Modeling Industrial Park: Strategic Decisions for Implementation.

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Abstract: This research developed a system model that enables allocation of land space to every proposed industry, that is, the allocation that consistent with the constraints, will produce the highest annual revenue to the investor through land leasing and taxes. Strategic decisions which are Annual Revenue from Labour Force spending pattern; Annual Income from utility and service charges; Annual Revenue from tax on Industrial Production and Annual Income from Plant Building Area to be leased for industries were formulated as the objective function. The objective function was optimized under Industrial Park constraints which are Capital Investment, Labour Force, Utility and service levels, Available acreage, Maximum and Minimum Plant Building Area. Data were collected from the five relevant industries to enable the formulation of Linear Programming (LP) model with tractable objective function and the critical twenty-three constraints. The formulated LP model equations was solved through simplex method. From the results of the analysis, the Maximum Annual Income for the five (5) proposed industries in the park was estimated as ₦ 14,417,340,953:82 with varied optimum Plant Building Areas. Labour Utilization, Utility and Service Levels were within limits. Since the optimized Investment Cost is ₦283,940,000:00, hence the result revealed that there is a good savings of ₦316,060,000:00 (52.67%) from the entire ₦600,000,000:00 budgeted as investment cost for plant buildings. The balance was proposed for procuring infrastructural facilities. From all the results, it is crystal clear that the statistical evaluations showed the model developed can minimize constraints to maximize profit for all the industries.

Keywords: Annual Income, Industrial Park, Strategic decisions, Tax,

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1. INTRODUCTION

This research established a strategic decisions approach for implementation of an Industrial Park (IP) which optimally indicated the maximum annual income of the entire industrial park and optimally allocated suitable acreage for each proposed company between the maximum and minimum building area required, ditto to others notable factored constraints during the linear optimization.

The effective instruments to promote industrialization and structural transformation, governments in different countries have been resorting to Special Economic Zones (SEZs) or Industrial Parks as one tool to advance the desired industrialization. However more than five decades long of modern SEZs or Industrial Parks experiences have shown mixed results of success and failures [1].

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The very concept behind the development of these Industrial Parks is to achieve four policy objectives, as stated by FIAS (2008) which are attracting foreign direct investment; serving as "pressure valves" to alleviate large-scale unemployment; supporting a wider economic reform strategy and serving as experimental laboratories for the application of new policies and approaches.

In general, Industrial Parks are said to confer "static" and "dynamic" economic benefits.

Zeng (2015) represented static economic benefits as employment generation, export growth, government revenues, and foreign exchange earnings while dynamic economic benefits were presented as skills upgrading, technology transfer and innovation, economic diversification, productivity enhancement of local firms among others.

Industrial Park development is of interest not only to researchers, but also to policymakers. The different approaches being implemented include studies conducted to analyze the impact of industrial park development on socio-economic development of countries [4], [5], [6], [7], [8], [9]. The use of primary and secondary data, and input-output resources method to examine the impact of industrial park development on socio-economy is very germane.

In the context of an under-developed, developing, and developed economy, industrial parks can be a solution for increasing the local competitiveness through what it provides – institutional framework, modern services in administration, financial consultancy, training, technical guidance, information services, shared facilities, research and own infrastructure designed to meet the needs of companies they gather by providing them with modern services for the business deployment and development [10].

Some researchers have disregarded the roles of governments and public authorities in enhancing or inhibiting industrial ecosystem development. In other words, industrial ecology research recognizes public actors i.e governments, as serving meaningful functions in EIPs without considering the practical manifestations of these roles in a detailed and structured manner. Previous studies concentrated on the public actor role as "a function or part performed especially in a particular operation or process," whereas the current researches treated the term as referring to "a character assigned or assumed" [11]. Public actors significantly contribute to facilitating the development of regional industrial ecosystems such as EIPs. Most EIPs are developed as part of local economic development strategies, and the level of public involvement in this development can be very high. [12].

The dispersed industries over time have been constituting harms to the environment. For an Investor that wishes to increase her revenue or income through developing an acreage tract of land for an industrial park and limiting harm, there must strategic decisions to be adopted for actualization of an IP to maximize profits through constraints minimizations.

2. METHODOLOGY

The Industrial Park Development using Linear Programming.

Engineering economy analysis must be calculated out to ascertain the economics feasibility of the proposed project, Industrial Park. This evaluation has to be carried out before and after-tax situations where tax is being given careful considerations.

2.1 Strategic Decisions for Model Development for an Industrial Park

According to Ammar Aries and Tahri Mohammed, (2019) who stated the important gains of the establishment of Industrial Parks on long-term economic development of any nation, some of the gains such as creating employment, generating income and increasing per capital income and lots more have significant effects on the economy in all developing countries. Through these gains, some strategics were discovered to generate the objective function.

The strategic decisions used to formulate the objective function and the constraints of this research are:

(a) Revenue from labour force spending habits
(b) Income from utility and other service charges.
(c) Revenue from tax on industrial production
(d) Income from plant building leases minus maintenance costs.

Furthermore, there are six constraints which include

(i) **Capital Investment:** This is the capital money of any proposed investor of Industrial Park. The maximum amount available to finance the entire Industrial Park.
(ii) **Working Area:** This is the working area which all calculations will be narrowed down to 92.90 sq. m. of plant building area for uniformity and equality of constraints during mathematical model development and linear programming using simplex method to optimize.
(iii) **Labour Force:** There are six categories of Labour Force in any developing Country.
  (i) Unskilled
  (ii) Semiskilled
  (iii) Skilled
  (iv) Clerical
  (v) Technical
  (vi) Managerial
(iv) Utility and Services Levels: The major categories of utility and service levels are considered, namely:
  (i) Electricity
  (ii) Water
  (iii) Gas
  (iv) Sewerage
  (v) Waste
(v) Available Acreage: This is the total dimensioned acres of land in question for the proposed Industrial Park.
(vi) Plant Building Areas: Plant Building areas are absolutely a calculated area meant for industrial building and other industrial activities within owned area. It can be viewed as
  (i) Maximum Areas and
  (ii) Minimum Areas

2.2 Model Formulation

(a) Revenue from Labour force spending habits

Labour Force: Labour Force in Industrial Park can be categorized into six categories: Unskilled Labour, Semiskilled Labor, Skilled Labour, Clerical Workers, Technical Personnel and Managers where **Maximum Numbers** and **Annual Average Income** (in currency) of each category must be known. Furthermore, to get Labour force spending habit, the percentage of average of State and Federal Taxes of Gross Income should be known to get disposable **Net Income Annually**. Similarly, Average percentage of Net income spent in the city area which will result to **cash flow into the city area.**

From taxes on sales and property from utilities, fuel, sanitation and so on, will average to 7.5% of the flow of disposable personal income (**cash flow into the city area).**

(b) Capacity from utility and other service charges

The utilities, sewerages and waste disposal systems must be known, such as : Electricity, in kW. hrs./year; Water, in million cu. m./year; Gas, in cu. m./year; Sewerage in million cu. m./year and Waste Disposal, in Megagram (Mg)/year

And the unit profits (currency) from the sale of utilities and other services to industrial customers must be known as: Electricity, ₦ /kW. hr; Water, ₦ /millions cu. m.; Gas, ₦ /cu. m.; Sewerage, ₦ /million cu. m. and Waste Disposal, ₦ /Megagram (Mg).

(c) Revenue from tax on industrial production

(i) The government tax on the gross annual production value of each industry should be known.

(ii) The value cost of the site in the location selected for Industrial Park should be known as well.

(iii) The average building construction costs for the various plants according to the number of Industries agreed to be in the Industrial Park.

(d) Income from plant building leases minus maintenance costs.

(i) The amount investor agreed to lease the building facilities (including grounds) at an annual cost to the industries should be known in sq. m. of the building area.

(ii) Maintenance cost should also be known per sq. m. of the building area per year

2.3 Mathematical Model Formulation

2.3.1 The Objective Function

$$\sum_{i=1}^{n}[\sum_{j=1}^{6} r_j L_{ij} + \sum_{k=1}^{5} C_k U_{ik} + 0.075\, P_i + 150000\,]x_i \quad (1)$$

2.3.2 The Constraints

Capital Investment

$$92.90 \sum_{i=1}^{n} b_i\, x_i \leq Z \quad (2)$$

where Z is the Maximum Amount for Financing Industrial Park minus (-) Cost for acquiring the entire allocated land for Industrial Park

Labour Force

$$\sum_{i=1}^{5} L_{ij}\, x_i \leq E_j; j = 1,..,6 \quad (3)$$

Utility and Service Levels

$$\sum_{i=1}^{5} U_{ik}\, x_i \leq U_k; k = 1,\dots,5 \quad (4)$$

Available Acreage

$$\sum_{i=1}^{n} s_i\, x_i \leq T_{AL} \quad (5)$$

T_{AL} is the total area of the land in acres or sq.m

Plant Building Areas

$$a_i \leq x_i \leq A_i ; i = 1, \dots, n \quad (6)$$

2.4 Nomenclature

Symbol **Meaning**

$\boldsymbol{a_i}$ is the proposed minimum acreage of industry *i*

$\boldsymbol{A_i}$ is the proposed maximum acreage of industry *i*

$\boldsymbol{b_i}$ is the average building construction cost per 92.90 sq. m.

C_k, k = 1, …, 5 is the unit profits from electricity, water, gas, sewerage, and waste disposal services

$\boldsymbol{E_j; j} = 1,..,6$ is the maximum available number of type j workers

IP is the Industrial Park

j = 1, …, 6 is indices representing Labour force in the following categories

k = 1, …, 5 is indices representing electricity, water, gas, sewerage, and waste disposal services;

$\boldsymbol{L_{ij}}$, **i** = 1, …, n and j = 1, … 6 is the number of workmen employed by industry i of type *j* per 92.90 sq. m. of plant building area;

$\boldsymbol{P_i}$, **i** = 1, …, nth, is the annual production for industry *i* in naira (dollars) per 92.90 sq. m. of plant building rea.

r_j, j = 1, …, 6 is the government revenue on the labour force local spending habits

S_i is the existing site acreage of the company.

TA_L is Total Available Land in acreage

u is the Annual net income per labour type

U_{ik}, **i** = 1, …, n, k = 1, …, 5 is the requirements of industry i for electricity, water, gas, sewerage, and waste disposal services

v is the cash flow into the city area per labour type

w is the Annual average city revenue per labour type

x_i, **i** = 1, …, nth is the plant building areas, in 92.90 sq. m. to be leased to industries 1 through nth industries respectively.

Z is the maximum amount for Financing IP minus (-) Cost for acquiring the entire allocated land for IP

2.5 Case Study and collected Data for the Strategic Decisions

General Requirements for the Industrial Park Development

- **a.** Working Area: The working Area which all calculations will be narrowed down to is 92.90 sq. m.
- **b.** Capital to Invest: The total proposed amount to finance the development of Industrial Park is ₦600,000,000:00
- **c.** Price Per Acre: The actual price of land per acre according a certified evaluation officer.

  The price per acre is ₦200,000:00
- **d.** Number of Acres: The existing tract of acres available for the Industrial Park.

  The total acres of land are 300.02
- **e.** Capacity for Utilities, Sewerage and Waste Disposal System: This is the entire capacity available for utilization in the Industrial Park plus the neighboring communities.
  Electricity is 12,500,000 kW.hrs./yr
  Water is 75 million cu.m./yr
  Gas is 40,000,000 cu.m./yr
  Sewerage is 30 million cu.m./yr
  Waste Disposal 15,000 Mg/yr

  Unit Profit on Utilities, Sewerage and Waste Disposal System
  Electricity is ₦62.66 per kW.hrs
  Water is ₦200:00 per cu.m.
  Gas is ₦468.68 per cu.m.
  Sewerage is ₦90.12 per cu.m.
  Waste Disposal is ₦ 20.00 per g
- **f.** Annual Lease cost of building area per sq. m. is ₦ 170:00
- **g.** Annual maintenance cost of building area per sq. m. is ₦ 20:00
- **h.** Income Tax in Nigeria as a case study:
  Income tax is imposed on employees in Nigeria, and includes any salaries, wages, gains or profits - including bonuses, premiums and benefits - derived from employment. Income tax is processed using the PAYE system and reported each month to the State Internal Revenue Service (SIRS). All Nigerian tax 'residents' are liable for income tax - that is, employees with duties of employment performed wholly or partly in Nigeria for up to six months per year. Nigerian tax residents are taxed on all income sourced from Nigeria, and all worldwide income.
  Tax rates in Nigeria are graduated across income bands, ranging from 7-24%. Income thresholds are as follows:
  Up to 300,000 naira: 7%
  Up to 600,000 naira: 11%
  Up to 1,110,000 naira: 15%
  Up to 1,600,000 naira: 19%
  Up to 3,200,000 naira: 21%
  Over 3,200,000 naira: 24%
  Value Added Tax (VAT)
  VAT is charged at a rate of 7.5%
  Some goods and services such as non-oil exports are zero rated
- **i.** Tax on utility, fuel, sanitation etc is 7.5%

Five Selected Companies were picked to run the strategic decisions 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 in the respective order.

Data are for company 1, 2, 3, 4, & 5 respectively to validate the models formulated through strategic decisions.

Table 1: Site and Services Requirements in Unit per 92.90 sq. m. of Plant Building Area for company 1, 2, 3, 4, & 5 respectively per cell of the table.

Site Acre	Electricity (Kw. hrs/yr)	Water (million cu. m./yr)	Gas (cu. m./yr)	Sewerage (million cu. m./yr)	Waste Disposal (Mg./yr)

ISSN 2229-5518

5	10	11.5	14.3	12.1	41300.53	32001.17	52076.11	44001.26	57009.33	0.50	0.100	0.030	0.0200	0.010	41000	7000	98000	73000	13000	0.004	0.04	0.02	0.02	0.01	18	27	43	39	2.4

Table 2: Labour Force Requirement in Men/Day (8hrs shift) per 92.90sq. m. of plant building area for company 1, 2, 3, 4, & 5 respectively per cell of the table.

Unskilled Labour					Semi Skilled Labour					Skilled Labour					Clerical Worker					Technical Personnel					Managerial				
0.75	9.0	13.0	4.3	14.7	0.22	13.5	4.6	6.4	3.4	0.38	3.0	4.6	3.2	1.7	0.24	6.0	5.8	7.5	1.7	0.15	3.0	2.3	3.2	6.9	0.05	1.5	4.5	0.7	1.1

Average Building Construction Cost per 92.90 sq. m. is ₦7800:00; ₦8840:00; ₦9880:00; ₦11440:00; ₦8320:00;

Annual Industrial Production of Plant Building Area per 92.90 sq. m. is ₦2,600,000,000:00; ₦3,640,000,000:00; ₦6,240,000,000:00; ₦7,840,000,000:00; ₦5,200,000,000:00;

Table 3: Plant Building Area Requirements Per 92.90 sq. m. for company 1, 2, 3, 4, & 5 respectively per cell of the table.

Maximum Area (sq. m.) x1000					Minimum Building Area (sq. m.) x1000				
11.15	7.43	6.50	9.29	13.83	3.72	1.85	2.41	2.60	3.25

3.0 RESULTS AND DISCUSSION

3.1 Labour Force Spending Pattern: To get
Annual Net Income, Cash Flow into the City and Average Annual Revenue Per Worker must be determined.

(i) Annual Net Income (**u**) = Average Income – (State & Federal Taxes x Average Income)
(ii) To get Cash Flow into City Area (**v**)
Cash Flow into City Area = Average % Spent on City x Annual Net Income
(iii) To get Annual Average City Revenue per Worker (**w**) = 7.5% x cash flow into city area for each of the labour type.

where (w) = r_j

Table 4: Labour Force Spending Pattern

Labour Type	Maximum No	Average Income ₦	State & Federal Taxes %	**u** - Annual Net Income ₦	**v** - % Spent on City	cash flow ₦	**w** - Average Annual ₦
Unskilled Labour	400	960,000	15	816000	90	734400	55080
Semi Skilled Labour	180	1,176,000	19	952560	85	809676	60725.7
Skilled Labour	100	1,344,000	19	1088640	70	762048	57153.6
Clerical Workers	150	900,000	15	765000	85	650250	48768.8
Technical Personnel	120	1,680,000	21	1327200	65	862680	64701
Managers	33	2,376,000	21	1877040	55	1032372	77427.9

From table 4, column a, b, c gives the summary of the calculations of sub-section 3.1

3.2 Objective Function Developed

From equation (1)

$$\sum_{i=1}^{n}[\sum_{j=1}^{6} r_j L_{ij} + \sum_{k=1}^{5} C_k U_{ik} + 0.075\, P_i + 150000\,]x_i$$

Company 1: Electrical Machinery Company, Osogbo, Osun State

= 389990624.16 x_1

Company 2: Cocoa Processing Company, Ede, Osun State

= 280526218.92 x_2

Company 3: Steel Mills Limited, Osogbo, Osun State

= 519148739.36 x_3

Company 4: Plastics Pipe Industry

= 623555478.25 x_4

Company 5: Wire Industry Limited

= 401542656.72 x_5

Therefore, the objective function can now be collated through the five companies as

Max I = 389990624.16 x_1 + 280526218.92 x_2 + 519148739.36 x_3 + 623555478.25 x_4 + 401542656.72 x_5

3.3. The Constraints development

3.3.1 Capital Investment: From equation (2)

$$92.90 \sum_{i=1}^{5} b_i\, x_i \le [\,Z]$$

b_i is average Building Construction per 92.90 sq. m. in Naira

x_i is the name of each company in the Industrial Park

1000 (7800 x_1 + 8840 x_2 + 9880 x_3 +11440 x_4 + 8320x_5) $\le 539{,}996{,}000$

7800000 x_1 + 8840000 x_2 + 9880000 x_3 + 11440000 x_4 + 8320000 x_5 $\le 539{,}996{,}000$

3.3.2 Labour Force: From equation (3)

$$\sum_{i=1}^{5} L_{ij}\, x_i \le E_j; j = 1,..,6$$

a. Unskilled Labour

0.75 x_1 + 9.0 x_2 + 13.0 x_3 + 4.30 x_4 + 14.7 x_5 $\le$ 400

b. Semi Skilled Labour

0.22 x_1 + 13.50 x_2 + 4.6 x_3 + 6.40 x_4 + 3.40 x_5 $\le$ 180

c. Skilled Labour

0.38 x_1 + 3.0 x_2 + 4.6 x_3 + 3.20 x_4 + 1.70 x_5 $\le$ 100

d. Clerical Worker

0.24 x_1 + 6.0 x_2 + 5.80 x_3 + 7.50x_4 + 1.70 x_5 $\le$ 150

e. Technical Personnel

0.15 x_1 + 3.0 x_2 + 2.30 x_3 + 3.20x_4 + 6.90 x_5 $\le$ 120

f. Managerial

0.05 x_1 + 1.50 x_2 + 1.50 x_3 + 0.70 x_4 + 1.10 x_5 $\le$ 33

3.3.3 Utility and Service Levels: From equation (4)

a. Electricity

4,1300.53 x_1 + 3,200.17 x_2 + 52,076.11 x_3 + 44,001.26 x_4 + 5,7009.33 x_5 $\le$ 12,500,000

b. Water

0.50 x_1 + 0.10 x_2 + 0.03 x_3 + 0.02 x_4 + 0.01 x_5 $\le$ 75

c. Gas

41,0000 x_1 + 7,000 x_2 + 9,8000 x_3 + 73,000 x_4 + 13,000 x_5 $\le$ 40,000,000

d. Sewerage

0.04 x_1 + 0.4 x_2 + 0.02 x_3 + 0.02 x_4 + 0.01 x_5 $\le$ 30

e. Waste Disposal

18 x_1 + 27 x_2 + 43x_3 + 39 x_4 + 2.4 x_5 $\le$ 15,000

3.3.4 Available Acreage: From equation (5)

5.00 x_1 + 10.00 x_2 + 11.50 x_3 + 14.30 x_4 + 12.10 x_5 $\le$ 300.02

3.3.5 Plant Building Areas: From equation (6)

$$a_i \le x_i \le A_i\,; i = 1, \ldots ,5$$

This means

Maximum Areas $\boldsymbol{x_i \le A_i\,; i = 1, \ldots, 5}$

$x_1 \le 11.15$
$x_2 \le 7.43$
$x_3 \le 6.50$
$x_4 \le 9.29$
$x_5 \le 13.93$

Minimum Areas $\boldsymbol{x_i \ge a_i\,;\ i = 1, \ldots, 5}$

$x_1 \ge 3.72$
$x_2 \ge 1.85$
$x_3 \ge 2.41$
$x_4 \ge 2.60$
$x_5 \ge 3.25$

3.4. Linear Programming model equations

The strategic decision implementation resulted to creation of an Optimization problem to form Linear Programming model equations which was solved using Simplex Method.

Objective Function

Max I = 389990624.16 x_1 + 280526218.92 x_2 + 519148739.36 x_3 + 623555478.25 x_4 + 401542656.72 x_5 (7)

Subject to

7800000 x_1 + 8840000 x_2 + 9880000 x_3 + 11440000 x_4 + 8320000 x_5 $\le 539{,}996{,}000$ (8)

0.75 x_1 + 9.0 x_2 + 13.0 x_3 + 4.30 x_4 + 14.7 x_5 $\le$ 400 (9)

0.22 x_1 + 13.50 x_2 + 4.6 x_3 + 6.40 x_4 + 3.40 x_5 $\le$ 180 (10)

$0.38\ x_1 + 3.0\ x_2 + 4.6\ x_3 + 3.20\ x_4 + 1.70\ x_5 \le 100$ (11)

$0.24\ x_1 + 6.0\ x_2 + 5.80\ x_3 + 7.50 x_4 + 1.70\ x_5 \le 150$ (12)

$0.15\ x_1 + 3.0\ x_2 + 2.30\ x_3 + 3.20 x_4 + 6.90\ x_5 \le 120$ (13)

$0.05\ x_1 + 1.50\ x_2 + 1.50\ x_3 + 0.70\ x_4 + 1.10\ x_5 \le 33$ (14)

$4{,}1300.53\ x_1 + 3{,}200.17\ x_2 + 52{,}076.11\ x_3 + 44{,}001.26\ x_4 + 5{,}7009.33\ x_5 \le 12{,}500{,}000$ (15)

$0.50\ x_1 + 0.10\ x_2 + 0.03\ x_3 + 0.02\ x_4 + 0.01\ x_5 \le 75$ (16)

$41{,}0000\ x_1 + 7{,}000\ x_2 + 9{,}8000\ x_3 + 73{,}000\ x_4 + 13{,}000\ x_5 \le 40{,}000{,}000$ (17)

$0.04\ x_1 + 0.4\ x_2 + 0.02\ x_3 + 0.02\ x_4 + 0.01\ x_5 \le 30$ (18)

$18\ x_1 + 27\ x_2 + 43 x_3 + 39\ x_4 + 2.4\ x_5 \le 15{,}000$ (19)

$5.01\ x_1 + 10.00\ x_2 + 11.50\ x_3 + 14.30\ x_4 + 12.10\ x_5 \le 300.02$ (20)

Maximum Areas $x_i \le A_i\,; i = 1, \ldots, 5$

$x_1 \le 11.15$ (21)
$x_2 \le 7.43$ (22)
$x_3 \le 6.50$ (23)
$x_4 \le 9.29$ (24)
$x_5 \le 13.93$ (25)

Minimum Areas $x_i \ge a_i\ ;\ i = 1, \ldots, 5$

$x_1 \ge 3.72$ (26)
$x_2 \ge 1.85$ (27)
$x_3 \ge 2.41$ (28)
$x_4 \ge 2.60$ (29)
$x_5 \ge 3.25$ (30)

$x_1, x_2, x_3, x_4, x_5, \ge 0;$

Therefore, the solutions from simplex method are:
Max Annual Income (Max I) = ₦ 14,417,340,953.8227
Therefore, decision variables, x_1, x_2, x_3, x_4, x_5 are to be in 1000 and also in respective company name 1-5

x_1 = 11.15 x 1000 = 11,150 sq. m. (2.76 acres)
x_2 = 1.85 x 1000 = 1850 sq. m (0.46 acres)
x_3 = 6.5 x 1000 = 6500 sq. m. (1.61 acres)
x_4 = 7.81084 x 1000 = 7810.84 sq. m. (1.93 acres)
x_5 = 3.25 x 1000 = 3250 sq. m. (0.80 acres)

Substituting the variables gotten into the following equations (8) – (30), we have;

Optimum Plant Building Areas

Initial Investment = $7800000\ x_1 + 8840000\ x_2 + 9880000\ x_3 + 11440000\ x_4 + 8320000\ x_5$
= ₦283,940,000

Available Acreage = $5.00\ x_1 + 10.00\ x_2 + 11.50\ (6.5) + 14.30\ x_4 + 12.10\ x_5$
= 300.02 acres (aprox)

Labour Utilization

Unskilled Labour = $0.75\ x_1 + 9.0\ x_2 + 13.0\ x_3 + 4.30\ x_4 + 14.7\ x_5$
= 191

Semi Skilled Labour = $0.22\ x_1 + 13.50\ x_2 + 4.6\ x_3 + 6.40\ x_4 + 3.40\ x_5$
= 118

Skilled Labour = $0.38\ x_1 + 3.0\ x_2 + 4.6\ x_3 + 3.20\ x_4 + 1.70\ x_5$
= 70

Clerical Worker = $0.24\ x_1 + 6.0\ x_2 + 5.80\ x_3 + 7.50 x_4 + 1.70\ x_5$
= 116

Technical Personnel = $0.15\ x_1 + 3.0\ x_2 + 2.30\ x_3 + 3.20 x_4 + 6.90\ x_5$
= 70

Managerial = $0.05\ x_1 + 1.50\ x_2 + 1.50\ x_3 + 0.70\ x_4 + 1.10\ x_5$
= 22

Utility and Service Levels

Electricity = $4{,}1300.53\ x_1 + 3{,}200.17\ x_2 + 52{,}076.11\ x_3 + 44{,}001.26\ x_4 + 5{,}7009.33\ x_5$
= 1387164.88 kW.hr/yr

Water = $0.50\ x_1 + 0.10\ x_2 + 0.03\ x_3 + 0.02\ x_4 + 0.01\ x_5$
= 6.14 million cu. m/yr

Gas = $41{,}0000\ x_1 + 7{,}000\ x_2 + 9{,}8000\ x_3 + 73{,}000\ x_4 + 13{,}000\ x_5$
= 5833891.26 cu. m./yr

Sewerage = $0.04\ (11.15) + 0.4\ x_2 + 0.02\ x_3 + 0.02\ x_4 + 0.01\ x_5$
= 0.84 million cu.m./yr

Waste Disposal = $18\ x_1 + 27\ x_2 + 43 x_3 + 39\ x_4 + 2.4\ x_5$
= 842.57 Mg/yr

Total land space used is the total sum of the optimized areas for each company.
11150 + 1850 + 6500 + 7810.84 + 3250 = 305630 sq. m.
To convert sq. m. to acres;
1 sq. m. = 0.0002471
Therefore, 30560 sq. m. is equivalent to 7.55 acres
To get
Unused land space
300.02- 7.55 = 292.47 acres

3.5 Discussion of the Results

The solution values are feasible since the maximum annual income showed that Optimal Income was realized. From the results, Optimum Plant Building Area results will guide Investor the particular Company to determine the plant building areas to be leased to each company which would yield the maximum revenue per year. It has shown clearly that the capacity of electricity, water, sewerage and waste disposal, are accommodating due to optimized results on the following utilities and service levels. The investment cost was ₦600,000,000:00 and the optimized value for investment is ₦283,940,000:00. Hence, the savings is ₦316,060,000:00. The percentage savings is 52.67%.

4.0 CONCLUSION

The Objective Function formulated with all the constraints were solved through Linear Programming and the results were feasible within the constraints limit. The Maximum Income generated from the proposed five (5) industries was encouraging to woo an Investor. To maintain and guide any loss in terms of tax generation and land leasing, the site location of the Industrial Park should be centralized within the metropolis of the city, in order not to loose money spent on city or being diverted to any closed by cities.

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