American Journal of Mechanical Engineering, 2023, Vol. 11, No. 3, 115-123
Available online at http://pubs.sciepub.com/ajme/11/3/3
Published by Science and Education Publishing
DOI:10.12691/ajme-11-3-3

Plant Layout Factor Impact to Attaining Optimal Approach in facility Layout Design in Plywood Industry

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Received September 03, 2023; Revised October 04, 2023; Accepted October 11, 2023

Abstract The research focus is redesigning the facility layout of Piedmont Plywood Industry, Port Harcourt, Rivers State, Nigeria. Optimal approach to productivity and cost to yielding in facility layout design modifications is the trend in this research work. The facility layout modification central idea is the plant layout factor. Plant layout factor deals path modification. That is arrangement of machine, equipment and work stations as close as possible for optimal utilization of available space in the work environment. The productivity index for the current layout or the existing layout is 0.000275m3/Naira. The Alternative 1 modification productivity index is 0.000289m3/Naira and that of Alternative 2 modification is 0.000296m3/Naira. This is an indication of higher rate of return on investment for the two alternative layout modifications. It is interesting to note that the results of the productivity index impacts positively on labor and capital cost of investment in such manner that there is tremendous cut back. The Alternative 1 modification resulted in total cost savings of N1,015,411.00/month while that of Alternative 2 is N1,436,545.00/month. These constitutes tremendous cut back on investments when accumulated over years. The Piedmont Plywood Product Industry and other wood product industries are strongly advised to inject the findings of the alternative layout modifications in the existing factory layout designs.

Keywords: *productivity index, current layout, alternative layout modification, higher rate of return on investment*

Cite This Article: Mathew Shadrack Uzoma, and Eseonu Obi, "Plant Layout Factor Impact to Attaining Optimal Approach in facility Layout Design in Plywood Industry." American Journal of Mechanical Engineering, vol. 11, no. 3 (2023): 115-123. doi: 10.12691/ajme-11-3-3.

1. Introduction

Equipment arrangement pattern has been object of great concern in production factories. In the sixth international conference in industrial engineering and operation management (IEOM), 2016 at Kualla Lamput Malaysia, equipment facility layout was discussed to have diverse effect on production industry's competitiveness with regard to cost, processes, capacity and flexibility. These implications are of great concern worldwide regarding handling the associated uncertainties.

Spiraling inflation, deforestation and climate change and depletion of forest resources have led to increased production cost in the wood industry with resultant drastic reduction in profit margin [1]. Table 1 shows wood consumption trend by different countries of the world from 2013 to 2017.

This research work is on Plywood as a product of the wood industry.

The United State is the second largest consumer of plywood products next to china, The consumption trend nose-dived between 2014 and 2015. It shows tremendous improvement between 2015 and 2016 and marginally between year 2016 and 2017. These two countries use the product for building construction, repairs and modeling. The consumption rate by the two countries represents 63% of plywood product usage [2]. The focus of this research is redesigning the facility layout of Piedmmont Plywood as a case study. The alternative redesigned layouts are to portray the beauty of cost and processes productivity optimization of a proper facility layouts.

2. Literature Review

Apple [3] broadly categorized facility layout into plant layout and material handling. Sarin [4] in his eclectic approach defined the varius aspects of factory layout to include flexibility, safety and ease to supervise factory operations among others. Drira [5] injected that personnel, machine and everything that participates in manufacturing are part parcel of facility layout. Tompkin [6] highlighted that the fusion between plant layout and material handling is imperative in the optimal design of facility layout and it is a huge part of enhanced productivity. To create definitive understanding of Tompkin concept of productivity, Heinz and Render [7] defines productivity as ratio of output (products) to input (resources, capital, etc). The depletion of these resources reduce productivity. It has been emphasized by Tompkin [6] that a better facility layout will lead to 10% to 30% increase in operating cost reduction. Tompkin [6] agreed with Frazelle [8] statement that cost optimization could be achieved by reducing material handling activities. On common platform of thought they both agreed that material handling contributes 20% to 30% of production cost in factory. Hence factory layout design is an integral decision making process in industries.

To design and redesign existing factory layout, according to Apple [3] impact must be on two factors mainly plant factor and material handling factor. The plant layout factor objectively minimizes flow paths and to optimize on direct flow paths. Tompkin defined direct flow path as flow from origin to destination excluding backtracking. According to Mayer and Steves [9] backtracking is any backward movement in the flow. Any flow path should be designed to get of backtracking and cross trafficking to a greater measure. The reason behind this novel idea is to drastically reduce material handling time between work stations to optimize on distance and cost of material handling. Flow path optimization subject to backtracking and cross trafficking issues has qualitative and quantitative implications.

Material handling is the moving, controlling and protecting materials in the work stations [6]. Apple [3] categorically stated that material handling constitutes 50% to 70% of the activities in a factory. Tompkin [6] added that it has about 15% to 70% cost effect in the expenditure in manufacturing industry.

Summarily, material handling labor factor, according to Sule [10] is defined as:

$$\text{Material labor ratio} = \frac{\text{Personnel Assigned to Handling Activities}}{\text{Total Operating Personnel}}$$

Sule [10] also defined storage space utilization ratio as:

$$\text{Storage space utilization ratio} = \frac{\text{Storage Space Occupied}}{\text{Total Available Storage Space}}$$

Facility layout evacuation measures the impact of factory layout on cost and productivity.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Production cost}}{\text{Labor cost} + \text{capital cost}}$$

The monthly record of output and input resources are measured from cost records.

Referring to the productivity formula, labor resources include employees salaries and remuneration while capital resources are raw materials, cost of machines, equipment, etc. Productivity report of the current or existing layout is compared along side the proposed alternatives to derive the facility layout factor on productivity.

3. Research Significance

Although plant layout are planned meticulously because in economic terms it could br wasteful to continue redesigning the layout. The significance of the research is to emphasize the need for management to revisit their layout design to seek for optimality .in productivity parameters as they impact on day on day to day activities of the establishment.

The prevailing parameters are such as:

(i) Ease of facility expansion
(ii) Smooth measurement of process flow
(iii) Ease of material handling
(iv) Output needs
(v) Space limitation
(vi) Easy communication between units
(vii) Safety and health issues

Table 1. Wood Products Consumption *Source: fuller (2009)*

Wood Resources Consumption (Domestic +Net export) in million cubic meters					
	2013	2014	2015	2016	2017
Lumber					
U.S	178.5	158.3	136.8	121.9	168.3
Africa	104.4	109.4	97.5	89	98
China	30.3	34.2	34	30.8	35.5
TOTAL	313.2	301.9	268.3		
Plywood					
U.S	16	14.1	12.1	10.4	12.7
Africa	8	8.4	8	7.2	7.9
China	30.6	33	3.4	27.5	30.2
TOTAL	54.6	55.5	23.5	45.1	50.8
Particle Board					
U.S	10.1	9	7.8	6.7	8.7
Africa	34.8	36.4	33.8	30.5	34
China	8.1	8.9	8.3	7.4	9
TOTAL	53	54.3	49.9	44.6	51.7
MDF/HDF					
U.S	6.6	6.2	5.4	5.4	6.6
Africa	11.7	21.1	12.3	11.4	12.5
China	25.2	27.8	25.5	22.7	27.8
TOTAL	43.5	55.1	43.2	39.5	46.9

4. Material and Methods

A. Preamble

In industrial engineering, Yin [11] defined case study as the acquiring depth of understanding with the aid of real life situations. This research utilizes Piedmont Plywood Industry to investigate the cost and process productivity of a proper facility layout. The objective like earlier stated is to redesign the layout and compare its variable with the existing to deduce cost and productivity implications.

B. Data Required

The data required to analyze the cost and production implications of the proposed redesigned layout are made up the components in Table 2.

Table 2. Components for The Plant Layout

Facility Layout	Data
Plant Layout	• Form to chat • Activity relationship • Distance between process activities • Transportation cost a unit load • Flow patterns

According to Eisenhardt [12], case study usage as a research tool comprises a lot of data integration method including questionnaires, interviews, archive documents etc. he also suggest that a good case study management is a work that handles variety of sources. This chapter discusses the topic with concentration and discus available qualitative and quantitative research data. The interviews with company's top management technical staff as a source of qualitative research data is shown in Table 3.

Table 3. Interviews With Management Technical Staff

Name	Company Position	Date	Interview duration
Engr Ofon Ubong	Operational manager	06-08-2018	1hr 20mins
Mr. Gift Simon	Supervisor 1	06-08-2018	55mins
Mr Ansalem Ola	Supervisor 2	08-08-2018	50 mins

C. Plywood Manufacturing Process

The process of manufacturing plywood is made of the processes in Figure 1. The process follows a simple route where the only disparity occur only in the work-in-progress 2 (WIP2) and the dimensional cutting process.

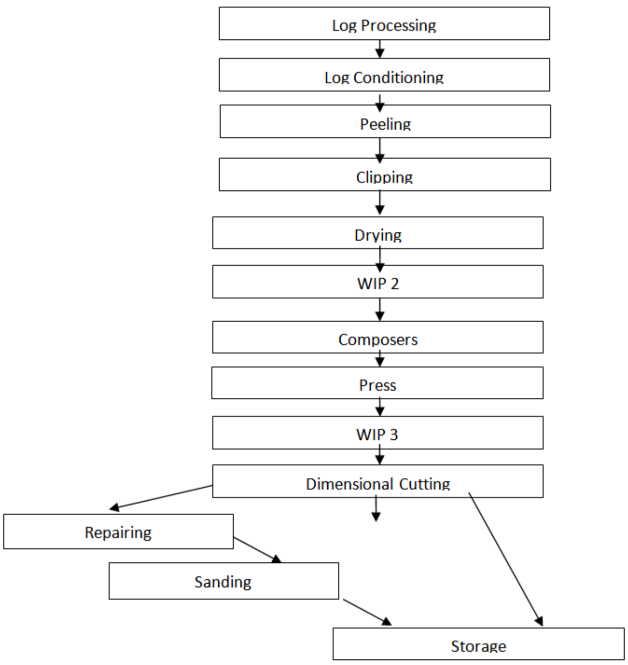

Figure 1. Process Algorithm

Log Processing: After Acquiring Forest Logs, the barks are removed by a machine with a special knife and are cut into required length and prepared conditioning process. Then they are transported to the next process.

Log Conditioning: After debarking the logs, the logs are immerse into a huge hot water body about 80°C to obtain softness and plasticity, which is first done for about 2 weeks. Then the logs are loaded for peeling.

Peeling: After conditioning, the logs are peeled by the peeling machine at 40°C temperature. The peeled bark from the peeling is utilized as fuel to power the boiler. After peeling, logs are sent for the clipping by a conveyor..

Clipping: This process involves the cutting of the logs to uniform layers (veneers), then treated according to specifications to remove defects and stacked before transported to the dryer. The treated veneers are called randoms.

Drying: in this process, the veneer goes through the dryer to lose humidity after which veneers are stack in the storage area (work in progress area 2) to be stored for 48 hours to stabilize its temperature. Then moved to the next process in a trolley.

Composer: At this stage, knives are used to cut the randoms to eliminate defects. Then the composers are glued to obtain short Veneers. These veneers when glued and assembled

Gluing and Assembly: From the composer, short veneers received and are glued and are assembled until required thickness is achieved according to specification. They are then moved for pressing.

Press: The glued veneers are moved into a cold pre-press where they are compressed together. Afterwards they are moved for hot press. In this stage, pressure is applied to the veneer to finish the assembled gluing, and then moved to the work in progress 3 for 12 hours cooling.

Dimensional cutting: After cooling, the plywood in this stage are cut according to dimension, then veneers are moved between either 3 possible routes. Sanding, preparing or straight for storage. The route will be determined by the state of plywood produced.

Repairing: In this stage, the defected plywood are repaired by removing the top defected part of the plywood and repaired with polyurethane. Repaired plywood are moved for sanding.

Sanding: The finished plywood are sanded for finishing and then moved for storage.

D. Plant Layout Factor Analysis

The current state of the plant was designed previously in the installation of the industry. Figure 2 is schematics of the current layout.

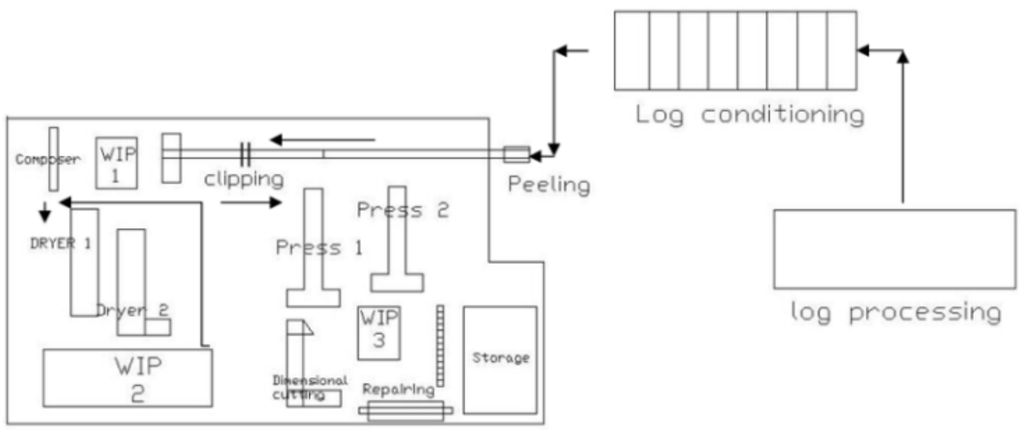

Figure 2. Current Layout Schematics

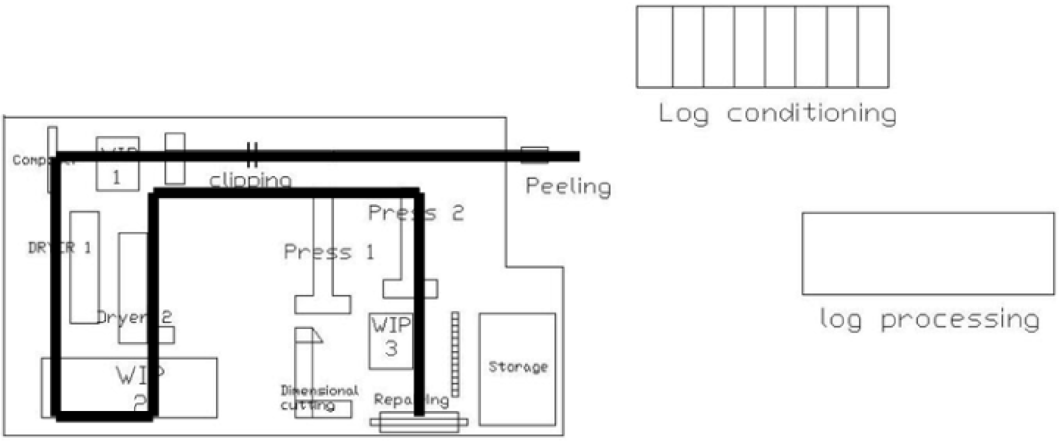

Figure 3. The s-shape pattern

This current layout is an s-shape pattern plant layout. This is good mainly because it effectively utilized the space. Despite the merit of the s-shape pattern, there are backtracking concerns that increase the process transportation and the increases likelihood of cross trafficking. Figure 3 shows the s-shape pattern.

After careful study, the two reasons why the s-shape pattern fits the plywood industries are

1. Basically, the process has one route till the dimensional cutting. The s-shape is good because the available space can be properly utilized without the concerns of cross traffic amongst processes.
2. Reduced process time: if the process was not s-shaped, the entire process will consume more time and the space will not be duly utilized.

E. Back tracking

The problem of back tracking adds to the distance of the material travel and increasing transportation. In this regard the current existing layout has two problems

1. Between the work-in-progress 2 and the composer, after drying, the veneers must travel back towards the composer located near dryer1. This increases the total transportation travelled. Figure 4 illustrates back track.

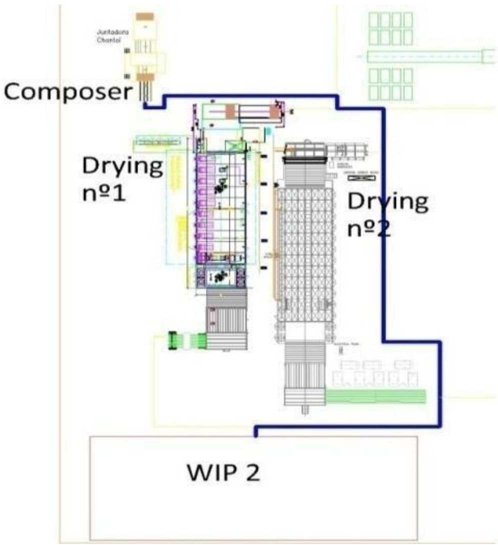

Figure 4. Back Tracking 1

1. After the second pressing machine 2, the veneer travels backwards towards the dimensional cutting shown in Figure 5.

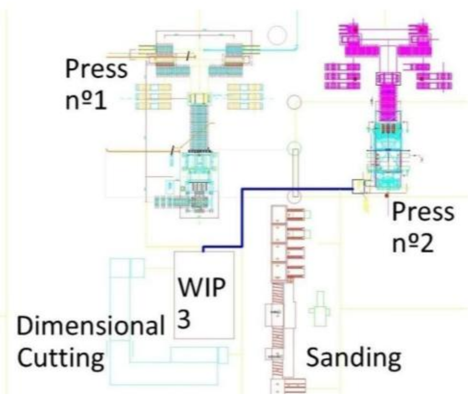

Figure 5. Back Tracking 2

Table 4. Process distance

Processes	Path Number	Distance (meters)
Log Processing ⟶ Log conditioning	1	24.15
Log conditioning ⟶ Peeling	2	26.89
Clipping(upper output) ⟶ drying		35.33
Clipping(upper output) ⟶ drying	3	44.80
Clipping(upper output) ⟶ drying		18.87
Clipping(upper output) ⟶ drying		14.25
Drying ⟶ WIP 2	4	34.81
Drying ⟶ WIP 2		36.14
WIP 2 ⟶ composer	5	18.67
Composer ⟶ WIP 1	6	14.26
WIP 1 ⟶ Press 1	7	34.81
WIP 1 ⟶ Press 2	8	139.46
WIP 2 ⟶ Press 1	9	143.62
WIP 2 ⟶ Press 2	10	172.63
Press1 ⟶ WIP3	11	18.04
Press 2 ⟶ WIP3		33.61
WIP 3 ⟶ Dimensional Cutting	12	4.15
Dimensional Cutting ⟶ repairing	13	20.59
Dimensional Cutting ⟶ sanding		44.67
Dimensional Cutting ⟶ storage(finished product)		78.63
Repai ⟶ Sanding	14	59.02
Sanding ⟶ Storage (finished product)		40.64

F. Cost evaluation

The cost evaluation of distances is the major way of evaluating the process flow. The distance is measured from the beginning of the process to the end of the process as displayed in the Table 3 below. The glue and assembly distance are not added because they are categorized to the pressing process and have negligible distance between them.

Although the added distance due to back tracking cannot be completely removed, but the distance due to backtracking will be considerably reduced in the proposed modified plant layout.

Table 5 displays the different length of path. The clipping and press are integrated into one output because of their average distance for simplicity.

The processes with considerably close average distance are merged together into one output to simplify comparison of the corresponding path between the current and the proposed layout redesign. The distance in path is represented in the Table 5.

Table 5. Distance in the paths

Path	Distance (meters)
1-2-3-4-5-6-9-10-11-12-13-14	424.38
1-2-3-4-5-6-9-10-11-13-14	389.44
1-2-3-4-5-6-9-10-11-14	482.76
1-2-3-4-5-6-7-8-9-10-11-12-13-14	541.16
1-2-3-4-5-6-7-8-9-10-11-13-14	506.22
1-2-3-4-5-6-7-8-9-10-11-14	499.54

	From/to (unit load=3 m3)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Log Processing	x	8435,67												
2	Log Conditioning		x	4499,02											
3	Peeling			x	2399,5										
4	Clipping				x	2207,52									
5	Drying					x	1942,62								
6	WIP 2						x	300,33		1642,29					
7	Composer							x	285,31						
8	WIP 1								x	285,31					
9	Press									x	1889,05				
10	WIP 3										x	1889,05			
11	Dimensional cutting											x	944,52	566,71	377,81
12	Repairing												x	944,52	
13	Sanding													x	566,71
14	Storage														x

Figure 6. Form to chat activity relationship

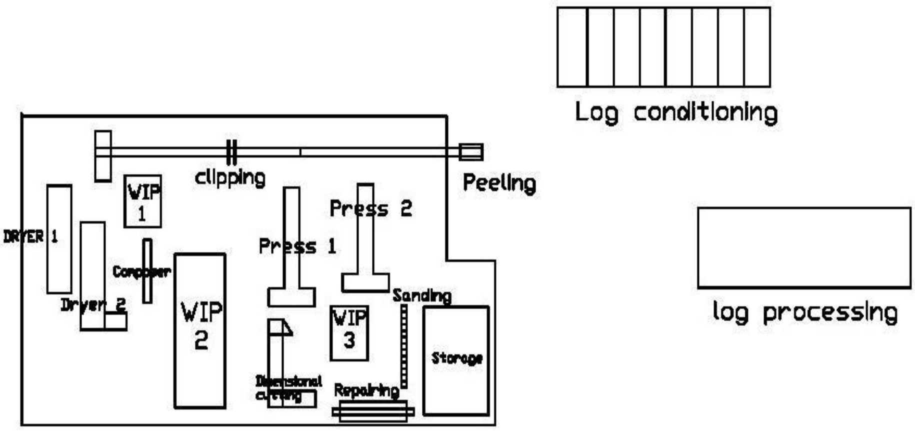

Figure 7. Facility Layout alternative 1

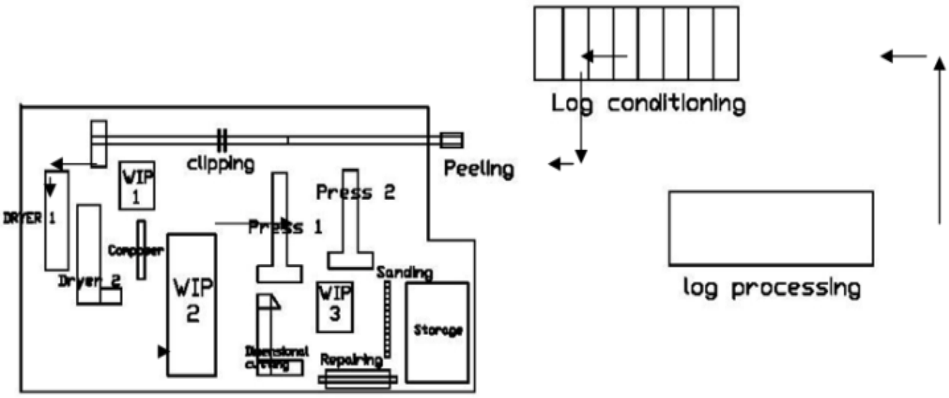

Figure 8. Alternative 2 Layout Modification

In Table 5, the back tracking distance shows the longest distances. They are;

1. The distance between the work in progress 2 and the composer
2. The press2 to the work in progress 3

In evaluating the existing layout, it is good to define explicitly the process flow and transportation cost for the unit load. The best method as discussed in chapter 2 is the form to chat method showing the factory's production summary.

Basically, operations are achieved by two material handling equipment moving materials between processes. These equipments are the front loader and the crane fork and they have the same capacity of approximately 3m3. Thus the unit load is defined as 3m3. The front loader performs log processing, Log conditioning and peeling while other movement throughout the process are performed by the crane fork.

The operation cost of transporting a unit load by crane fork established by company is N1500.00 and front loader is N5000.00. This cost includes operators' salaries, fuel and maintenance.

These costs values are estimated values the company spends to rent these machinery monthly.

Table 6 shows the incurred cost in the many route materials can flow. Materials flow is divided in two main parts. They are

1. From the log processing to the work in process area
2. From the press to the dimensional cutting.

The table above displays that the processes with the highest cost are the ones performed by the crane fork because the front loader has considerably high expenses compared to the crane fork. Also, the processes of the early stages that involve forest resources are moved considerably much distance than the later processes. In path 2b, the incurred cost for process 13 and 14 are not included owing that it has already been included in path 2a, thus the monthly total incurred cost is N 6,099,215.

Table 6. Transportation cost in path

Path	Cost (N/month)
1) 1-2-3-4-5-6	3,596,160
a) 6-9	483,000
b) 6-7-8	1,490,009
2) 9-10-11	198,169
a) 11-12-13-14	182,698
b) 11-13-14	89,924
c) 11-14	55,255
Total	6,099,215

G. Productivity Evaluation

As stated in chapter 2, productivity is derived by comparing the output to the input and is given by the formula

$$\text{Productivity} = \frac{Production(m^3)}{labour + Capital\left(naira\right)}$$

The input in this statistics only includes the volumetric produce of 5,600m^3 worth of finished plywood for a 1 month period without including equipment purchase and others.

The variables from Table 7 will be utilized to ascertain the productivity factor and the proposed alternative layouts modification design can be compared. Therefore, the productivity (productivity factor) for the current or existing layout is computed as:

Table 7. Resources and cost

Recourse	Monthly values
Output Production	5,600 (m^3)
Input Labor Capital Raw materials Machine maintenance Material Handling Equipment Transportation Electricity Others	2,808,000 10,715,364 432,000 6,099,215 180,000 150,000
Total	20,384,579

$$Productivity = \frac{production}{labour + capital}$$

$$= \frac{5,600\left(m^3\right)}{2,808,000 + 17,576,579\left(naira\right)}$$

$$= 0.000275\text{m}^3 / \text{ naira}$$

Table 8. Process distance for alternative 1

Processes	Distance (meters)
Log Processing → Log conditioning	24.15
Log conditioning → Peeling	25.89
Clipping(upper output) → drying	35.33
Clipping(upper output) → drying	44.60
Clipping(upper output) → drying	18.67
Clipping(upper output) → drying	14.26
Drying → WIP 2	34.81
Drying → WIP 2	36.74
WIP 2 → composer	67.87
Composer → WIP 1	1.95
WIP 1 → Press 1	61.59
WIP 1 → Press 2	90.6
WIP 2 → Press 1	143.62
WIP 2 → Press 2	172.63
Press1 → WIP3	43.22
Press → WIP3	13.75
WIP 3 → Dimensional Cutting	12.91
Dimensional Cutting → repairing	16.66
Dimensional Cutting → sanding	51.18
Dimensional Cutting → storage(finished product)	60.13
Repair → Sanding	17.67
Sanding → Storage (finished product)	24.53

H. Matlab Algorthm For Productivity

```
%Program that computes the productivity given,
% the total production, total labour cost and total capital cost
%
production = str2num(input('Enter the Production: '));
labourCost = str2num(input('Enter the total Labour cost '));
capitalCost = str2num(input('Enter the total Capital cost '));
```

```
ratio = production/(labourCost + capitalCost);
disp('Productivity = '+ratio);
```

I. Plant layout alternatives

a. Practical Limitations

In the attempt to rearrange the equipment layout, certain stringent considerations were put in view to decipher the plausibility of these alterations. Highlighted by the staffs interviewed, some challenges would be uninstalling the heavy duty machines and their installations may take at least 3 to 4 months. This is peculiar to peeling and the drying process. For the dryer, if the duct that goes to the boiler is moved, it may become complicated and create pressure problems. For pressing process, the equipment foundation and skids would be expensive to construct.

b. Alternative 1

In the first modified design, the form to chart and activity relationship was considered and this alternative design was created. In this modification, the position of the composer, dimensional cutting, repairing and sanding process are moved. The Figure below displays the changes. The composer was moved closer to the pressing process which is also near the work in progress area 2. The repairing process was also moved closer to the sanding.

c. Cost Evaluation

The table below shows path and total distances between them. To calculate the cost impact, the data required is the flow path distance and the transportation cost with the flow path.

Table 9. Distances in path network

Path	Distance (meters)
1-2-3-4-5-6-9-10-11-12-13-14	373.46
1-2-3-4-5-6-9-10-11-13-14	365.78
1-2-3-4-5-6-9-10-11-14	374.73
1-2-3-4-5-6-7-8-9-10-11-12-13-14	361.25
1-2-3-4-5-6-7-8-9-10-11-13-14	378.1
1-2-3-4-5-6-7-8-9-10-11-14	362.52

The new path distances are less compared to the path distance in the current layout. In other to analyze definitively, the economic and productivity implication of the modification of the new alternative 1 layout, the associated costs of each path is displayed in Table 10.

Table 10. Cost of transportation in path

Path	Cost (NGN/monthly)
3) 1-2-3-4-5-6	3,599,150
c) 6-9	483,000
d) 6-7-8	690,000
4) 9-10-11	160,000
d) 11-12-13-14	90,690
e) 11-13-14	50,200
f) 11-14	13,750
Total	5,083,800

The combined monthly cost associated with transporting flow within the processes in this alternative design is N5, 083,800 which is N1, 015,415 lesser than that of the current layout monthly cost on transportation within the network. Implementing this alternative layout design saves the company N12, 184,980 annually.

d. Productivity Evaluation

The implication of this modification on the productivity is simple because with reduced input, and same output of 5600m^3 per month, the productivity increase poses to increase. Hence the table below depicts and defines the input and output recourses required in this alternative modification. Table 11 displays the cost of the input resources.

Table 11. Input recourses cost

Recourse	Monthly Cost
Output	
Production	5,600m^3
Input	
Labor	N2,808,000
Capital	
Raw materials	N10,715,564
Machine maintenance	N432,000
Material Handling Equipment Transportation	N5,083,800
Electricity	
Others	N180,000
	N150,000
Total Labor	N2,808,000
Total Capital	N16,561,169
Total Input	NN19,369,168

Table 12. Distances Between Processes

Processes	Distances (meters)
Log Processing → Log conditioning	24.15
Log conditioning → Peeling	26.89
Clipping(upper output) → drying	35.33
Clipping(upper output) → drying	44.80
Clipping(upper output) → drying	18.67
Clipping(upper output) → drying	14.26
Drying → WIP 2	76.49
Drying → WIP 2	12.52
WIP 2 → composer	26.82
Composer → WIP 1	4.37
WIP 1 → Press 1	56.67
WIP 1 → Press 2	85.18
WIP 2 → Press 1	64.40
WIP 2 → Press 2	93.41
Press1 → WIP3	43.22
Press → WIP3	13.75
WIP 3 → Dimensional Cutting	12.91
Dimensional Cutting → repairing	16.66
Dimensional Cutting → sanding	51.18
Dimensional Cutting → storage(finished product)	60.13
Repair → Sanding	17.67
Sanding → Storage (finished product)	24.53

$$Productivity = \frac{production}{labour + capital}$$

$$= \frac{5600\left(m^3\right)}{2808000 + 16561169\left(naira\right)}$$

$$= 0.000289\left(m^3\right)/naira$$

The reduction in the cost of transportation alters the combined capital input, hence increasing the productivity implication of the modified layout.

e. Alternative 2

In this modification, the work in process area 2 is moved because it restricts ease of flow around the dryer, the press and the composer. In addition, the composer and the work-in-process1 were also moved a biat transportation cost reduction. The Figure blow shows the modification of alternative 2.

f. Distances and Costs

The distance and cost for the alternative 2 plant layout were also calculated to enumerate the cost and productivity changes. The Tables 12 to 14 below highlight the distances and the associated.

Explicitly, there is a significant change in distance compared to alternative 1. For example the distance from the work in process 2 to the composer was reduced by 50.14m. In comparison, the reduced distance was achieved by eliminating mostly the backtracking movement. Now, this alternative has significantly reduced distance of 26.82m. Table 13 below clearly shows a significant change in the paths of new layout alternative.

Table 13. The Transport Distance Between Processes

Path	Distance (meters)
1-2-3-4-5-6-9-10-11-12-13-14	302.97
1-2-3-4-5-6-9-10-11-13-14	319.82
1-2-3-4-5-6-9-10-11-14	304.24
1-2-3-4-5-6-7-8-9-10-11-12-13-14	326.18
1-2-3-4-5-6-7-8-9-10-11-13-14	343.03
1-2-3-4-5-6-7-8-9-10-11-14	327.45

Table 14. Monthly Costs between Paths

Path	Cost (N/month)
5) 1-2-3-4-5-6 e) 6-9 f) 6-7-8	3,596,160 241,450 510,420
6) 9-10-11 g) 11-12-13-14 h) 11-13-14 i) 11-14	160,000 90,690 50,200 13,750
Total	4,662,670

Table 15. Recourses Input

Recourse	Monthly values
Output Production	5,600 (m^3)
Input Labor Capital Raw materials Machine maintenance Material Handling Equipment Transportation Electricity Others	N2,808,000 N10,715364 N432,000 N4,662,670 N180,000 N150,000
Total Labor	N2,808,000
Total Capital	N16,140,034
Total Input	N18,948,034

For productivity, since the associated cost in the path distance is reduced, the productivity would definitely increase compared to alternative 1. Table 15 describes the input resources.

$$Productivity = \frac{production}{labour + capital}$$

$$= \frac{5600\left(m^3\right)}{2808000 + 16,140,034\left(naira\right)}$$

$$= 0.000296 \mathrm{m}^3 / \text{ naira}$$

For this alternative layout design, Table 15 above shows a further reduction in transportation costs which will as well alter the productivity. In this alternative 2, the company saves N1, 436,545 monthly if implemented and an annual savings of N17,238,540. The productivity is as calculated below:

5. Recommendations

The topic of facility layout is huge and the aspects considered in this dissertation constitute only a small portion of the scope. Different companies have different facility layout structures and the areas for improvements are great. Thus, it is recommended that facility engineers should focus beyond their company layout and operations but also consider possible modifications from other similar companies operations. Therefore, to corroborate the views of this dissertation, more case studies should be researched with supportive conclusions in revenue generation and percentage return on investment.

6. Conclusion

From the current state of the layout progressing from Alternative 1 modification to Alternative 2 modification, the productivity index substantially improved. This is an indication that the alternative layout are prone to greater return on investment. In the same vein, the company will saving N1.02 million monthly if Alternative 1 should be implemented while Alternative 2 modification will yield N1, 436,545 monthly. What a great financial relief on investment if the company implements any of the two alternative layouts modifications

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