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Cost Minimization Modeling of Niger Delta Multi-Purpose /Multi-Objective Diesel Spill Land Reclamation Project

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ABSTRACT
This research is aimed at developing cost minimization model of Niger Delta multi-purpose/multi-objective diesel spill land reclamation project. The objectives are to contaminate specific soil depth at varying contaminant volumes and rainfall intensities, determine the accrued benefits of cultivating yam, maize, cassava, oil palm and also fishery on five different hectares of diesel oil spill reclaimed land in Bori, and develop an optimization model that will minimize the cost of executing a multi-purpose/multi-objective project on reclaimed spilled land in Bori. Diesel spill contamination poses problems such as impacting on environmental aspects like soils and groundwater, gross reduction in farm produce, killing of aquatic lives, altering of the ecosystem, and causing cancerous and mutagenic effects on inhabitance of the polluted area. Game theory was used to develop an optimization model from the accrued benefits of cultivating on reclaimed diesel spilled land. The accrued benefits of cultivating on all hectares of the reclaimed diesel spill land in Bori per year for five different crops are ₦ 1,495,050,000, ₦ 2,295,050,000, ₦ 5,265,050,000, ₦5,291,000,000 and ₦ 4,401,000,000. These were used to develop a 5x5 payoff matrix. Cost minimization model of the benefit accrued in the multi-purpose/multi-objective project development using game theory showed that player A best minimized cost at strategy $0.04_{y1}+0.07_{y2}+0.16_{y3}+0.16_{y4}+1.32_{y5}$ to obtain optimal score of ₦5,835,750 ,000 with a game value of 0.04. The Ministry of Agriculture, Environment and the Niger Delta Development Commission (NDDC) should subscribe to the adoption of the developed optimization model. Nigerian Government should pass a law for the implementation of the optimization model as it will help to increase the GDP of the Nation

KEYWORD: Game theory, cost minimization model, game value, accrued benefit, saddle point

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I. INTRODUCTION

The research was done at Bori, located at Latitude 4°40′34″Nand Longitude7°21′54″E. Its elevation above sea levelis18m (59ft). It is in Khana Local Government Area of Rivers State in the Niger Delta region of Nigeria. Diesel oil spill in Bori has contaminated huge portions of land. UNEP report (2011) has shown that plant and animals are now going into extinction, soil and groundwater have been thoroughly contaminated, livelihood of Niger Deltans are now unacceptably low. Citizens are likely to suffer from chronic effects like carcinogenesis and mutagenesis. Oil spill reclamation of the affected area is not the panacea. It is important that the cost of reclaiming the land be recovered, hence an optimization model for cost minimization on investing in a multi-purpose/multi-objective project shall be developed. First, the predicted models shall be used to determine the best spill containment method at optimal cost, then the benefit of investing into different farm produce such as cassava, maize, yam, oil palm and fishery would be obtained. Game theory shall be used to develop the optimization model that would help generate enough funds that would consequently recover the cost of reclaiming the land and rehabilitate the affected persons in the oil spill area (Archetti, M , 2013). Cost minimization model of the 5x5 matrix of the benefits shall be developed.

Infinite optimization model of oil-water fluid interaction in Bori soil is necessary to be researched on due to the prevalent cases of oil spill and its catastrophic effects on humans living in the environment(Sarbatly, Kamin and Krishnaiah,

2016), plants and animals (UNEP report, 2011). Research has shown that Bori community is an Agricultural hub. Its indigenes are mainly fishers and farmers by occupation (Akpotor ,2019;Bartels , Eckstein , Waller , Wiemann , 2019), with fragile vegetation and ecosystem (Refugee Review Tribunal Australia, 2007). Hence, oil spill in the land spells doom and catastrophe (Pegg and Zabbey , 2013). Its citizens are likely to suffer from chronic cancerous and mutagenic effects within the nearest 15 to 20 years (Ihesinachi and Eresiya, 2014). Crops are dying and some have even gone into extinction (Oshienemen ,Amaratungaa and Richard ,2018). Its rich farm produce are no longer yielding well (Senewo, 2015). Some sea foods have gone into extinction (Kadafa, 2012). Hence there is need to reclaim the oil spilled land (Fentimana and Zabbey , 2015). An optimization model of the accrued benefits of multi-purpose/multi-objective project using Game theory is necessary to recover the cost of reclaiming the land.

II. METHODOLOGY

Experimental data were obtainded from experiments conducted and used to develop models for prediction of the extent of contamination that would occur when ever there is a spill as shown in equations 1 and 2. The best containment method for reclaiming the soil was optimaly and suitably implemented. Several farm land in Bori-Ogoni have been contaminated with approximately 500,000,000 liters of diesel (UNEP report, 2011). The spilled diesel products afficeted approximately 20,720 hectares of land used to grow cassava and maize crops. The contamination is caused by pipeline vandalization, poor mantainance of pipline facilities and over presurizartion of the flowing fluids in the pipe.

$$LC = -12458-432.07000* Cv +64936* RI +26287* Cv \text{ ^2+60880* } RI \text{ ^2+1136* } Cv * RI \quad (1)$$

$$RC = 138.41111+92.24833* Cv -0.88167* RI +89.00833* Cv \text{ ^2-172.19167* } RI \text{ ^2-1.61000* } Cv * RI \quad (2)$$

2.1 COST MINIMIZATION AND PROFIT MAXIMIZATION MODEL

Game theory was used to develop an optimization model.

2.2 Model Assumptions

i. The game has mixed strategies (Player A and Player B)
ii. Player A is the minimizer with an objective function of minimizing the costs of cultivating maize, yam, cassava, palm fruit and rearing of fishes.
iii. Player B is the maximizer with an objective function of maximizing profits from the five hectares of reclaimed diesel spilled lands in Bori.
iv. The payoff matrix is obtained from the accrued benefits of cultivating maize, cassava, yam, oil palm and that of rearing fishes on five hectares of reclaimed diesel spilled land in Bori.
v. Diesel spill occurred on 10%, 32%, 10%, 23% and 25% of land in Hectares A,B,C,D,E and F of Bori respectively.

Table 1. Payoff Matrix of Accrued Benefit from Farm Produce on Reclaimed Diesel Spill on Five Hectares of Land in Bori

Player A

Player B	Maize	Cassava	Yam	Oil Palm	Fishery
Hectare A	149,550,000	229,550,000	526,550,000	529,100,000	440,100,000
Hectare B	149,550,000	229,550,000	526,550,000	529,100,000	440,100,000
Hectare C	149,550,000	229,550,000	526,550,000	529,100,000	440,100,000
Hectare D	149,550,000	229,550,000	526,550,000	529,100,000	440,100,000
Hectare E	149,550,000	229,550,000	526,550,000	529,100,000	440,100,000

Table 2. Payoff Matrix of Accrued Benefit of Farm Produce on Five Different Farm Types Per 100 Hectares of Reclaimed Diesel Spilled Land in Bori (Each in billion naira)

Player A

Player B		Maize	Cassava	Yam	Oil Palm	Fishery
	Hectare A	0.1	0.2	0.5	0.5	4.4
	Hectare B	0.1	0.2	0.5	0.5	4.4
	Hectare C	0.1	0.2	0.5	0.5	4.4
	Hectare D	0.1	0.2	0.5	0.5	4.4
	Hectare E	0.1	0.2	0.5	0.5	4.4

Since diesel spill occurred on 10%, 32%, 10%, 23% and 25% of land in hectares A,B,C,D,E and F of Bori respectively. The new payoff matrix becomes:

Table 3. Payoff matrix of diesel spill on 10%, 32%, 10%, 23% and 25% of land in hectares A, B, C, D, E and F of Bori respectively.

Player A

		Maize	Cassava	Yam	Oil Palm	Fishery
	Hectare A 10%	0.01	0.02	0.05	0.05	0.44
	Hectare B 32%	0.04	0.07	0.16	0.16	1.32
Player B	Hectare C 10%	0.01	0.02	0.05	0.05	0.44
	Hectare D 23%	0.03	0.05	0.11	0.11	0.88
	Hectare E 25%	0.01	0.02	0.05	0.05	0.44

From the new payoff matrix, using game theory, firstly, the saddle point is determined. In determining the saddle point we have,

Table 4. Determining the saddle point

Player A

		Maize	Cassava	Yam	Oil Palm	Fishery	
	Hectare A	0.01	0.02	0.05	0.05	0.44	0.01
	Hectare B	0.04	0.07	0.16	0.16	1.32	(0.04)
Player B	Hectare C	0.01	0.02	0.05	0.05	0.44	0.01
	Hectare D	0.03	0.05	0.11	0.11	0.88	0.03
	Hectare E	0.01	0.02	0.05	0.05	0.44	0.01
		(0.04)	0.07	0.16	0.16	1.32	

Therefore, since saddle point exists. The players have pure strategies at Saddle point (2,1).
Player A can best minimize his cost at $Z_{min}=0.01y_1+0.02y_2+0.05y_3+0.05y_4+0.44y_5$ at game value of 0.04 where the saddle point exists.

III. RESULTS AND DISCUSSIONS

Table 5. Payoff Matrix of Accrued Benefits from Farm Produce on Five Hectares of Reclaimed Diesel Spill in Bori (in billion naira)

		Player A				
		Maize	Cassava	Yam	Oil Palm	Fishery
	Hectare A 10%	0.01	0.02	0.05	0.05	0.44
	Hectare B 32%	0.04	0.07	0.16	0.16	1.32
Player B	Hectare C 10%	0.01	0.02	0.05	0.05	0.44
	Hectare D 23%	0.03	0.05	0.11	0.11	0.88
	Hectare E 25%	0.01	0.02	0.05	0.05	0.44

Discussion of the result in table 5

i. Figure 5 shows the payoff matrix of diesel spill that affected 10%, 32%, 10%, 23% and 25% of land in hectares A,B,C,D,E and F of Bori respectively.
ii. Player A plays his strategy to minimize costs of cultivating maize, cassava, yam oil palm and fishery while player B plays his strategy to maximize profits on hectares A, B, C, D and E.
iii. The value in the payoff matrix is the accrued benefit in billion naira of a multi-purpose/multi-objective project.

Table6. Determination of the Game

		Player A					
		Maize	Cassava	Yam	Oil Palm	Fishery	
	Hectare A	0.01	0.02	0.05	0.05	0.44	0.01
	Hectare B	0.04	0.07	0.16	0.16	1.32	(0.04)
Player B	Hectare C	0.01	0.02	0.05	0.05	0.44	0.01
	Hectare D	0.03	0.05	0.11	0.11	0.88	0.03
	Hectare E	0.01	0.02	0.05	0.05	0.44	0.01
		(0.04)	0.07	0.16	0.16	1.32	

Discussion of the result in table 6

i. Saddle point exists.
ii. The players have pure strategies at Saddle point(2,1).
iii. Player A can best minimize his cost at $Z_{min}=0.04y_1+0.07y_2+0.16y_3+0.16y_4+1.32y_5$
iv. The game value is 0.04 where the saddle point exists.
v. This agrees with the thoughts of Gupta and Hira (2014).

Table 7 Cost of production per hectare of land

FARM TYPE	**PRODUCTION COST(₦)**
Maze	930.450,000
Cassava	940,450,000
Yam	885, 450,000
Oil Palm	1,345,900,000
Fishery	3,849,000,000
Total	**7,951.250,000**

Discussion of the result in table 7

i. Maize and fishery had the lowest and highest cost of production.
ii. The total cost of production for maize, cassava, yam, oil palm and fishery is ₦7,951,250, 000.
iii. Player A can best minimize his cost with strategy $Z_{min}=0.04y_1+0.07y_2+0.16y_3+0.16y_4+1.32y_5$ at a minimal score of ₦5,540,746,000.
iv. The game value is 0.04 for Z_{min}.
v. This also agrees with the thoughts of Gupta and Hira (2014).

IV. CONCLUSION

i. Table 7 shows that the production cost of maize, cassava, yam, oil palm and fishery per plot are ₦930,450,000, ₦940,450,000, ₦885,450000, ₦28,125,000,000, and ₦849,000, 000 respectively.
ii. The productivity of maize, cassava, yam, oil palm and fishery per hectare are ₦16,200,000, ₦17,550,000, ₦21,180,000,₦ 1,345,900, and ₦1,23,750,000respectively.
iii. The accrued benefit per hectare of land per year are ₦149,550,000, ₦229,550,000, ₦526,550,000, ₦529,100,000 and ₦4,401,000,000.
iv. The net benefit of all the hectares of land per year is ₦5,835,750,000.
v. Figure 8 shows the payoff matrix of diesel spill that affected 10%, 32%, 10%, 23% and 25% of land in hectares A, B, C, D, E and F of Bori respectively.
vi. Player A plays his strategy to minimize the costs of cultivating maize, cassava, yam oil palm and rearing fishes while player B plays his strategy to maximize profits on hectares A, B, C, D and E.
vii. The value in the payoff matrix is the accrued benefit in billions of a multi-purpose/multi-objective project.
viii. Saddle point exists hence, the players have pure strategies at saddle point (2,1).
ix. Player A can best minimize his cost at $Z_{min}=0.04y_1+0.07y_2+0.16y_3+0.16y_4+1.32y_5$with game value is 0.04 where saddle point exists and this agrees with the work of Gupta and Hira (2014).

V. RECOMMENDATIONS

The following are recommended.

i. The Niger Delta Development Commission should financially support local famers in large scale farming on reclaimed diesel spilled land.
ii. The national assembly in alliance senate of the federal republic of Nigeria should pass a law for the implementation of the developed optimization model of reclaimed diesel spilled soil since it will help to optimally minimize cost of production and fulfill the requirements of ISO 14001:2015 standards.

CONTRIBUTION TO KNOWLEDGE

i. This research work agrees with the implementation of Environmental Management System as per clause 5, 6,7, 8,9 and 10 of ISO14001:2015.
ii. It will help to minimize the cost of implementing Niger Delta multi-purpose/multi-objective diesel spill land reclamation project.

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