American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-10, Issue-12, pp-214-220
www.ajer.org
Research Paper Open Access

System Design Approach for Layouts of an Industrial Park Development in a Developing Economy

Akinnuli, Basil Olufemi[1]
[1]*Department of Mechanical/Industrial Engineering, Federal University of Technology Akure, Nigeria*

Kareem, Biliaminu[2]
[2]*Department of Mechanical/Industrial Engineering, Federal University of Technology Akure, Nigeria*

Oluwadare, Samuel Adebayo[3]
[3]*Department of Computer Science, Federal University of Technology Akure, Nigeria*

Atoyebi, Adeyinka Abiodun[4]
[4]*Department of Mechanical Engineering, Osun State Polytechnic, Iree, Nigeria*
Corresponding Author: Atoyebi, Adeyinka Abiodun

ABSTRACT
Development of an Industrial Park (IP) Layouts has to be grouped adequately for seamless traffic if and only if all layouts are being grouped adequately into workable percentiles. There should be a template design for all the layouts in an Industrial Park design. By considering attributed factors of an Industrial Park, this research developed a system model that grouped allocation of Industrial Development plan for Land allocated space: Plant Building Layout and Supporting Layouts. The Plant Building Layout comprises of Industrial Buildings areas and Road networks areas. The Supporting Layouts comprises of Commercial Centers, Cars and Lorry Parks Centers, Recreational centers and Utilities and Service Stations. From visitation to different isolated industries, a model was developed and data was collected from five industries at different isolated geographical region to validate. From the computed results, the following average percentages were established: Commercial Center 5% of IP acreage; Cars and Lorries Park Centers as 10% of IP acreage; Recreational Centers as 4% of IP acreage and Utilities and Service Stations as 11% of IP acreage. The total supporting layouts made 30% of the acquired Land, while real Plant Building Layout took 70%. This percentage template layouts served as a tool which guided an Investor in developing a seamless and workable Industrial Park Layout. All the layouts were linked together and economically established when combined to form a single IP.

KEYWORDS*:* *Industrial Park (IP), Plant Building Layout, Supporting Layouts, Percentage.*

Date of Submission: 16-12-2021 Date of acceptance: 31-12-2021

I. INTRODUCTION

A basic condition for an Industrial Park (IP) to be economically viable is to demonstrate that the sum of benefits achieved by working collectively is higher than working as a standalone facility [1] .

Industrial Park Layout should be the first tool any Industrial Park Investor must lay his hand on. This tool will definitely guide in layouts planning within the tract of land available. Coming together of all Industries in a Park will definitely reduce the cost of start off for not being Isolated and increase the advantages of enjoying amenities within the park.

Industries in an Industrial Park will enjoin common facilities together to minimize their cost of investment and to encourage industrialization.

Through this percentage layouts, basic amenities will be in place and at good position that will be convenient for investor for maximizing space and industrialists for accessibility. Since coming together of Industries in a park will reduce or eradicate acquisition of Land and will encourage Land leasing which will caters for future inflation to maximize income generation for investor, also minimize acquiring land without use. Bringing all Industries into an allocated park will definitely promotes so many aspects of Industrialization which will accrue income for investor.

Due to inability to lay hand on a workable system design Layout for Industrial Park, Industrial Park Investor has not been following any template to develop an Industrial Park which has been resulting to future layouts cumbersome. Nigerian as a case study, citizens do experience traffic around some of the Isolated Industries which was as a result of no provision of supporting layouts when developing such industry. Even aftermath remedy to the existing layout to minimize such problem has not been a good design that do accommodate future expansion of such supporting layout.

Industrial Park attracts foreign investors, increases the competitiveness of company products, staff renumerations and even enhance a good interacting medium between companies and the users. An engrossment of a variety of activities and services such as stable electricity, water and so on to support the industry can influence investors' decision to switch to such a region even if there is non-availability or no raw materials. Successful industrial parks can therefore become centers of growth and innovation, supporting local development and contributing to the development of the national economy [2].

This system design will also eradicate or minimize to the barest minimum, the era of procurement of land for industries which gives no annual returns to investor or acquiring lands for industries development without making use of reasonable percentage out of it. For an Investor who wishes to increase her revenue or income through developing an acreage tract of land for an industrial park, there must be a system model approach to be adopted for actualization. Therefore, an industrial system design layout approach model is in place that will give highest annual revenue or income to government or Investor for optimum allocation of space.

II. REVIEW LITERATURE

In the majority of studies of Industrial Park development, Energy and water system have always been optimized. Nair et al., (2016) developed a methodology for inter-plant heat integration in an IP. These authors also proposed to apportion the different costs of participating enterprises. Another recent study dealt with the optimal allocation of renewable energy sources in an IP with a MILP optimization model[4]. Moreover, very few studies deal also with raw material/products sharing in IPs[5]. On the other hand, regarding modeling and optimization methods, different recent studies deal with advanced decision-making techniques based on optimization in order to deal with the design of EIPs, staying based on the water-sharing network design (Chew et al., 2009) developed a game theory approach for the decision-making process for water integration in an IP.

Ramos, *et al.*, 2015 worked on multiple followers' methodology based on our previous study about game theory approach devoted to the design of water networks. Minimizing fresh water consumption is a valid environmental objection function, since only one resource is taken into account [8-10]. Ramos et al., (2016) developed an alternative methodology to multi-criteria optimization generally used in the field of process engineering, by applying the methodology in an industrial ecology context (water networks), by using multi-leader-follower game (MLFG) models due to the introduction of an EIP authority in the model. The latter research compared the obtained results with traditional multi-objective optimization results and proved that the proposed game theory model methodology was indeed more effective than traditional multi-objective/multi-decision optimization methods, e.g. goal programming. Andiappan et al. (2016) also demonstrated a framework that couples a cooperative game model with a stability analysis and a stability criterion[12]. Their work allows proposing a cost-optimal network by satisfying the stability of raw material costs.

At the present state, the optimization of EIP lies on the decoupling of networks. In the literature review, it is emphasized that authors optimized either the water network, or the energy links or waste disposal facilities but never the whole networking. However, it is important to optimize simultaneously the water and the energy network because these networks have to interact (through exchange of steam for instance) to increase the symbiotic relations among industries in an EIP. This issue also raises the specific barrier to collect a lot of data relative to each plant of the potential EIP. Facing this issue, a lot of fictive problems have been created to validate methodologies[1].

The design of eco-industrial parks is a part of these recent initiatives and, alongside of several years of qualitative studies, a lot of quantitative approaches are involved during the last years. Inherently, an eco-industrial park needs to operate optimally or near its optimal conditions regarding several antagonist objectives. The idea of industrial park development was based on several principles which most of all included allocation of specialized infrastructure in selected areas with the aim of decreasing costs connected to building infrastructure, and, furthermore, capability of a country to attract new investors, which would eliminate social and ecological impacts caused by industrial production[13]. Indirect benefits are difficult to verify but are very important for long-term economic development, including the creation of indirect employment through improved skills and training, technology transfer, regional development and good governance practices.

The most important gains from the establishment of industrial parks, which are reflected in the quality of life, are:
(i) creating direct employment, generating income and increasing per capita income;
(ii) Attract foreign direct investment;
(iii) avoid regulatory fines due to fees and waste;
(iv) export growth and diversification and the strengthening of government revenues;
(v) Increase the competitiveness of companies and increase sales through green marketing and with enhancing the mental image of companies to the consumer;
(vi) low waste management costs;
(vii) Reducing the costs of energy, water, transport and various resources used in production;
(viii) improving the business climate;
(ix) Integration with regional, national and international markets[14].
This study focuses on layout development of an Industrial Park which can cause disorderliness in any Industrial Park to minimize waste of land space and maximizing Plant Building layout.

III. METHODOLOGY

The method of this research is: identifying the attributed factors and its attributes of Industrial Parks, classify them and put into each classification into percentage of an Industrial Park acreage.

Attributed Factors of an Industrial Parks

To present a system design approach for developing industrial parks in a developing economy, some factors are to be highlighted and analyzed accordingly to develop a system for a standard industrial park land planning.

The factors are: Geographical Area (acres of land), Raw Materials, Government Policies, Transportation, Workforce, Power, Water System, Land/Buildings, Markets, Environment, Capital: such as financial & Technical, Social Infrastructure, Sewage, Waste Disposal, Natural and Climatic Considerations, Personal Factors, Technology, Health Center, Industrial Symbiosis and Industrial Guards/Police Post.

Industrial Park Land Facilities Percentage

The land facilities are percentile into two namely:

i. Plant Building Layout: Industrial Building and Road Networks

ii. Supporting Layouts: Commercial Centers; Cars and Lorries Parks Centers; Recreational Centers; and Utilities and Service Stations

The following are the details of the supporting layouts.

Commercial Centers: This is a place allocated for Shopping Center, Petrol Filing stations, Guest House/Hotels, lodging and boarding, service and repair shops, communications/Point of Sale (POS) booths, and so on

Cars and Lorries Park Center: This is a place allocated for cars and lorries moving in to wait for available of space before reaching the desired industry.

Recreational Centers: This is a place allocated for Buffer Zones, Parks, Sport Field, and so on

Utilities and Service Stations: This is a place allocated for Gas Station/Substation, Power Station/Substation, Common Effluent Treatment Plants (CETPs), Pumping Station, Underground Reservoir Station, Firefighting Stations and other utilities, and so on

IP = Plant Building Layout + Supporting Layouts 1

Plant Building Layout in acres of an IP

Supporting Layouts in acres of an IP (SLIP)

TI_L is the Total Industrial Land acreage of the sample industries

Where IP is the Industrial Park in acres
Layout for Commercial Centers of an Isolated Industries – L_{CC}
Layout for Cars and Lorries Parks Centers of an Isolated Industries – L_{CLC}
Layout for Recreational Centers of an Isolated Industries – L_{RC}
Layout for Utilities and Service Stations of an Isolated Industries – L_{USS}

x_i, i = 1, …, nth is the plant building areas to be leased to industries 1 through nth industries.

Summation of Layouts for Commercial Centers of an IP (u) = $\sum_{i=1}^{n} L_{CCi}$ 2
Summation of Layouts for Cars and Lorries Parks Centers of an IP (v) = $\sum_{i=1}^{n} L_{CLCi}$ 3

Summation of Layouts for Recreational Centers of an IP (w) = $\sum_{i=1}^{n} L_{RCi}$ 4

Summation of Layouts for Utilities and Service Stations of an IP (y) = $\sum_{i=1}^{n} L_{USSi}$ 5
n is the number of sample companies.

L_{CCi} is the layouts for Commercial Centers of an IP
L_{CLCi} is the layouts for Cars and Lorries Parks Centers of an IP
L_{RCi} is the layouts for Recreational Centers of an IP
L_{USSi} is the layouts for Utilities and Service Stations of an IP

n is the number of sample companies.

Supporting Layouts in acres of an IP (SLIP) = u + v + w + y 6

Supporting Layout for Commercial Centers of an IP = u % of TI_L 7
Supporting Layout for Cars and Lorries Parks Centers of an IP = v % of TI_L 8
Supporting Layout for Recreational Centers of an IP = w % of TI_L 9
Supporting Layout for Utilities and Service Stations of an IP = y % of TI_L 10

Table I: Data for layouts of five selected Isolated Industries

		Layouts of an Isolated Industries			
COMPANY NAMES	**Total Land acreage of an Isolated Industries (TI_L) - acres**	**Commercial Centers (u) - acres**	**Cars and Lorries Park Centers (v) - acres**	**Recreational Centers (w) - acres**	**Utilities and Services Stations (y) - acres**
Electrical Machinery Company	5	0.25	0.5	0.2	0.55
Cocoa Processing Company	10	0.5	1	0.4	1.1
Steel Mills Limited	11.5	0.575	1.15	0.46	1.265
Plastics Pipe Industry	14.3	0.715	1.43	0.572	1.573
Wire Industry Limited	12.1	0.605	1.21	0.484	1.331
TOTAL	TI_L = 52.9	u = 2.6	v = 5.29	w = 2.116	y = 5.819

Table I showed the data collected from five selected companies in Osun State Nigeria that will be used to validate the layout model developed.

IV. RESULTS AND DISCUSSION

Five Selected Companies were picked to run the model developed and they are as follows:
1. Electrical Machinery Company, Osogbo, Osun State
2. Cocoa Processing Company, Ede, Osun State
3. Steel Mills Limited, Osogbo, Osun State
4. Plastics Pipe Industry, Osun State
5. Wire Industry Limited, Osun State

Available data collected from the 5 companies listed are as follows:

To get Supporting Layout in acres
From
Layouts Summation for Commercial Centers of the five Isolated Industries (u) = 2.6 acres
Layouts Summation for Cars and Lorries Parks Centers of the five Isolated Industries (v) = 5.29 acres
Layouts Summation for Recreational Centers of the five Isolated Industries (w) = 2.116 acres
Layouts Summation for Utilities and Service Stations of the five Isolated Industries (y) = 5.819 acres
TI_L is the Total Industrial Land acreage of the five Isolated Industries = 52.9 acres

From equation 7 for **Supporting Layout for Commercial Centers of an IP** = u % of TI_L
% of u = u/ TI_L x 100
2.6/52.9 x 100

= 4.914
= 5% approx. of IP

From equation 8 for **Supporting Layout for Cars and Lorries Parks Centers of an IP** = v % of TI_L

% of v = v/ TI_L x 100

5.29/52.9 x 100

= 10 % of IP

From equation 9 for **Supporting Layout for Recreational Centers of an IP** = w % of TI_L

% of w = w/ TI_L x 100
2.116/52.9 x 100
= 4 % of IP

From equation 10 **for Supporting Layout for Utilities and Service Stations of an IP** = y % of TI_L

% of y = y/ TI_L x 100
5.819/52.9 x 100
= 11 % of IP

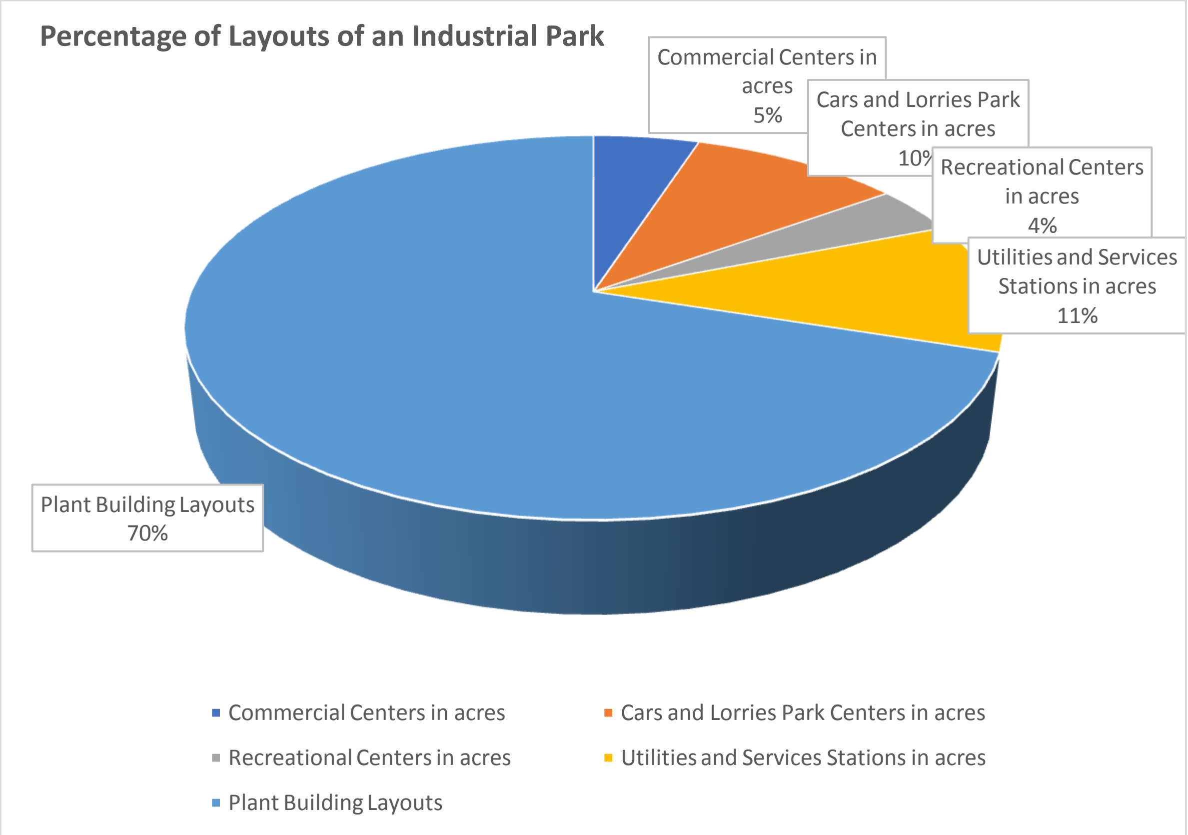
From equation 6,
Supporting Layouts in acres of an IP (SLIP) = u + v + w + y
5% + 10% + 4% + 11% = 30% of IP

Therefore, from equation 1, IP = Plant Building Layout + Supporting Layouts
100% IP = Plant Building Layout (70% of IP) **-** Supporting Layouts (30% of IP)
Plant Building Layout = 70% of IP acreage

Table II validated the model developed which helped to determine the layout percentages of an Industrial Park layouts

Table II: Percentage of Layouts of an Industrial Park.

	Supporting Layout of an Industrial Park				**Plant Building Layout**
Layout type	**Commercial Centers in acres**	**Cars and Lorries Park Centers in acres**	**Recreational Centers in acres**	**Utilities and Services Stations in acres**	**Plant Building Layouts**
% of Layouts of IP	5% of IP	10% of IP	4% of IP	11% of IP	70% of IP



V. DISCUSSION

The results tabulated in Table II showed the percentages of Commercial Centers; Cars and Lorries Park Centers; Recreational Centers; and Utilities and Services Stations. Utilities and Services Stations; and Cars and Lorries Park Centers took predominant roles out of the 30% realized for Supporting Layouts. From the five selected companies, 11% was averagely arrived at for Utilities and Services Station out of the total acreage for the five companies. Similarly for the cars and lorries park centers, this also took 10%. Commercial centers and Recreational Centers were also averagely arrived as 5% and 4% respectively. The 30% for supporting layouts was deducted from the entire 100% of IP to give the 70% real Plant Building Layout through equation 1.

VI. CONCLUSIONS

Industrial Park Layouts system made the development of an Industrial Park easier to actualize for an Investor since the layout's percentage has catered for future expansion. All the major attributed factors of an Industrial Park have been captured under Plant Building Layouts or Supporting Layouts. There was no explicit literature that showed the percentage of layouts of Plant building and supporting layouts of an Industrial Park which might have been creating little or large problem in designing or developing an Industrial Park. The percentage design approach used Isolated Industries supporting Layouts to formulate a mathematical model which can be used for all industries when coming together. The results showed clearly the percentage of each of the supporting layouts and from this, the Plant Building Layouts can be easily known since all layouts must be 100% of the tract of land available for the Industrial Park.

REFERENCES

[1]. Boix, M., Montastruc, L., Pibouleau, L., Azzaro-Pantel, C., and Domenech, S.,: Industrial water management by multiobjective optimization: from individual to collective solution through eco-industrial parks. Journal for Cleaner Production. 2012, 22, 85e97.

[2]. Meşter L.E, and Bugnar N.G,: The Role of Industrial Parks in Economic Development MH SR. Manuál pre poskytovanie podpory na zriaďovanie priemyselných parkov. 2017, Retrieved from http://www.economy.gov.sk . (Accessed 20/04/2020)

[3]. Nair, S.K., Guo, Y., Mukherjee, U., Karimi, I.A., Elkamel, A.,: Shared and practical approach to conserve utilities in eco-industrial parks. Comput. Chem. Eng. 2016, 93, 221-233. https://doi.org/10.1016/j.compchemeng.2016.05.003. (Accessed 24/05/2021)

[4]. Theo, W.L., Lim, J.S., Wan Alwi, S.R., Rozali, N.E.M., Ho, W.S., Abdul-Manan, Z.,: An MILP mode! for cost-optimal planning of an on-grid hybrid power system for an eco-industrial park. Energy 2016, 116, 1423-1441. doi:10.1016/j.energy.2016.05.043.

[5]. Kantor, I., Betancourt, A., Elkamel, A., Fowler, M., Almansoori, A.,: Generalized mixed-integer nonlinear programming modeling of eco-industrial networks to reduce cost and emissions. J. Cleaner Prod. 2015, 99, 160-176. doi:10.1016/j.jclepro.2015.03.017.

[6]. Chew, I.M.L., Tan, R.R., Foo, D.C.Y., Chiu, A.S.F.,: Game theory approach to the analysis of inter-plant water integration in an eco-industrial park. J. Clean. Prod. 2009, 17, 1611e1619.

[7]. Ramas, M.A., Boix, M., Aussel, D., Montastruc, L., Vilamajo, P., Domenech, S.,: Water exchanges in eco-industrial parks through multiobjective optimization and game theory. Comput. Aided Chem. Eng. 2015, 91, 198-210.

[8]. Boix, M., Montastruc, L., Pibouleau, L., Azzaro-Pantel, C., Domenech, S.,: Eco industrial Parks for water and heat management. In: Pistikopoulos, E.N., Georgiadis, M.C., Kokossis, A.C. (Eds.), 21st European Symposium on Computer Aided Process Engineering. Elsevier Science Bv, Amsterdam, 2011, pp. 1175e1179.

[9]. Ramas, M.A., Boix, M., Montastruc, L., Domenech, S.,: Multiobjective optimization using goal programming for industrial water network design. Ind. Eng. Chem. Res. 2014, 53, 17722-17735.

[10]. Ramas, M.A., Boix, M., Aussel, D., Montastruc, L., Domenech, S.,: Water integration in eco-industrial parks using a multi-leader-follower approach. Comput. Chem. Eng. 2016, 87, 190-207.

[11]. Andiappan, V., Tan, R.R., and Ng, D.K.S.,: An optimization-based negotiation framework for energy systems in an eco-industrial park. Journal for Cleaner Production. 2016, 129, 496507. http://dx.doi: 10.1016/j.jclepro.2016.04.023. (Accessed 11/01/2021)

[12]. Wang, G., Feng, X., Chu, K.H.,: A novel approach for stability analysis of industrial symbiosis systems. J. Cleaner Prod. 2013, 39, 9-16.

[13]. Jarmila Vidova,: Industrial Parks - History, Their Present And Influence On Employment. Review of Economic Perspective, 2010, Volume X. Issue 1, 2010.

[14]. Ammar A. and Tahri M: Role of Ecological Industrial Parks in Promoting the Quality of Life within Industrial Regions- A Literature Review of the Danish and Vietnamese Experience. International Journal of Youth Economy. 2019, 3, No. 1, 11-26. DOI. http://dx.doi.org/10.18576/ijye/030103 (Accessed 11/01/2020).

Akinnuli, Basil Olufemi. "System Design Approach for Layouts of an Industrial Park Development in a Developing Economy."*American Journal of Engineering Research (AJER),* vol. 10(12), 2021, pp. 214-220.