from 30 to 200 tonnes. About 950 of these are under foreign flags, mostly from Thailand, Taiwan, South Korea and Japan. Significantly Indonesia has only 63 home owned tuna long liner boats, most of which are old and ill equipped. The licensing of foreign vessels which began in 1986 was replaced in 1989 with a charter system. The fees, which are paid according to the size of the refrigerated holds and the type of catch, brought the Indonesian government over USD 26 million in 1990(McBeth 1996).

A large number of fishing vessels are needed to achieve the targeted production of 770,000 tonnes per year from the Indonesia Exclusive Economic Zone (IEEZ). If all of this projected production is to be met from Indonesian fishing vessels, then at least 1200 craft are required(Sainsbury 1977). It has been calculated that this implies an additional 660 new fishing vessels as well as 157 fishing vessels that will be required to replace some of the ageing Indonesian fleet. Further, if the total projected production in Indonesian waters is to be caught by an all Indonesian fleet then as many as 945 fishing vessels are required to replace the foreign flag vessels currently working under license or charter agreements. In the light of these figures it can be understood why the Indonesian Ministry of Agriculture projections indicated in 1994 that an additional 1,850 fishing vessels were required(Murdjio 1995). With a potential demand of this magnitude there is clearly an opportunity to improve the standard of living of the coastal communities whose artisanal activities include both fishing itself and the construction of the craft which are the necessary tool of this trade.

2 Development strategies

2.1 Historical context

Attempts to develop the traditional fishing sector by introducing western technology have generally been unsuccessful. Prior to the 1970's it was widely believed that raising the living standards of traditional fishermen could be achieved through improved vessel and gear technology(Sainsbury 1977, Smith et al 1983). At that time it was wrongly assumed that the resources upon which small-scale fisheries are based are infinite. The logical argument that followed from this erroneous assumption was that to increase the yield per fisherman, and hence to raise their living standards, all that was required was to mechanise the boats and to introduced more efficient equipment. While the introduction of improved technology into this sector would certainly increase productivity in the short term, it would also necessitate a drastic reduction in the number of fishermen in order to maintain fish yields on a sustainable basis.

In the past been the preferred choice for developing countries has often been to introduce capital intensive techniques(Pack 1974, Steward 1977). However this choice has almost always resulted in peripheral industrialisation and created substantial unemployment. It has rarely proved to be socially beneficial. Once the capital intensive techniques failed many developing countries turned to a contrasting strategy, where the emphasis was on labour intensive production using self reliant or indigenous technology. Unfortunately the results of this strategy have on occasion proved even less successful(Pfaffenberger 1993), in part due to an incomplete understanding of the problems. However technical alternatives to capital intensive approaches do exist. These can include older technology from advanced countries, appropriate technology either specifically designed for the development setting or derived from traditional techniques, and low cost decentralised versions of advance technology(Steward 1977, Pfaffenberger 1993). Development strategies of this nature relevant to the context of Indonesian fisheries have been explored in recent years(Soegiono et al 1998, Birmingham 1999).

2.2 Distributed assembly

In the Indonesian context it is proposed that a large number of the required fishing vessels can be built as a collaborative enterprise between several traditional boatyards (spread throughout the country) and a more modern shipbuilding facility, rather than concentrating production at one central high technology site. Involving the traditional shipyards in the project not only distributes employment opportunities more widely but also gives the fishing communities a chance to either collaborate with the capital intensive fishing companies (by building and manning their vessels) or to compete with them using well found affordable boats.

The concept of distributed production is a development strategy for the traditional boatyards that is more compatible with the current economic and social structure of the communities. Rather than trying to developing each traditional shipyard to modern standards, an existing shipyard equipped with modern technology is used to develop and build interim which are and then sent to the boatyards to be assembled. Each interim product has to be designed, built in a knock down form, and packed as a set that can be handled using relatively simple tools. The work packages containing interim products to be assembled together technical with all necessary technical information regarding the packages. The essential information for each work package is as follows:

1. Technical and dimensional data of the interim products
2. Drawings of the interim products
3. Interim product positions within assembly stages
4. Assembly methods and required tools
5. Estimated required man hour to assembly the interim products

There are many anticipated advantages of guiding the development of traditional boatyards via collaboration with a modern shipyard, an important one of which is the introduction design improvements to the vessels themselves.

For the traditional boatyards this development strategy should enable the building quality to be improved without the need for large investment in equipment or training. However basic management techniques, such as planning and scheduling, will be central to the development process. There will also be an automatic introduction of good production practices, such as the use of standardised components. The introduction of more advanced technology and new building techniques can be a gradual process, driven by the traditional boatyards aspirations, as more of the work is transferred from the shipyard to the boatyard. This transfer of technology can be carefully planned as a specific development strategy for each traditional boatyard.

While this proposed development strategy (the introduction of a manufacturing procedure involving distributed production) is conceptually straightforward its efficient implementation is in practice complicated by the fact that each traditional boatyard has unique characteristics in terms of labour resources, technological capability, and transportation links. In order to develop appropriate work packages the current level of technological development has to be understood, and the integration of the large and small facilities carefully planned. The first of these two considerations has been addressed by undertaking an extensive survey of traditional boatyards, and the second by developing a computer model to simulate the interaction between the main shipyard and small traditional boatyards. In the following sections of this paper these two aspects of this work are briefly described.

3 Boatyard surveys

The basis for work package development must be a clear understanding of the technology level currently employed in the boatyards, this reflecting the technological stage of the society in which the boatyards are situated. In order to establish this a survey of 19 traditional boatyards throughout the Indonesian archipelago was undertaken in 1998 and 1999. Most of the Indonesian traditional boatyards lay in what is defined by Gasset (1981) as transitional technology, which is the technology of the craftsman. An individual's technological abilities are regarded as a gift that enables the craftsman to make a living, in this case by the building of boats. The necessary building skills are acquired through long thorough apprenticeships which result in the craftsman following established patterns of work, these being the traditions of his community. Modification and improvements are regarded as differences of personal skill or preference rather than as innovations.

The surveys considered two aspects of the technology employed in the boatyards, these being production and management technologies. In addition the general technological level within the local fishing communities was observed.

Elements related primarily to production included:

- Number of workers
- Working patterns
- Available tools
- Size of boat that could be produced
- Boatyards facilities
- Local infrastructure

Elements related primarily to management included:

- Production cost structure
- Organisational structure
- Planning and scheduling methods
- Material flow
- Material sourcing

Figure 1: Block diagram modeling a system with only a single sub shipyard

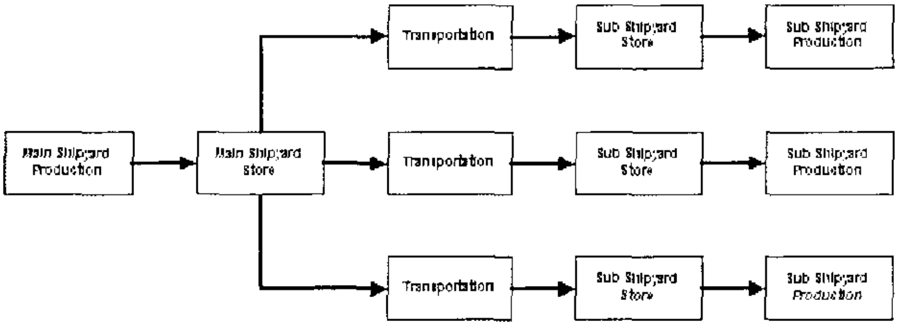

Figure 2: Block diagram modeling a system with several sub shipyard

The surveys also provided detailed views on how each task is organised and completed by the workers, tools that they used.

In addition performance surveys recorded the time taken to complete each task and then calculated the required man hours for each boatyard to manufacture and assemble every major component, such as the keel, frames, hull planking and deck planking. This data has been used in the production simulation model to develop appropriate work packages.

4 Simulation development

4.1 Model development and simplification

The proposed system of distributed production can be portrayed in the form of block diagrams which then facilitates the creation of a simulation model to explore possible organisational arrangements. The aim in constructing the blocks is to simplify the specification of the interactions within the system. Each block describes a part of the system that depends upon a few input variables (and preferably only one) and results in a small number of output variables. The system as a whole can then be described in terms of the interconnections between the blocks and can be represented graphically as a simple block diagram (see Figures 1 and 2). The simulation model developed from theses analyses includes only aspects of the system that are relevant to the objectives of the study. Any irrelevant information is excluded because it increases the complexity of the model and results in longer run times when simulating various scenarios.

4.2 Simulation using object oriented technology

The proposed collaborative production method, with work shared between a main shipyard and several traditional boatyards, is an event oriented system. The modelling of this system has been developed using SiMPLE ++, an object oriented and event oriented simulation package, which offers a graphical user interface for integrated modelling, simulation and animation.

The basic concept of the Object Orientated approach is inheritance, with a distinction being made between classes and instances. Classes are defined by their attributes and functions, and in SiMPLE++ are referred to as building blocks. Values for the attributes of a block (or class) are only established when the program is run, and this then becomes an instance. 'Offspring' blocks can be created by copying and modifying an existing block, with the newly created one being related to the first in a hierarchical way. It is possible to create a complex family tree as offspring are developed from offspring. Within each block there will be both new attributes and attributes inherited from other classes higher in the hierarchy.

There are a variety of types of block used in SiMPLE++, including material flow blocks, information flows block, method blocks and Event controllers. Method blocks control the simulation of individual events and as such are the basis for every model. They are activated by either material flow blocks or other method blocks. All blocks however are subordinated to the Event controller which co-ordinates the order of the activities as the program steps from one event to next. It is this block that calculates the time that would have elapsed between two events that follow directly on from each other. These time intervals do not affect the actual duration of a simulation run, but are used in generating the reported results of the run.

4.3 Work package development steps

Using the simulation model the optimum design of work packages can be found. The first step in running the simulation programme is to create artificial work packages that contain no information except the man hours required to do the work. The total number of man hours required to finish a complete boat is divided equally, so creating several work packages each with equal man hours.

These dummy work packages are sent to the transportation simulation module to check the time required to send each of the packages to the boatyards. Since the data used in the transportation module is statistically derived from the transportation companies' records the result of the simulation will give an accurate indication of the actual transportation times, see the first step in Figure 3 below. The arrival time is used as the assembly starting time and must be integrated into the general pattern of the boatyard's working schedule. At this stage the only information derived from the simulation program is an adjustment of the delivery times of the work packages from the main shipyard, but by running the simulation repeatedly an optimal size of dummy work package can be found.

The second step (also shown in Figure 3) is to convert the dummy work packages into actual proposals for elements of work of requiring the desired number of man hours. The work packages will now contain real information concerning the building materials, including both weights and dimensions. Because the proposed elements of work and associated building materials generally do not fit the dummy package perfectly, adjustments are required to obtain realistic and viable work packages. These are then entered into the simulation programme, the results of which are the actual transportation times, transportation costs, buffer store levels, finishing time and level of worker utilisation. Once again the process is iterated until the best combination of work elements are found, which optimise the utilisation of the boatyard's workforce. good work packages for traditional boatyards can be established, the simulation move to the next step.

At this stage work packages have been developed which are ideal from the traditional boatyards perspective, but may not be configured in a way that allows the main shipyard to produce

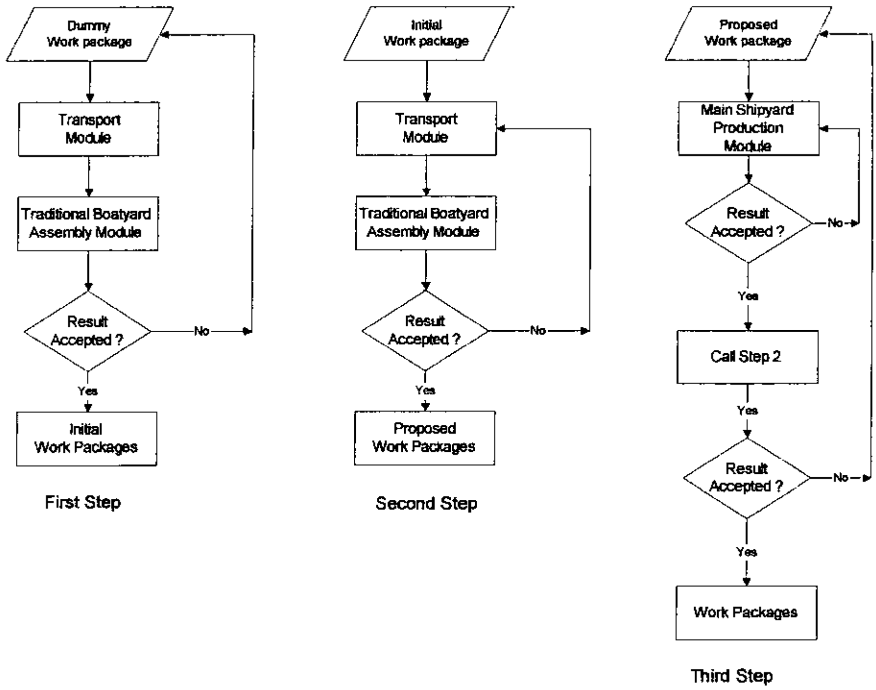

Figure 3: Simulation steps

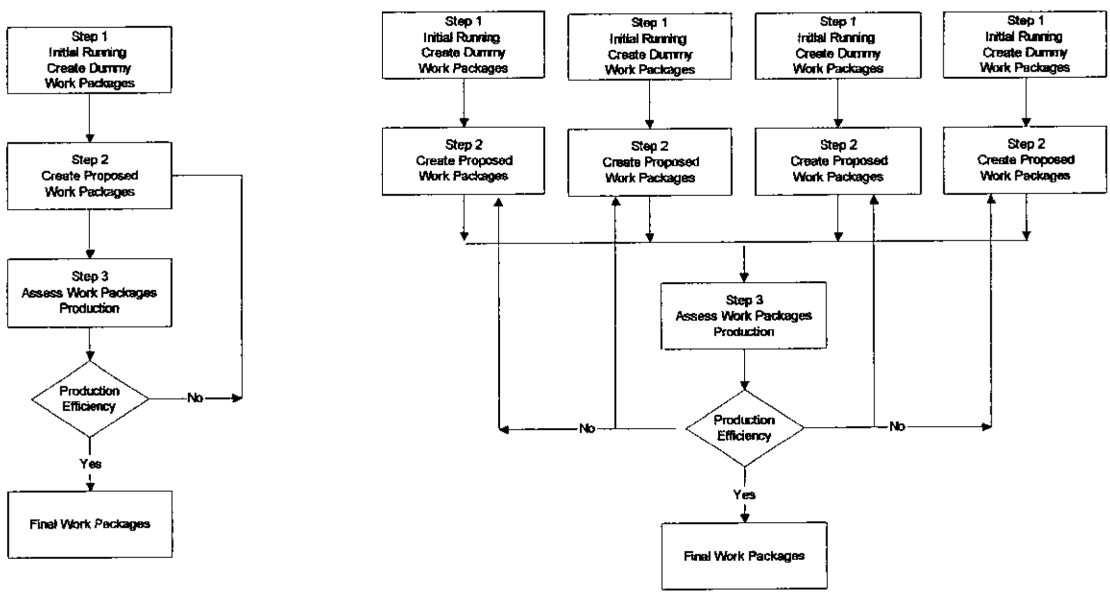

Figure 4: Iteration of steps with one traditional boatyard, and extended to show iteration for a model with several traditional boatyards

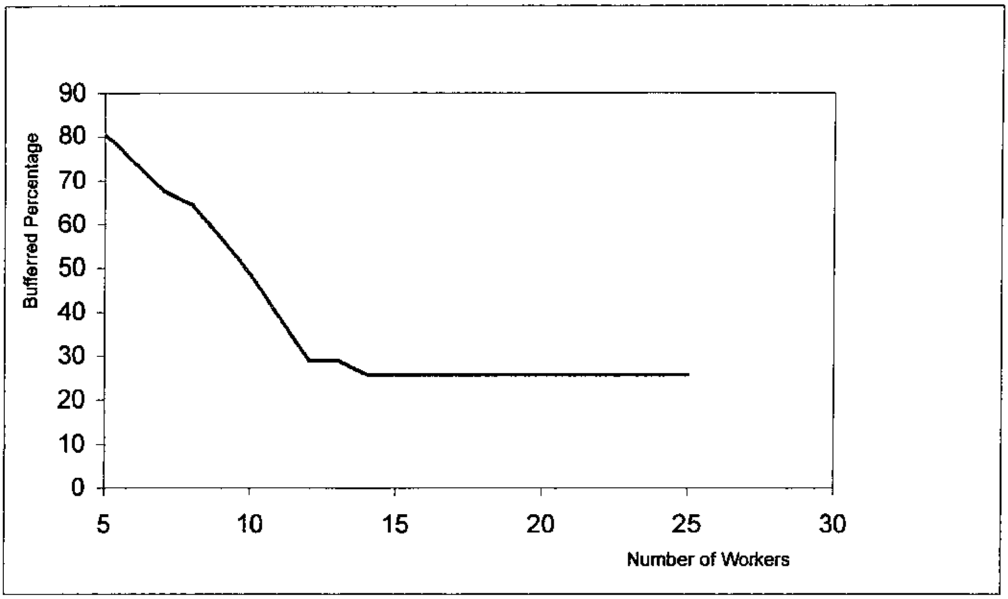

Figure 5: Simulation result: Buffers vs number of workers

them efficiently. The step therefore is to asses the work packages in the main shipyard module to see how efficiently the packages can be produced. If the work packages are not satisfactory in the context of the main shipyard, adjustments are made to the work content and so new packages are proposed. When this is necessary then the work packages have to be checked down stream again, in both the transportation and traditional boatyard modules, by repeating the second step. Several iterations may be needed until the work package can be produced at a reasonable cost and in acceptable time. The process is only complete when the configuration of the work packages is such that it satisfies the efficiency requirements of all simulation modules.

The iterative loops required between the three steps are shown in Figure 4. Firstly this shows the simulation of a system using only one traditional boatyard as the sub shipyard. This is a necessary initial stage in the formulation of the work packages, however the final result must be obtained from a simulation of the entire proposed distributed production organisation, also shown in Figure 4. At this stage the iterative loops follow the same pattern, although the complexity increases.

5 Demonstration of result

The simulation model can be used to explore the behaviour of a distributed production system, as well as to develop the optimal work package configuration. The first of these two procedures can be used to identify which traditional boatyards are most appropriate to include in the production system. The work packages can then be developed specifically for the adopted yards.

One aspect of the behaviour of the system is demonstrated in Figure 5. This shows that the required storage capacity (buffer size) in the traditional boatyards can be reduced by a factor of three if the work force in the yard is increases from 5 to 12 people. However no further reduction in storage capacity is possible, even if the work force is dramatically increased.

The impact of effectively configuring work packages is demonstrated in Figures 6 to 9. These

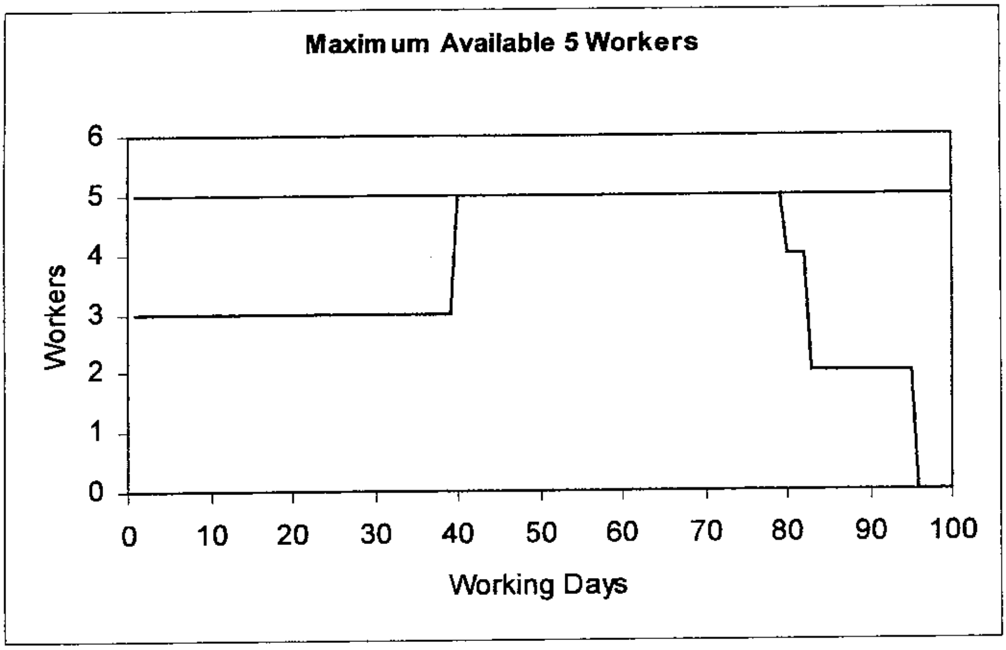

Figure 6: Traditional boatyards with 5 workers

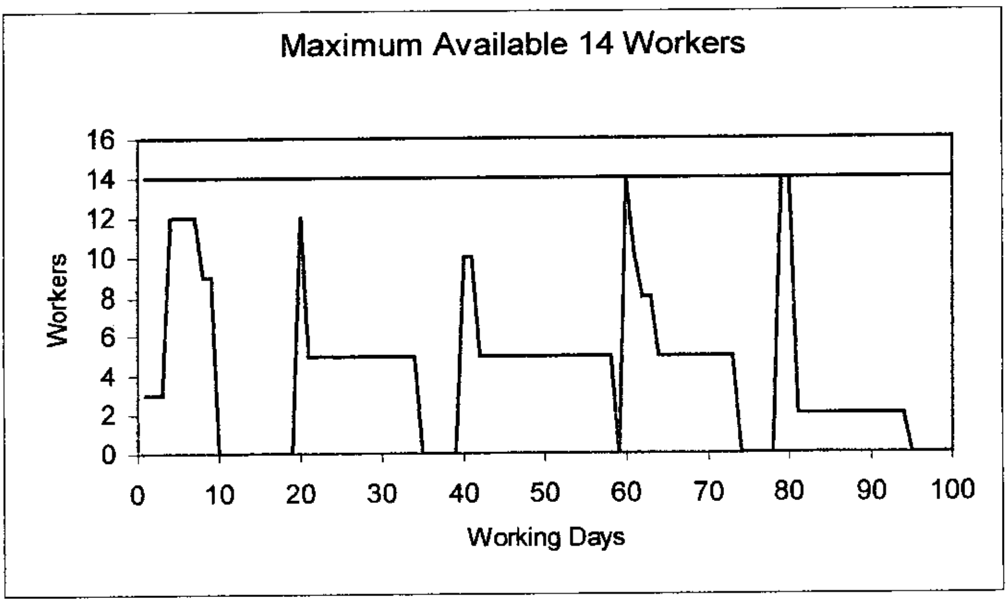

Figure 7: Traditional boatyards with 14 workers

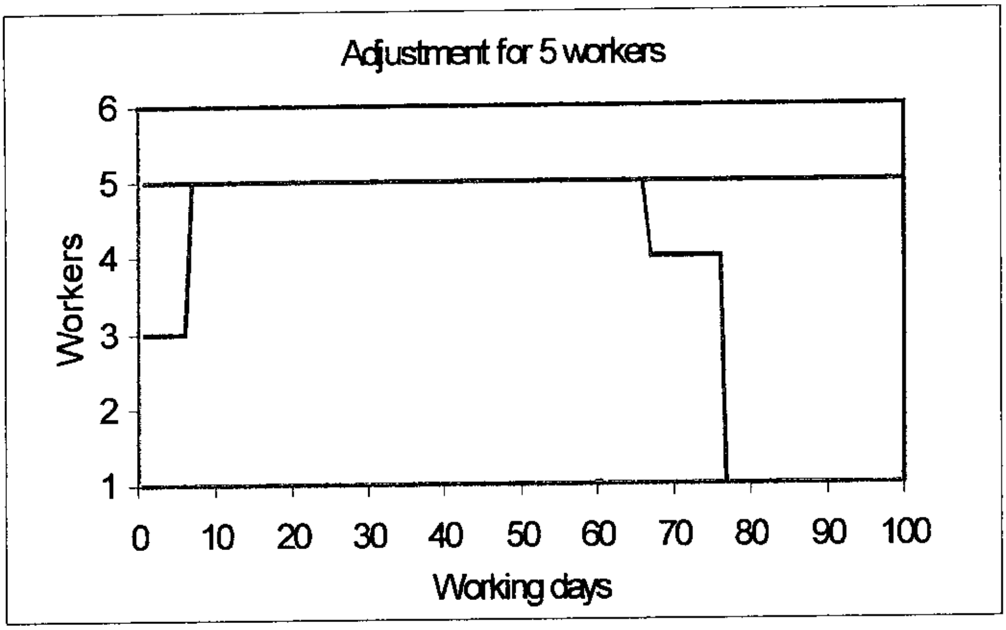

Figure 8: Adjustment results for 5 workers

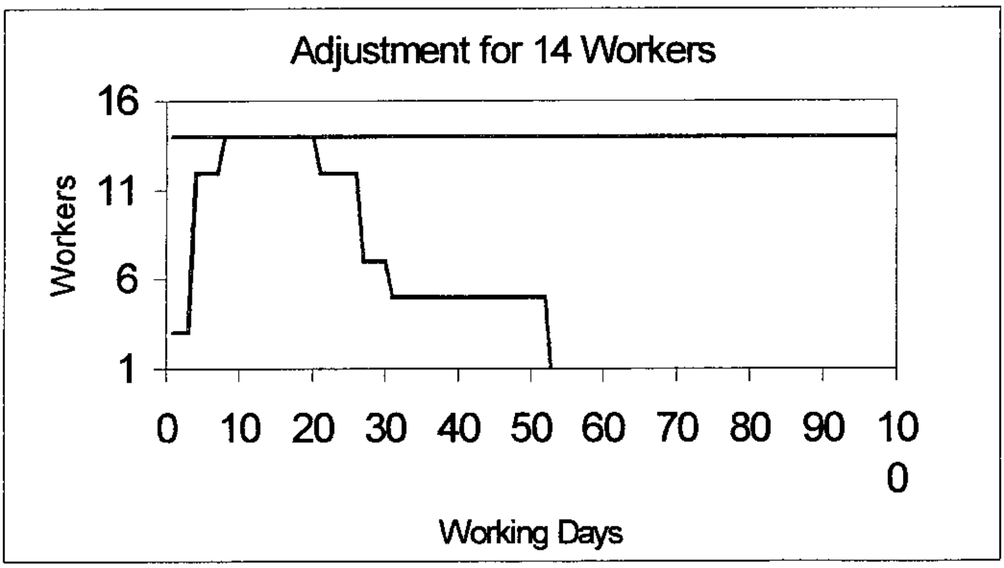

Figure 9: Adjustment results for 14 workers

figures show the level of worker utilisation in a traditional boatyard during the construction of one vessel. Figures 6 and 7 are for boatyards with 5 and 14 workers respectively, and indicate the level of worker utilisation that can be anticipated when supplied with standard work packages (i.e. before the step two adjustments discussed above). In the smaller boatyard only 3 of the 5 workers will be able to be used assembling the supplied packages during the first 40 days, and in the larger yard less than half of the 14 man work force is utilised for much of the time. In real conditions the other workers would not be completely idle, but the simulation does indicate that for a large proportion of the building time many of the workers in both yards would not be working effectively, and as a result the time to completion would be around 96 working days in both yards, with a statistical margin of error of five per cent.

In the larger boatyard one solution appears to be to reduce the size of the work force, but in many cases in the context of traditional artisanal facilities this is not an acceptable option. However by adjusting the configuration of the work packages and the time of delivery to the yards a more efficient utilisation of the available man hours is possible. For the smaller boatyard Figure 8 shows that adjustments to the work packages can greatly increase efficiency, with the result that completions is achieved twenty days earlier.

For the larger boatyard, with 14 workers, adjustment of the work packages does not result in such complete worker utilisation (as shown in Figure 9) However for at least half of the build time efficiency is high resulting in the time to completion being reduced by more than forty days. In addition it is evident by inspection of Figure 9 that there is the possibility of the start of the assembly of the next vessel being overlapped to further increase efficiency.

6 Conclusion

The development of traditional Indonesian boatyards can be facilitated by setting up a collaborative scheme where a large and technically advanced shipyard provides work packages for distribution to traditional boatyards, who the complete the vessels using simpler technology. The advantages of this scheme are that it avoids capital intensive development while introducing more advanced building procedures to the yards, and improved designs of fishing boat. The traditional boatyards can continue to progress their development by taking on more of the upstream work. This process can be timed according to the boatyards own aspirations, and can be aligned with the fishing industry's requirements whether considered at the local, national or regional level. If successfully implemented the results of this development strategy will be twofold. Better boats will be produced, which is prerequisite for an effective and efficient fishery, and better managed and more efficient traditional boatyards will be developed. These yards will be able to either collaborate or compete with the modern shipyards in building the boats required by Indonesia in order that it can exploit its fishing potential.

This paper has described how the simulation of such a distributed production system, which will inevitably be reliant on the existing Indonesian transport infrastructure, can be used to set up such a system. The simulation model is a tool that can both identify appropriate boatyards to include in the scheme, and develop work packages that will ensure that the main shipyard and the traditional boatyards will be working efficiently. Before this scheme can be implemented much further work is required, much of it of a non technical nature, but as a development strategy the proposed scheme will spread jobs evenly throughout the Indonesian archipelago and should be a positive agent in raising the quality of life for fishing communities.

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