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Modeling Climate Change Effect from Deforestation using Bayesian Decision Model.

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Abstract

This study is aimed at carrying out a study on the effects of deforestation as a result of global warming and climate change crisis. A model was established using the Bayesian decision model to know the impact of deforestation here in the environment. The model was formulated from the data gotten from Bill of Engineering Measurement and Evaluation on benefit and purpose of water resource projects in Delta state. Consequently, from the results of prior probabilities of the state of nature and the likelihood of the alternatives courses of action, and applying prior-posterior decision models to the uncertain system, the following decision were arrived at: plantation and forestry has the highest expected monetary value at 1st iteration with the value of N 24.0B, hydropower has the highest expected monetary value at 2nd iteration with the value of N26.61B.The results of Bayesian decision model gave a clear indication that energy resource project of hydropower has the highest expected monetary value of N26.61 at 2nd iteration, making it the most suitable for government to invest on, for maximum yield. The Environmental authority is expected to pay the researcher/consultant or forecaster the expected value of system information, value of N8.43B for information generated using the Bayesian decision model spreadsheet. there should be government regulations to curb the felling of trees by enforcing rules and laws to govern it and the government should enforce a law to ensure monitoring the forests and defaulter penalized. Deforestation crisis should be reduced to the bearest minimum with the felling of one tree leads to planting of ten seedling of trees as a sustainable measure put in place.

1. Introduction

The year 2020 was the year of record temperatures and increasing climate changes catastrophes such as floods, droughts, storms, wildfires, and locust swarms. These phenomena have an economic cost of billions of dollars, in addition to the suffering they cause in ecosystems

and societies [1].Ecuador contributes less than 1% of greenhouse gas emissions worldwide [2] however, the impact of climate change in the country is quite devastating compared to the countries that emit a greater number of polluting gases. Despite this, the country is committed to generating policies ,programed, and projects that contribute to limiting the rise in temperature by up to 1.5c.in addition, it is an environmental problem of greater relevance in our time with potential and drastic consequences for both society and the ecosystem[3]the effects that scientists predicted in the past regarding climate change are happening, i.e. ,loss of sea ice, the accelerated rise in sea level, and more intense heat waves, which generate concern on the part of governments and world organizations[4].empirical studies linking deforestation with climate change are scarce. However, [5] mention that deforestation can substantially alter climate variability and generate warmer future climate projections with greater probabilities of droughts and fires.
Likewise, [6] indicate that the forest has control over the climate and that the lack of actions to control the removal of natural vegetation increases deforestation, causing large changes in temperature and rainfall variations over time.
The rise in urbanization steadily over the past few years has seen a decline in the forest cover in the world. Large towns and cities now stand in place of areas that were once booming forests. The food and agricultural organization estimates that by 2050 at least 68% of the world's population will be living in urban centers [7]. The current urban centers cannot sustain all these people leading to the expansion of towns and cities. The expansion of towns cannot happen without the decimation of the natural environment around them such as forests and other critical natural resources like Rivers.

2. Materials and Methods

Bayes theorem is one of the methods of computing posterior probabilities from prior probabilities Theorem. A further analysis of problems using these probabilities with respect to new expected payoffs with additional information is called **prior-posterior analysis**. The Bayes' theorem in general terms can be stated as Follows:

Let A1,A2, ……………… An be mutually exclusive and collective exhaustive outcomes.
The probabilities P (Ai), P (A2),… P (An) are known.

There is an experimental outcome B for which the conditional probabilities P (B/A1), P (B/A2)…P (B/An) are also known. Given the information that the outcome B has occurred, the revised conditional probabilities of outcomes Aj, i.e., P (A1/B), i = 1, 2…n are determined by using following conditional probability relationship: Thus, a Bayesian Decision Theory Model will be used to simulate deforestation crisis for an optimum result.

The mathematical model is of the form:
P (A/DATA) = [P (DATA/A) X P (A)]/P (DATA) ………………………………………….. 1
Model Objective Optimization can be handled as follows:
Where:
P (A/DATA) = K [P (A/DATA) P (A)] ……………………………………………………….. 2

And the constraints are as follows:
Constraints:
P (A/DATA) = 0 ………………………………………………………………………… 3

P (DATA/A) = 0 ……………………………………………………………………………… 4
P (A) = 0 ………………………………………………………………………………………..5
P (B) = 0 ………………………………………………………………………………………..6

A –Deforestation Purpose: Irrigation Agriculture, flood control, erosion control, hydropower and plantation/forestry].

DATA- Values of the various Objective [Economic Efficiency, Federal economic Efficiency, Social well-being, Youth Employment and Environmental quality improvement] Yields expressed as courses of action and likelihoods corresponding to the Deforestation Purposes.

P (A/DATA)-Probability of A occurring given the DATA [Objective-Likelihood].
P (DATA/A)-Probability of the Data occurring given the A [Posterior]
P (A) - Prior Probability of A
P (DATA) - Probability of DATA occurring [Marginal Probability or Evidence of Objectives].

The Bayesian theory stated above is transformed to a Bayesian Decision simulation model and iteration method as displayed below in a flow chart:

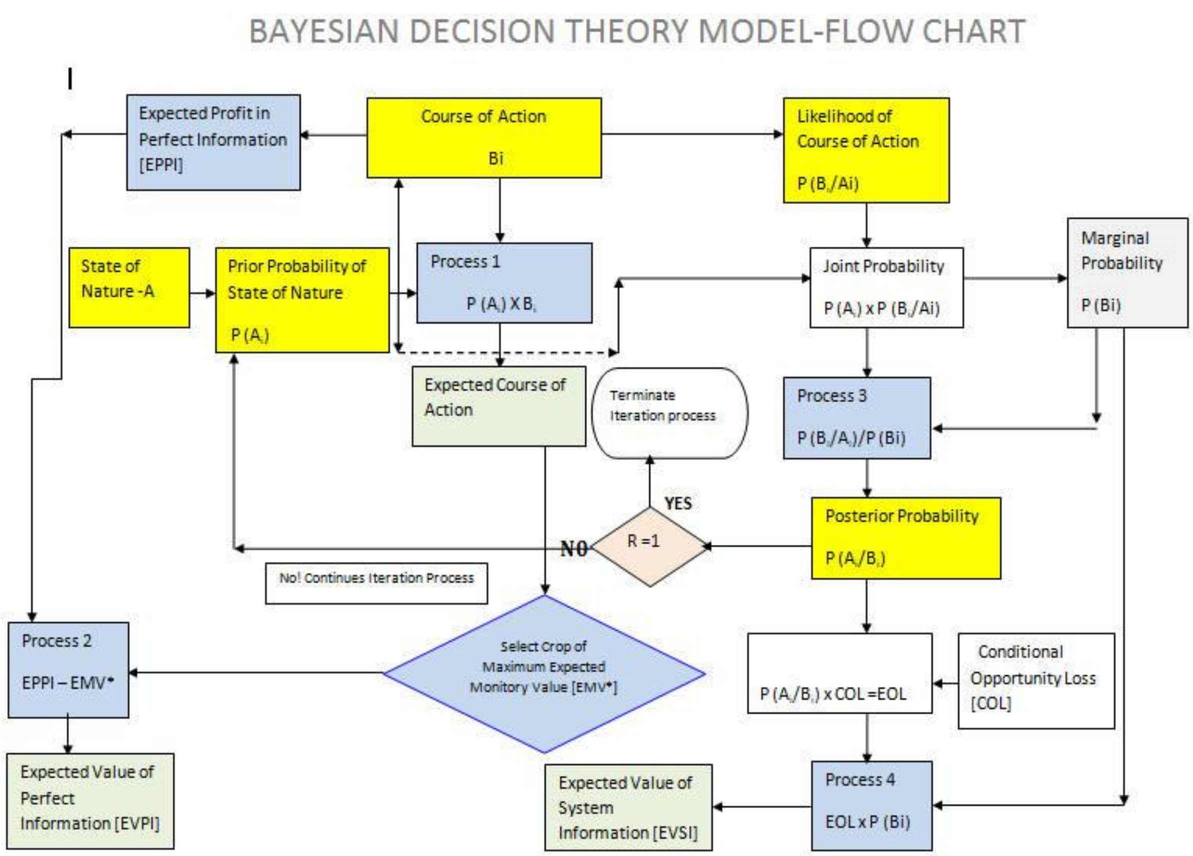

Figure 1: Bayesian decision theory model flow chart

2.1 Bayesian Decision Modeling and Simulation processes

1st Iteration In line with the Bayesian Decision Flow Chart (Fig.1), the Products of Prior Probability generated from table 1 & Course of Action of table 2 [1stIteration] resulted to the following output: table 4[EMV], table 5[EPPI & EVPI], table 6[Marginal Probability], table 7[Posterior Probability], table 8**[**EOL of Economic Efficiency], table 9[EOL of Federal Economy], table 10[EOL of Social well-being Distribution], table 11[EOL of Environmental Control], table 12[EOL of Youth Employment], table 13[EVSI] from which expected Monetary values of the benefits were obtained as follows. This process will be said to have been performed without data because it was computed with the first prior.

2nd Iteration

Similarly, in line with the Bayesian Decision Flow Chart (Fig.1), the Products of Posterior Probability(2nd Iteration Prior) generated in table 7& Course of Action of table 2 [Table 14] resulted to the following outputs: Table 15[**2nd** EMV], table 16[EPPI & EVPI], table 17[Marginal Probability], table 18[Posterior Probability], table 19**[**EOL of Economic Efficiency], table 20[EOL of Federal Economy], table 21[EOL of Social well-being Distribution], table 22[EOL of Environmental Control], table 23[EOL of Youth Employment], table 24[EVSI].

3. Results and discussions

Table 1: Estimate of Prior

State of nature	**Objectives**						
	Economic Efficiency	Federal Economic Efficiency	Social Well-being	Youth Employment	Environmental Quality Improvement	∑	Estimate prior P(N)
Irrigation Agriculture	13.87	14.49	7.71	20.53	7.22	63.82	0.14104
Flood Control	34.3	18.4	13.91	22.91	7.27	96.79	0.21391
Erosion Control	25.3	15.76	16.56	21.74	14.7	94.06	0.20788
Hydropower	9.15	16.96	15.94	19.85	19.19	81.09	0.17921
Plantation/Forestry	30.25	19.04	15.8	25.52	26.11	116.72	0.25796
Total						452.48	1.00000

Table 1 shows the outcome of the estimated prior probability from the calculated objective each state of nature**.** The table shows the likelihood forecast probabilities from various courses of action for net benefits/objectives. These probabilities were used in calculating the joint probability outcomes on first iteration in order to determine marginal probability outcomes.

Table 2: Benefit versus Purpose

Development Projects	**Objectives**				
	Economic Efficiency	Federal Economic Efficiency	Social Well-being	Youth Employment	Environmental Quality Improvement
Irrigation Agriculture	13.87	14.49	7.71	20.53	7.22
Flood Control	34.3	18.4	13.91	22.91	7.27
Erosion Control	25.3	15.76	16.56	21.74	14.7
Hydropower	9.15	16.96	15.94	19.85	19.19
Plantation/Forestry	30.25	19.04	15.8	25.52	26.11

The table above shows the calculation gotten from the BEME of benefit versus purpose of the deforestation projects. It Explained the summary results calculation of Net benefits from Bill of engineering measurement and evaluation (BEME) in billions of naira. Under irrigation Agriculture the highest benefits of ₦20.53B for youth employment while the least amount of benefit was ₦7.22B from environmental quality improvement and so on.

Table 3 Likelihood forecast of observed deforestation benefit.

Deforestation Purposes	**Likelihood Forecast**				
Purposes state of nature	$P(A_1/N_1)$	$P(A_2/N_2)$	$P(A_3/N_3)$	$P(A_4/N_4)$	$P(A_5/N_5)$
Irrigation Agriculture N_1	0.22	0.23	0.12	0.32	0.11
Flood Control N_2	0.35	0.19	0.14	0.24	0.08
Erosion Control N3	0.27	0.17	0.18	0.23	0.16
Water Supply/ Hydropower N_4	0.11	0.21	0.20	0.24	0.24
Plantation/Forestry N_5	0.26	0.16	0.14	0.22	0.22

The forecast likelihood in table 3 as calculated by dividing each value of the summering of Net benefit in Table 2 by the total value in each row of the table. The expected profit with perfect information (EPPI) was obtained by multiplying each prior probability by their respective highest net benefit on each row and adding up the value which is 24.0billion.The expected value of perfect information (EVPI) was obtained by subtracting the value of maximum expected monetary value (EMV) ₦24.0B from the amount of expected profit with perfect information (EPPI) ₦24.0B.

Table 4. Expected Monetary Value

Deforestation projects	**Expected Benefit**				
State of nature	Economic Efficiency	Federal Economic Efficiency	Social Well-being	Youth Employment	Environmental Quality Improvement
Irrigation Agriculture	1.96	2.04	1.09	2.90	1.02
Flood Control	7.34	3.94	2.98	4.90	1.56
Erosion Control	5.26	3.28	3.44	4.52	3.06
Water Supply/ Hydropower	1.64	3.04	2.86	3.56	3.44
Plantation/Forestry	7.80	4.91	4.08	6.58	6.74
EMV	24.0	17.21	14.45	22.46	15.82

Table 4 shows the expected monetary value at 1st iteration the maximum expected monetary value is ₦24.0B .EMV (course of action), $S_j = \sum \frac{m}{j} = i\ p_1\ jpj$

EMV = $\sum \frac{m}{j}\ 1\ pij\ pj$ = ₦24.0B

The maximum expected monetary value from Table 4= ₦ 24.0B

The table explained the summary results calculation of Net benefits from Bill of engineering measurement and evaluation (BEME) in billions of naira. Under irrigation Agriculture the highest benefits of ₦2.90B for youth employment while the least amount of benefit was ₦1.02B from environmental quality improvement and so on.

Table 5 EPPI and EVPI

EPPI	(0.014104 X 13.87) + (0.21391 X 34.3) + (0.20788 X 25.3) + (0.17921 X 9.15) + (0.25796 X 30.25) = ₦24. 0B
EVP1	EPPI – EMV ₦ = 24.0B =0

From the table shown above the EPPI was deducted from the EMV to get the EVPI which confirms that the calculation is correct. The expected perfect information is given as: expected profit with perfect information (EPPI) = (0.014104 X 13.87) + (0.21391 X 34.3) + (0.20788 X 25.3) + (0.17921 X 9.15) + (0.25796 X 30.25) = ₦24. 0B .The expected value of perfect information (EVPI) = EPPI –EMV = ₦24B - ₦24B =0 which confirm that the calculation is correct. i.e., EPPI must be equal

Table 6 marginal probability

State of nature	Prior prob. P(N)	Likelihood $P(Ai/N_1)$	Joints Probability $P(A_1nN_1) = P(Ni)\ P(Ai/Ni)$				
N_1	0.14	0.22	0.308				
		0.23		0.0322			
		0.12			0.0168		
		0.32				0.0448	
		0.11					0.0154
N_2	0.21	0.35	0.0735				
		0.19		0.0399			

		0.14			0.02940		
		0.24				0.0504	
		0.08					0.0168
N_3	0.21	0.27	0.0567				
		0.17		0.0357			
		0.18			0.0378		
		0.23				0.0483	
		0.16					0.0336
N_4		0.11	0.0198				
		0.21		0.0357			
		0.20			0.036		
		0.24				0.432	
		0.24					0.0432
N_5	0.26	0.26	0.0676				
		0.16		0.0416			
		0.14			0.0364		
		0.22				0.0572	
		0.22					0.0572
Marginal Probability			0.2484	0.1872	0.1564	0.2439	0.1662

The joint values probabilities outcomes were calculated by multiplying prior probability of each state of nature by the conditional probability outcomes and adding of the result of each of them to obtain the marginal probability values as shown on (Table 4.17)

The values of the marginal probabilities are 0.2484 for economic efficiency, 0.1872 for regional economic, 0.1564 for social well-being, 0.2439 for youth employment and 0.1662 for environment quality. MIT should be noted that in the tables the prior probabilities of states of nature P(Ni) for i = 1,2,3,4, and 5 are multiplied by each of the conditional probability's outcomes P(Bi/Ni) to get the joint values probabilities outcomes i.e., P(BinNi) = P(Ni) P(Bi/Ni) as shown above

Table 7: Posterior Probability of the Deforestation Benefit (NO DATA) (1ST Iteration)

Outcome (Ai)	Marginal Prob. P(Ai)	Joint Prob. P(Ai n Ni) = $P(N_1)$ P	Posterior Prob.
A_1	0.2448	0.0308	0.123994
		0.0735	0.295894
		0.0567	0.228261
		0.0198	0.079710
		0.0676	0.272142
A_2	0.1872	0.0322	0.172009
		0.0399	0.213141
		0.0357	0.190705
		0.0378	0.201923
		0.0416	0.222222
A_3	0.1564	0.0168	0.107417
		0.0294	0.187980
		0.0378	0.241688
		0.036	0.230179
		0.0364	0.232737
A_4	0.2439	0.0448	0.183682

		0.0504	0.206642
		0.0483	0.198032
		0.0432	0.177122
		0.0572	0.234522
A_5	0.1662	0.0154	0.02659
		0.0168	0.101083
		0.0336	0.202166
		0.0432	0.259928
		0.0572	0.344164

The posterior probability was computed by dividing each state of Nature total joint probabilities (referred to as marginal probabilities) by probability values of each outcome for each of the objectives as stated before for all N_1, N_2, N_3, N_4, and N_5 for each the objectives. For example, the objective A_1 (Economic efficiency) and the values of posterior probabilities under it were: N_1 (irrigated agriculture) = 0.123994, N_2 (Flood control) = 0.29589, N_3 (Erosion control) = 0.228261, N_4 (Hydro power water supply) = 0.079710, N_5, (plantation and forestry) = 0.272142. these are shown in table 4.18

Table 8: Expected Opportunity Loss (EOL) of Economic efficiency.

State of Nature	Posterior Probability	Conditional Opportunity loss (COL)	Expected Opportunity Loss (EOL)
N_1	0.12394	6.66	0.82580
N_2	0.295894	6.04	1.78720
N_3	0.228261	12.82	2.92631
N_4	0.079710	0	0
N_5	0.272142	13.31	3.62221
Posterior Expected Opportunity Loss			9.16152

The forecast outcomes for the objectives/benefits (posterior expected opportunity loss) was obtained by multiplying each of the posterior probabilities for each state of nature by the condition opportunity loss (COL) and adding results.
The total posterior expected opportunity loss (EOL) for the objective of economic efficiency is ₦9.1615B

Table 9: Expected Opportunity Loss (EOL) of regional Economic

State of Nature	Posterior Probability	Conditional Opportunity loss (COL)	Expected Opportunity Loss (EOL)
N_1	0.172009	0	0
N_2	0.213141	15.9	3.38894
N_3	0.190705	20.39	3.88847
N_4	0.201923	11.39	2.29990
N_5	0.222222	27.03	6.00666
Posterior Expected Opportunity Loss			15.58397

The forecast outcomes for the objectives/benefits (posterior expected opportunity loss) was obtained by multiplying each of the posterior probabilities for each state of nature by the condition opportunity loss (COL) and adding results. The total posterior expected opportunity loss (EOL) for the objective of regional economic is ₦15.5839B

Table 10: Expected Opportunity Loss (EOL) of social well-being

State of Nature	Posterior Probability	Conditional Opportunity loss (COL)	Expected Opportunity Loss (EOL)
N_1	0.107417	0	0
N_2	0.187980	9.54	1.79333
N_3	0.241688	8.74	2.11235
N_4	0.230179	3.56	0.81944
N_5	0.232737	10.6	2.46701
Posterior Expected Opportunity Loss			7.19213

The forecast outcomes for the objectives/benefits (posterior expected opportunity loss) was obtained by multiplying each of the posterior probabilities for each state of nature by the condition opportunity loss (COL) and adding results.
The total posterior expected opportunity loss (EOL) for the objective of Social well-being is ₦7.1921B

Table 11: Expected Opportunity Loss for Youth employment

State of Nature	Posterior Probability	Conditional Opportunity Loss (COL)	Expected Opportunity Loss (EOL)
N_1	0.183682	1.07	0.19654
N_2	0.206642	2.89	0.59720
N_3	0.198032	3.91	0.77431
N_4	0.177122	0	0
N_5	0.234522	0.66	0.15478
Posterior Expected Opportunity Loss			1.72283

The forecast outcomes for the objectives/benefits (posterior expected opportunity loss) was obtained by multiplying each of the posterior probabilities for each state of nature by the condition opportunity loss (COL) and adding results.
The total posterior expected opportunity loss (EOL) for the objective of Youth employment is ₦1.7228B

Table 12: Expected Opportunity Loss for environmental quality

State of Nature	Posterior Probability	Conditional Opportunity loss (COL)	Expected Opportunity Loss (EOL)
N_1	0.092659	0	0
N_2	0.101083	11.21	1.3314

N_3	0.202166	14.45	2.92130
N_4	0.259928	4.73	1.22946
N_5	0.344164	4.14	1.42484
Posterior Expected Opportunity Loss			6.70874

The forecast outcomes for the objectives/benefits (posterior expected opportunity loss) was obtained by multiplying each of the posterior probabilities for each state of nature by the condition opportunity loss (COL) and adding results. The total posterior expected opportunity loss (EOL) for the objective of environmental quality is ₦6.7087B

Table 13: Expected Value of System Information (EVSI) of prior probability

Outcome (Ai)	Marginal Prob. P(Ai)	Posterior (Expected Opportunity Loss)	Expected Value of system Information
A_1	0.2484	9.16152	2.27572
A_2	0.1872	15.58397	2.91732
A_3	0.1564	7.19213	1.12485
A_4	0.2439	1.72283	0.42020
A_5	0.1662	6.70874	1.11499
Total			7.85308

The expected value of sample information (ESVI) for each of the objectives are obtained by multiplying the marginal probabilities of each objective by the expected opportunity loss of each objective. The values are ₦ 2.2757B for economic efficiency, ₦ 2.9173B for federal economic efficiency, ₦ 1.1248B for social well-being, ₦ 0.4202B for youth employment and ₦1.1149B for economic quality improvement. The total expected value of sample information (EVSI) ₦7.8530 B indicates the money which can be paid for hiring the services of consultants for deforestation operation yield for all purposes which include: irrigation Agriculture, flood control, erosion control, water supply/hydropower generation, plantation/forestry. If all the five objectives of economic efficiency, Federal economic efficiency, social well-being, youth employment and environmental quality improvement are to be achieved for full utilization of the deforestation crisis in Delta State.

Table 14: Prior Probability and Course of action at the 2nd iteration

Deforestation purpose State of nature	Prior probability	Economic efficiency	Regional economic	Social well-being	Youth employment	Environmental Quality
Irrigation agriculture	0.123994	13.87	14.49	7.71	20.53	7.22
Flood control	0.295894	34.3	18.4	13.91	22.91	7.27
Erosion control	0.228261	25.3	15.76	16.56	21.74	14.7
Hydropower	0.079710	9.15	16.96	15.94	19.85	19.19
Plantation/forestry	0272142	30.25	19.04	15.8	25.52	26.11

The table above shows the calculation gotten from the 1st iteration deforestation projects

Table 15: Expected Monetary Value with Data

Deforestation purpose	Expected benefit				
Deforestation purpose State of nature	Economic efficiency	Regional economic	Social well-being	Youth employment	Environmental quality improvement
Irrigation agriculture	1.71980	1.79667	0.95599	2.54560	0.89524
Flood	10.14916	5.44445	4.11589	6.77893	2.15115
Erosion control	5.77500	3.59739	3.78000	4.96239	3.35544
Flood control	0.72500	1.35188	1.27058	1.58224	1.52963
Plantation/forestry	0.72935	5.18158	4.29984	6.94506	7.10563
Expected Monetary Value	26.60561	17.37197	14.4223	22.81422	15.03709

Table 15 shows the expected monetary value at 1st iteration the maximum expected monetary value is ₦26.605B. Expected Monetary Value (course of action) Si $=\sum j \frac{m}{n} = 1\ pij\ pi$
$\sum mv = \sum j \frac{m}{n} = 1\ pij.pj = 26.605$. The mix EMV from Table 4.15 = ₦26.605B

Table16: EPPI and EVPI

EPPI	0.123994 x 13.87.87 + 0.295894 x 34.3 + 0.228261 x 25.3 + 0.079710 x 9.15 + 0.272142 x 30.25 = ₦ 26.606B
EVPI	EPPI – EMV = ₦ 26.606B – ₦ 26.606B = 0

Table 17: Product of likelihood and prior probability of 2nd iteration

State of nature	Prior prob. P(N)	Likelihood $P(Ai/N_1)$	Joints Probability $P(A_1nN_1) = P(Ni)\ P(Ai/Ni)$				
N_1	0.123994	0.22	0.02728				
		0.23		0.02852			
		0.12			0.01488		
		0.32				0.03968	
		0.11					0.01364
N_2	0.295894	0.35	0.10356				
		0.19		0.05622			
		0.14			0.04143		
		0.24				0.07101	
		0.08					0.02367
N_3	0.228261	0.27	0.06163				
		0.17		0.0880			
		0.18			0.04109		
		0.23				0.05250	
		0.16					0.03652
N_4		0.11	0.00877				
		0.21		0.01674			
		0.20			0.01594		
		0.24				0.01913	
		0.24					0.01913
N_5	0.272142	0.26	0.07076				
		0.16		0.04354			
		0.14			0.03810		

		0.22				0.05987	
		0.22					0.05987
Marginal Probability			0.272	0.18382	0.15144	0.24219	0.5283

Table 18: Posterior probability of the Deforestation Benefit at 2nd iteration (with data)

Outcome (Ai)	Marginal Prob. P(Aj)	Joint Prob. P(Ai n Ni) $P(N_1)$ P(Ai/Ni)	Posterior Prob. P(Ni n Ai) = P(Ai n Ni/PAi)
A_1	0.272	0.02728	0.1003
		0.10356	0.3807
		0.6163	0.2266
		0.00877	0.0322
		0.07076	0.2601
A_2	0.18382	0.2852	0.1552
		0.05622	0.3058
		0.03880	0.2111
		0.01674	0.0911
		0.04354	0.2369
A_3	0.15144	0.01488	0.0983
		0.4143	02736
		0.4109	0.2713
		0.01594	0.1053
		0.03810	0.2516
A_4	0.24219	0.03968	0.1638
		0.07101	0.2932
		0.05250	0.2168
		0.01913	0.0790
		0.05987	0.2472
A_5	0.1662	0.01364	0.0892
		0.02367	0.1549
		0.03652	0.2390
		0.01913	0.1252
		0.05987	0.3917

Table 19: Posterior opportunity loss (Expected Opportunity Loss) for Economic Efficiency

State of Nature	Posterior Probability	Conditional Opportunity Loss	Expected Opportunity Loss
N_1	0.1003	6.66	0.66800
N_2	0.3807	6.04	2.29943
N_3	0.2266	12.82	2.90501
N_4	0.0322	0	0
N_5	0.2601	13.31	3.46193
Posterior EOL			9.33437

Table 20: Posterior Expected Opportunity Loss for Regional Economy

State of Nature	Posterior Probability	Conditional Opportunity Loss	Expected Opportunity Loss
N_1	0.1552	0	0
N_2	0.3058	15.9	4.86222
N_3	0.2111	20.39	4.30433
N_4	0.0911	11.39	1.03763
N_5	0.2369	27.03	6.40341
Posterior Expected Opportunity Loss			16.60759

Table 21: Posterior Expected Opportunity Loss for Social well-being

State of Nature	Posterior Probability	Conditional Opportunity Loss	Expected Opportunity Loss
N_1	0.0983	0	0
N_2	0.2736	9.54	2.61014
N_3	0.2713	8.74	2.37116
N_4	0.1053	3.56	0.37487
N_5	0.2516	10.6	2.66696
Posterior Expected Opportunity Loss			8.02313

Table 22: Posterior Expected Opportunity loss for Youth Employment

State of Nature	Posterior Probability	Conditional Opportunity Loss	Expected Opportunity Loss
N_1	0.1638	1.07	0.17527
N_2	0.2932	2.89	0.84735
N_3	0.2168	3.91	0.84735
N_4	0.0790	0	0
N_5	0.2472	0.66	0.16315
Posterior Expected Opportunity Loss			2.03346

Table 23: Posterior Expected Opportunity Loss for Environmental Quality

State of Nature	Posterior Probability	Conditional Opportunity Loss	Expected Opportunity Loss
N_1	0.0892	0	0
N_2	0.1549	11.21	1.73643
N_3	0.2390	14.45	3.45355
N_4	0.1252	4.73	0.59220
N_5	0.3917	4.14	1.62164
Posterior Expected Opportunity Loss			7.40382

Table 24: Expected Value of System Information at posterior probability

Outcome (Ai)	Marginal Probability P(Ai)	Posterior Expected Opportunity	Expected Value of System Information
A_1	0.272	9.33437	2.53895
A_2	0.18382	16.60759	3.05281
A_3	0.15144	8.02313	1.21502
A_4	0.24219	2.03346	0.49248
A_5	0.152283	7.40382	1.13153
Total			8.43079

Table 24 is the Expected Value of System Information; the ministry environment has to pay for hiring the services of the forecaster

Table 25: Prior and posterior Pearson product moment correction co-efficient for 1st iteration

S/N	X prior	Y posterior	XY	X^2	Y^2
1	0.14104	0.123994	0.017488	0.019892	0.015375
2.	0.21391	0.295894	0.063295	0.045757	0.087553
3	0.20788	0.228261	0.047751	0.043214	0.052103
4	0.17921	0.079710	0.014285	0.032116	0.006354
5	0.272142	0.272142	0.070202	0.066543	0.074061
$\sum$	1.00000	1.00000	$\sum xy$ 0.212721	$\sum x^2 = 0.207522$	$\sum y^2 = 0.235446$

Pearson (r) $\frac{\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2)][n\sum y^2 - (\sum x)^2]}}$

$r = \frac{5(0.212721)-(1x1)}{\sqrt{5(0.207522)-(1)^2(5x0.235446-(1)^2)}}$

$r = \frac{1.063605-1}{\sqrt{(0.03761)\ (1.17723-1)}}$

$r = \frac{0.063605}{\sqrt{0.0066656203}}$

$r = \frac{0.063605}{\sqrt{0.8164325018}}$

r = 0.779 = 0.81

There exist a strong correlation between prior and posterior probability in the 1st iteration.

Table 26: Prior and posterior Pearson product moment correlation coefficient for 2nd iteration

S/N	X prior	Y posterior	XY	X^2	Y^2
1	0.123994	0.1003	0.012437	0.015375	0.010060
2.	0.295894	0.3807	0.112647	0.087553	0.144932
3	0.228261	0.2266	0.51724	0.052103	0.051348
4	0.27214	0.0322	0.002567	0.006354	0.001037
5	0.27214	0.260	0.070756	0.074061	0.067652
$\sum$	1.00000	1.00000	$\sum xy = 0.250131$	$\sum x^2 = 0.235446$	$\sum y^2 = 0.2775029$

Pearson (r) $\frac{\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2)][n\sum y^2 - (\sum x)^2]}}$

r = $\frac{5(0.250131)-(1x1)}{\sqrt{5(0.235446)-(1)^2(5x0.275029-(1)^2)}}$

r = $\frac{1.250655-1}{\sqrt{(1.17723-1)\,(1.375145-1)}}$

r = $\frac{0.250655}{\sqrt{0.006648694835}}$

r = $\frac{0.250655}{\sqrt{0.2578506319}}$

r = 0.9720 = ₦1.0

There exit a strong correlation between prior and posterior probability of the 2nd iteration

4.0 Conclusion and Recommendation

From the research work, the researcher was able to know some climate change resulting from deforestation with negative impacts such as increase in ambient temperature, drought, flooding, erosion, biodiversity loss, and increase in global warming, increase in greenhouse gas emissions, famine, ecosystem collapse and death. The expected monetary values of water resource objectives were optimized. The value of economic efficiency was optimized from 1st iteration to 2nd iteration with the expected monetary values of ₦24B (plantation and forestry) and ₦26.61B (hydropower) respectively. The Pearson correlation coefficient of prior and posterior of the 1st and 2nd iteration gave a value of r = 0.81, r = 0.9720 and respectively. If the allocation for water resource project in Delta State is ₦24B from 2018-2022 (5 years) is deducted from ₦26.61B generated, then the state will make a profit margin of ₦2.61B from the investment. The environmental authority is expected to pay the researcher the expected value of system information (EVSI) value of ₦8.43B for information generated using the Bayesian decision theory model spreadsheet There should be government regulations to curb the falling of trees by enforcing a series of rules and laws to govern it. Banning and clear cutting of forest will curb the total depletion of the forest cover. It is practical solution and it is very feasible. Reforestation and afforestation should be enforced and land skinned of its tree cover for urban settlements should urge to plant tree in the vicinity and replace the cut trees. Reduce consumption of paper, try to reduce consumption, reduce waste of paper and also opt for recycled paper products make life simple and wherever possible, go paperless. The government should educate the people because many are entirely unaware of the global warming, we are facing by sharing the deforestation facts, its causes, and the effect. This can make an impact. Deforestation crisis should be reduced to the bearest minimum with the felling of one lead to planting of ten seedling as a sustainable measure put in place. The law that govern protection of forest, should be properly implemented and enforce to the law with proper policing and monitoring and stringent punishment. Moderate resolution imaging spectrometer (MODIS) should be lunched onboard Nigeria satellite so as to enable the monitoring of deforestation and necessitate quick action in case of unlawful deforestation.

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