Decision Support System for Drafting of Sustainable Agriculture Production Policy for Odisha

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Abstract — Agriculture production planning must aims at sustainability and progress at the same time. Production policy has farmers, government officials, political party, inputs for production, finance, market demand and pace of development as drivers for policy formulation. Selection of crops sequence in a geographical area is very difficult as it has sustainability parameter inbuilt in to policy. DSS can assist the policy planners to get different baskets of options for choosing the best SMART basket of option. The variation of rain-fall, climatic factors, and market trend of different crops have been considered to frame the basket of crops options to be grown in a hilly district of Odisha, India. The DSS formulation has inbuilt mechanisms for blending of the qualitative and quantitative parameters used in crop sequence planning in the agricultural policy. With reduction in rainfall, there is a chance that the paddy crop growing may not be feasible. Some low water requiring crops are used to determine the other basket of option. Under present context, KBK region of Odisha, India with less rain fall can have the best alternate crop as per the residual moisture has been found to be pulses crop for hilly area of the state. Similarly the area with higher rainfall can have paddy – paddy cropping pattern as per present practice. However there is scope for cash crops like maize, groundnut in the crop sequence.

Keywords— *DSS, KBK, Cropping Sequence, Cash Crops, SMART,*

1. Introduction

Sustainable development in agriculture sector is associated with economic, social and environmental facts. Finding a suitable basket of option for crop production planning is a difficult preposition. The sustainable program needs balance address of food security, soil health and profitability. The growth in agriculture sector considering above parameters is a tough job. The blending of qualitative and quantitative facts is very much required for finding the best set of options. Decision Support System (DSS) can be suitably formulated to develop the basket of operation to be used by the planner. These baskets of operations consider the need of the area, eco-system, profitability and need of the society. The DSS development process includes careful evaluation of the scope of the DSS in relation to the human and fiscal resources available. During the formulation of DSS careful attention should be paid to the needs of the intended target user group(s) through matching the proposed technology appropriately with the user, and gathering input from a broad spectrum of potential users when performing a DSS requirement analysis. Simpler tools or database information generated from simulation analysis of alternative management options may have been more appropriate for delivery to producers and consultants. The capability to rapidly update major components (simulation model, databases) in order to address different farm management questions or problems is an absolute necessity of the hour. DSS development uses interrelated factors, processes, resources, and institutions. Present research used DSS to answer practical agricultural problems and simultaneously identify gaps using computer software. Microsoft excel spread sheet software could perform integrated farm resource analysis of alternative crop sequence. The computation is based on much uncertainty related activities for computation, adoption and implementation.

The computer analysis has been conducted for finding the growth trend of inputs (sale of implements) and its use in Odisha. The data has been collected from the block / district level offices, and plotted using MS Excel for analysis and interpretation. The trend analysis for use of the farm machinery in Odisha has been plotted and the correlation coefficients have been computed from the graph through hit and trail method to arrive at the best fitted model (higher r^2). The best matching model has been computed and confirmed through the r^2 value. The relationship shows about 90% of the data collected for analysing the increased trend of use of agricultural implements in Odisha best matches to exponential pattern of growth. The increasing trend of sale of agricultural implements/ machineries shows that more man days of work is being put in agricultural production process. The

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operational model has clearly indicated that the equipment like tractor, power tiller, combine harvester, water pump, power operated implements, threshers, trans planters, rotavators, reapers, manual implements have shown positive development in terms of its use by common farmers. About 10 years sales figure through government incentive has been collected for analysis from all the line department officers through personal contact. The analysis has been conducted to find the best model fitted for this data set. It has been observed that the models most befitting is found to be either linear model or power function model or polynomial model. These equations can be used for optimization of production for the state as a whole and district as particular.

2. Review of Literature

Watershed and its management have been simulated by [5] researchers using web based program and DSS interface. This has been developed for computer illiterate people with GUI. The effects of change in land use depending upon water quantity and quality has been comprehended. This DSS guides the users to use the resources to fullest extent. DSS has been used to manage and develop the conditions of Coastal lagoons by [2] [21] using databases which contain a geological information system, historical data and data analysis tools. The data analysis tool has been developed along with a knowledge base, by taking into account the benchmarking exercises, mathematical models and the information gathered from scenario analysis[14][20]. The utilization of the available resources has been done and tested in five lagoons in southern Europe. The problem of the lagoons' environment and the national and regional authorities has been addressed using DSS. The same tool has been applied to allocate the housing loans to the denationalized buildings of Slovenia in the city of Ljubljana [12][13]. A qualitative multi-attribute model has been developed based on a DEX Methodology for ranking applicants according to their priority. A decision support tool named [4][18] SMAC Advisor has been used to assess the co-existence between conventional and genetically modified maize. A qualitative multi attribute DEXi Model is the base for this assessment. The simulations of excessive gene flow due to cross pollination (which is obtained by a simulator called MOPED®) is used along with rules of Agronomy as source for this model[1][3][19]. The use of DSS in the field of generation of option for the planner is very common. The DSS use in agriculture planning is important as it has many dimensional approach[6][15][7][17]. The scientific management has to be clubbed with the experience to make the approach a long term sustainable. The maintenance of echo system for longer period of time is the main objective of this planning. The sustainability clauses of the agricultural planning can be addressed using DSS tool [8][11] . The basket of options are suitably selected and implemented for sustainability which is the present trend of research [9][16].

The DSS options will consider the rank, rating to determine the score of the individual basket. The options with scores below the cut off score will be rejected. The options with higher score will be considered for implementation with present demand considerations [22][23].

3. Materials and Methods

Considering sustainable agricultural production planning involving economic development, social parameters and environmental safety one has to mix the qualitative and quantitative parameters. A basket of options for varying production environment has to be developed. The process adopted in this research is decision matrix / AHP matrix (COWS). The decision and scoring matrix are used to find the best basket of operation where the scoring matrix does not have a clear cut result. Listed criteria are ranked and the ratings are noted. Similarly the experts' opinions are listed in weight column. The score are computed to find out the best of the bread versus the integrated solution. This is a proven process involving data collection, determination of the correlation coefficients. The correlation coefficients are to be ranked. The qualitative parameters like social parameters, economic development parameters and ecological parameters are considered. The values are collected from the researchers, leading farmers and the experts in these fields and the requirements of the region with respect to above parameters are ranked. The basket of operations with little increase or decrease of the weight are made to see the sensitivity of the solution and the all in one versus the best of the breed is obtained.

3.1 Collection of Data

The collection of production data from a region for last ten years has been collected from the economic and statistics department of government of Odisha and agriculture department separately. The validations of the data are done and average has been computed. The Correlation matrix has been computed using the SPSS - 17 package. The ranking of the correlation with respect to different input (fertilizer, seed, area, labour, finance, water and different produces are computed and used in COWS process.

3.2 Expert Selection

Professors of State Agriculture University, Odisha, India has been considered as experts to rank the requirement of the product of a region Kalahandi, Balangie and Koraput (KBK). Similar experts from Krishi Vugyan Kendras (KVK) Balangir who are more associated with the agricultural field work are consulted and their weight values of the crops are considered for determining the basket of options.

The agriculture department officials are consulted for determining the feasibility of the growing of the proposed crops. Expert opinions from the farmers are taken to consider the sustainability and social parameters. The COWS score are determined using the correlation coefficients as rating and experts opinion as weight and the scores are computed.

Graphical representation are carried out to make is visible and placed before the planners for consideration for implementation. The mathematical and the score functions used are given below.

Correlation coefficient

$$r = \frac{n\,(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n\sum x^2 - (\sum x^2)][n\sum y^2 - (\sum y^2)]}} \qquad (1)$$

COWS score

$$Score = \sum (Weightage * Rating) \qquad (2)$$

3.2.1 Results

Correlation coefficients of the crops presently grown are determined using SPSS -17 package and the item under reference are ranked with respect to the other parameters. The input for crop production like fertilizer, seed, area, labour, finance and water are also used for computation of correlation coefficients. The rating has been made and its weightage and rating are multiplied and added to determine the score for consideration of the basket of options. Similar computation have been made for the crops grown in the area under study in Odisha, India and the basket of options are obtained for the use of the planners and government officials.

4. Results and Discussions

Crop production data for last 50 years has been collected and analysed for correlation coefficient for major crops like rice, green gram, black gram, ground nut, maize, wheat, coarse grains, oilseeds, cotton, sugarcane, fibre crops and other crops. The bar graph plotted for 10 years average using data for cereals, pulses, oil seeds and other crops show that rice has less fluctuation in its' total production. Wheat crop production shows an increase trend over five decades. Similar trend has been noticed in the growth of other crops. These changes in the bar graphs show that sustainable issues have brought in changes in such crop production. The decrease in crop like course cereals and pulses are due to change in food habit of the SC / ST community and non-availability of the processing as well as value addition facility Fig(1) .

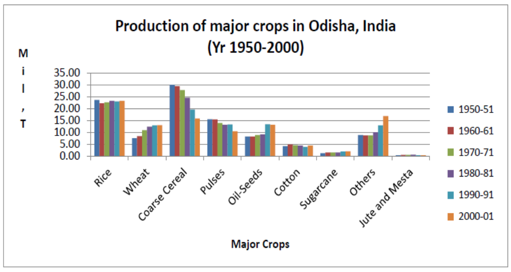


Figure 1 Production of major crops, Odisha, India

The land area for agricultural purpose has been collected and plotted. The use of land for agricultural purpose has increased from7500 hectare to 34500 hectare during IX five year plans in Odisha. The increase in area under cultivation and the change in area under a particular crop over a period of time make the agricultural planning difficult one. The planning must make the basket of plan to be offered to the farmer to consider for production to have maximum profit. The area under agriculture is increasing and crop calendar is varing depending upon need of the area and the nearby market. It has to be considered in the planning process for best result and sustainability.

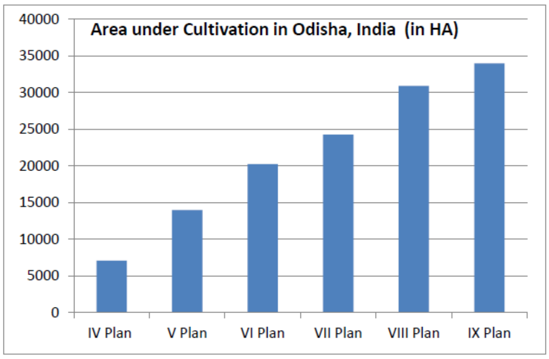


Figure 2 Area under cultivation in Odisha, India

The inputs and the crops to be grown are to be analyzed for determining the best suitable plan for crop sequencing so that the production is sustainable, profitable and environmental friendly. The inputs like seed, fertilizer, area, labor, water and finance are considered for finding the correlation among themselves. Out of the above inputs it has been observed that the labor availability is a major bottle neck. The farm mechanization has been studied in detail and the trend of sale of the farm equipment like tractor, Power tiller, Combine Harvester, Power operated equipment, Paddy thresher, paddy trans planter, paddy reaper, irrigation pump sets and manual implement sales are analyzed. Sale of tractor and the transplanter has fluctuation or less regression coefficient but all other farm machineries have excellent marketing in Odisha due to availability of subsidy from State and central government. This is a good indicator of growth of the production of agriculture crops. The basket of option to be determined can be well achieved due to availability of large number of farm machinery.

Table 1 Regression coefficients of the farm mechanization development, Odisha

Agricultural Implements	Best Fitted Regression Model	R^2 value
Tractor	Linear	0.67
Power tiller	Polynomial (2)	0.908
Combine Harvester	Polynomial (2)	0.983
Power operated Equipments	Power	0.94
Paddy Thresher	Power	0.908
Paddy Transplanter	Straight line	0.65
Rotavator	Power (4)	0.94
Paddy Reaper	Exponential	0.955
Pump set	Polynomial (3)	0.9955
Manual implements	Polynomial (4)	0.96

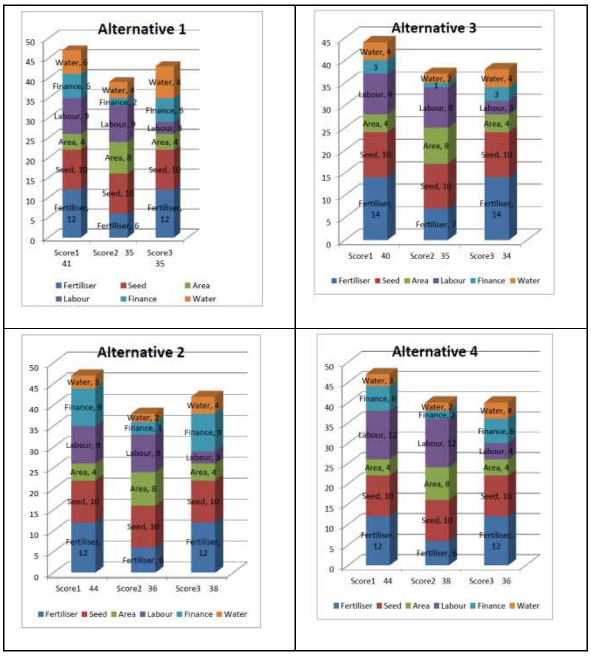
Major input parameters for crop production have been listed (fertilizer, seed, area, labour, finance and water) and to simplify the computation most significant factors are selected based on the experts' opinion. The correlations among these parameters are computed from the available data of the state government data base. The production and its correlation with the parameters are determined for ranking and interpretation. These are ranked and the baskets of operation are determined using the COWS technique.

Basket of options for selecting inputs

Correlations								
Production	I	1.00	0.77	0.06	0.62	0.79	0.79	0.71
Fertiliser	I	0.79	0.61	0.14	0.65	0.77	1.00	0.60
Seed	I	0.79	0.83	0.05	0.44	1.00	0.77	0.59
Area	I	0.77	1.00	0.06	0.43	0.83	0.61	0.53
Labour	I	0.71	0.53	0.33	0.47	0.59	0.60	1.00
Finance	I	0.62	0.43	0.06	1.00	0.44	0.65	0.47
Water	I	0.06	0.06	1.00	0.06	0.05	0.14	0.33

		Alternative Inputs 1					
Criteria		Option A		Option B		Option C	
	Weights	Rating	Score1 41	Rating	Score2 35	Rating	Score3 35
Fertiliser	6	2	12	1	6	2	12
Seed	5	2	10	2	10	2	10
Area	4	1	4	2	8	1	4
Labour	3	3	9	3	9	1	3
Finance	2	3	6	1	2	3	6
Water	1	3	6	2	4	4	8
			41		**35**		**35**

The Correlation Coefficients are ranked and the ranking values are used with the weight scale provided by the experts in computation of the score of the alternatives. Three options (A, B, C) have been computed for growing of the crops with available inputs. The rating of the components like water, seed, finance, area, labour and fertilizer have been performed by the group of experts in the field of production. They are state agriculture university professors, Krishi Vikash Kendra Officers, agriculture department officers and leading farmers of the area. Depending upon the sustainability issues, the ranking and weight has been multiplied and added to get the scores for options. It has been observed that the SAU, KVK, DDA and the farmer's opinion are converted to a numerical value and the computation is performed to add qualitative and quantitative parameters. The scores vary from 34 to 44. Planners get a pictorial form of the ready



reckoner for use in policy formulation of making a smart goal. The implementation of the finding purely depends upon the planner. The resources, HR and financial availability guides for deciding the best basket to be used for the area. These baskets to be chosen will vary from area to area. Hence similar calculation has to be performed for the areas where such interventions are being proposed. Evenly distributed stacked plot with score 40 (Option A of Alternative -3) seems to be a sustainable preposition for selection of crops. This option needs to be examined at the time of implementation and requirement of the people of the area.

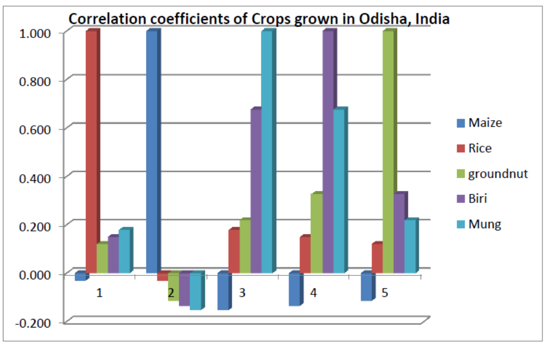
Basket of option for Crop Production

Knowing the best basket of inputs the best basket of option for crop production for sustainable development has been computed in this research.

Rice	1.00	-0.03	0.18	0.15	0.12	-0.26	-0.16	0.03
Mung	0.18	-0.15	1.00	0.68	0.22	-0.04	0.12	0.22
Biri	0.15	-0.13	0.68	1.00	0.33	-0.07	0.11	0.18
groundnut	0.12	-0.11	0.22	0.33	1.00	-0.13	-0.04	-0.06
Til	0.05	-0.08	0.16	0.14	-0.02	-0.03	0.15	-0.05
Gram	0.03	0.20	0.22	0.18	-0.06	-0.06	0.33	1.00
Mustard	0.00	0.03	-0.06	-0.02	-0.03	-0.04	0.28	0.09
Maize	-0.03	1.00	-0.15	-0.13	-0.11	0.09	0.15	0.20
Arhar	-0.16	0.15	0.12	0.11	-0.04	0.25	1.00	0.33
Niger	-0.22	0.14	-0.23	-0.19	-0.19	0.66	0.35	0.07
Ragi	-0.26	0.09	-0.04	-0.07	-0.13	1.00	0.25	-0.06

Correlations								
Ragi	-0.26	0.09	-0.04	-0.07	-0.13	1.00	0.25	-0.06
Niger	-0.22	0.14	-0.23	-0.19	-0.19	0.66	0.35	0.07
Arhar	-0.16	0.15	0.12	0.11	-0.04	0.25	1.00	0.33
Maize	-0.03	1.00	-0.15	-0.13	-0.11	0.09	0.15	0.20
Til	0.05	-0.08	0.16	0.14	-0.02	-0.03	0.15	-0.05
Mung	0.18	-0.15	1.00	0.68	0.22	-0.04	0.12	0.22
Mustard	0.00	0.03	-0.06	-0.02	-0.03	-0.04	0.28	0.09
Gram	0.03	0.20	0.22	0.18	-0.06	-0.06	0.33	1.00
Biri	0.15	-0.13	0.68	1.00	0.33	-0.07	0.11	0.18
groundnut	0.12	-0.11	0.22	0.33	1.00	-0.13	-0.04	-0.06
Rice	1.00	-0.03	0.18	0.15	0.12	-0.26	-0.16	0.03

The basket of option for crops to be grown considering economic, social and environmental factors has been considered. The raking of the correlation coefficient has been done after computing the correlation coefficients.



		Alternative 1					
		Option A		Option B		Option C	
Criteria	Weightage	Rating	Score1	Rating	Score2	Rating	Score3
Rice	2	2	4	1	2	2	4
Green Grar	1	2	2	2	2	2	2
Black Grar	3	1	3	2	6	1	3
Groundnut	5	3	15	3	15	1	5
Maize	4	3	12	1	4	3	12
			Score 36		Score 29		Score 26

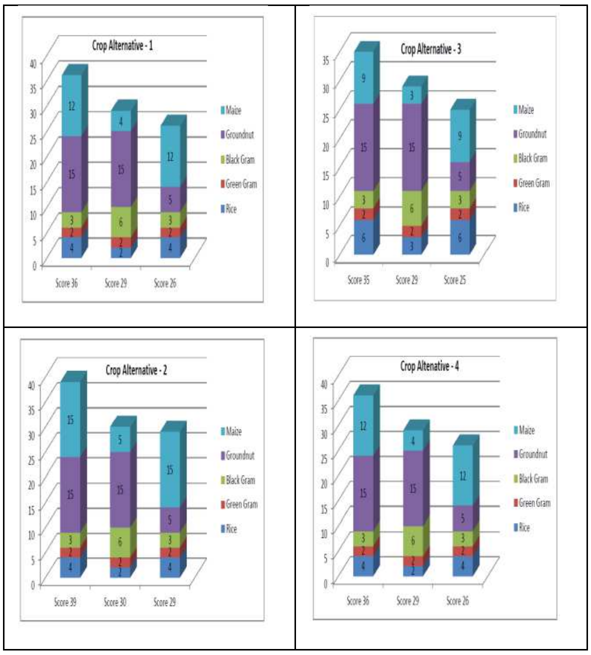
		Alternative 2					
		Option A		Option B		Option C	
Criteria	Weightage	Rating	Score1	Rating	Score2	Rating	Score3
Rice	2	2	4	1	2	2	4
Green Grar	1	2	2	2	2	2	2
Black Grar	3	1	3	2	6	1	3
Groundnut	5	3	15	3	15	1	5
Maize	5	3	15	1	5	3	15
			Score 39		Score 30		Score 29

		Alternative 3					
		Option A		Option B		Option C	
Criteria	Weightage	Rating	Score1	Rating	Score2	Rating	Score3
Rice	3	2	6	1	3	2	6
Green Grar	1	2	2	2	2	2	2
Black Grar	3	1	3	2	6	1	3
Groundnut	5	3	15	3	15	1	5
Maize	3	3	9	1	3	3	9
			Score 35		Score 29		Score 25

		Alternative 4					
		Option A		Option B		Option C	
Criteria	Weightage	Rating	Score1	Rating	Score2	Rating	Score3
Rice	2	2	4	1	2	2	4
Green Grar	1	2	2	2	2	2	2
Black Grar	3	1	3	2	6	1	3
Groundnut	5	3	15	3	15	1	5
Maize	4	3	12	1	4	3	12
			Score 36		Score 29		Score 26

The coefficients are ranked and used as the rating parameter. This is quantitative components of the COWS. The qualitative components (weight) which involve the social and sustainable issues are addressed by the experts from SAU, KVK, DDA and leading farmers. Considering three cropping pattern or options A, B and C the scores are computed. Similar options are obtained for the four experts and the graphical components of the finding are developed.

Major crops like maize, groundnut, black gram, green gram and rice have been considered in this



analysis. The food security, health of soil and the festive need for the people has been included in this model formulation. It has been observed that the score for crop production has higher value as high as 39. Considering the need of paddy (rice) for food security a middle score basket seems to be more feasible (Score 35). This basket option may change every year depending upon the need of the time and market trend. Such graphs once prepared with mathematical ranking and the rating score of the experts will help to plan the sustainable planning. It has been observed that huge data and the vast experience in field of production and market demand will guide the formulator to formulate various options for consideration and best result on use. The experts weights are added some times to guide the experts for deciding course of action. It has been proved that the score obtained with little variation in weight and determining the corresponding scores gives a clear cut visual presentation for the implementation / planner to draft a sustainable policy for development of agriculture under adverse condition.

5. Conclusions

Complex situation in agricultural planning arises out of erratic inputs for crop production which requires guidelines to be followed for best solution. The users are illiterate farmers. Their requirements are different for different location of the state. The planners have a definite growth rate factor as mandate. The growth rate and the economic as well as environmental need detect the agricultural production policy. The rainfall, availability of seed, machinery, water, and fertiliser prompts the planner to combine the availability of input with the need of the time and area to find the basket of options. The best options for crop production out of the determined ones are to be selected and implemented so that the profitability of the region is highest. Farmers will have better planning once such a planning is practised. In the present context where the rainfall is less it has been observed that considering the food security and sustainability second higher scored basket is preferred for implementation. Alternative 2 shows that, the area under the segments like fertiliser, mechanization etc. is almost same in the graphical representation. The planners can observe that the food security and fertiliser management has been well considered in the model alternative 2. Depending upon the location the alternatives may vary. This basket once implemented will take care of the need of the people and sustainable development.

From this research it has been observed that such computation can be done before planning for the change in the production pattern in a region due to change in input. The utility of his simulation will help all the villagers to produce profitable crops. The ecological balance and best use of natural production parameters can be synergistically used for better agricultural growth of the region.

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