OPTIMAL CROPPING PATTERN IN AN IRRIGATION PROJECT

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ABSTRACT

System approach has been followed to quantify the areas on which different crops can be raised, subject to land availability and total quantity of water available at the head of the command area at different points of time. Modified Simplex Algorithm has been used to optimize net return. To obtain optimum cropping pattern, concept of ‘block’- area under same agronomic, climatic, rainfall, and economic factor, has been introduced. In the present study, optimal cropping pattern has been determined for Mayurakshi Command Area, a semi-arid region in India for five crops, three soil-classes, five blocks, two agronomic zones, two economic zones, two climatic zones and two rainfall zones.

Keywords: Optimal Cropping Pattern, Modified Simplex Algorithm, Mayurakshi Command Area

1. INTRODUCTION

Due to ever increasing water demand for increasing food production, water management for irrigation has got momentum. About 45% of agricultural production in India is dependent on monsoon period precipitation which is very erratic in its spatial and temporal variation. Due to erratic behavior of monsoon dependability of rainfall on agricultural production is thus low and storage is essential to sustain crops during non-monsoon period as well as for irrigation during years of low rainfall.

From a storage reservoir water is supplied in its command area. Our main aim will be the optimum utilization of the stored water as well as optimum net return. The decision regarding the raising of a particular crop in order to get optimum net return is influenced by a number of factor such as availability of water, suitability of soil, climatic and rainfall conditions of the area, local practice, availability of labour, inputs like fertilizer, agriculture implements etc and sale value of crop raised. All these parameters have made the cropping pattern to get optimum net return very
intricate. In such a situation system approach has been accepted as a viable tool in making such decision.

2. LITERATURE SURVEY

Limited numbers of works have dealt with optimum allocation of irrigation water under multi-crop situation. Kumar and Khepar[1980] developed optimal cropping pattern by modifying a fixed yield model by incorporating the stepwise crop water production function. Rao et al. [1990] developed a model for optimal weekly allocation of water by applying Dynamic Programming (DP) considering the area for a particular crop as fixed a priori. Maleka[1993] has developed optimal cropping pattern for a number of crop by using Target MOTAD in an irrigation project at Zambia. Vedula and Kumar[1996] developed a steady-state optimal operating policy along with optimal allocation of crop water by combined use of linear programming and Stochastic Dynamic Programming(SDP). Singh et al. [2001] developed a linear programming model to suggest the optimal cropping pattern for maximum net return at different water availability levels in the command area of Shahi Distributary in India. Kipkori[2002] developed optimum cropping pattern by applying DP optimization technique in northern Tunisia. Khare et al. [2003] developed optimal cropping pattern using linear programming with various hydrological and management constraint to get optimum net return in an irrigation project in Indonesia. Darwish et al. [2007] introduced a 5-year dynamic linear programming model was developed to determine the optimal cropping pattern in South Lebanon. Pant et al [2010] used Evolutionary Algorithm (EA) to develop optimal cropping pattern with the objective function of optimum net return and compared the said model algorithms with LINGO, software of Linear Programming model for an irrigation project at Kerala, India. Ahmed et al [2012] has formulated a mathematical sector model with the help of LINGO for maximizing the net annual return in agricultural sector in Saudi Arabia.

In this study optimal cropping pattern has been developed to get maximum net return subject to land availability and total quantity of water available at the head of command area at different point of time in Mayurakshi Command Area, India using Modified Simplex Algorithm.

3. DESCRIPTION OF THE SYSTEM UNDER STUDY

Mayurashi command area is extended from 24°31´ N latitude at north 23°33´ N latitude at south and 88°08´ E longitudes at east to 87°30´ E longitudes at west. The project takes care of about 21% of total irrigation of the provincial state West Bengal, India. Out of 4878 sq. km of total catchment area of Mayurashi river, 1510 sq. km is located up stream of Massanjore dam and is shaped like a leaf, undulating in nature with land under paddy cultivation (44%), other cultivated land (18%), cultivable waste land (24%), forest land (6%) and pasture land (8%). Massjore dam has a capacity of 616 Mm$^3$ out of which 68 Mm$^3$ is dead storage, 400 Mm$^3$ is live storage and rest is flood storage. Tilpara barrage is located 37 Km downstream of Massanjore dam. There are two main canals on either side of barrage with a discharge capacity of 100 cumec. The distribution system consists of a network of main canals, branch canals, distributaries, minors, water courses and field channels.

Annual rainfall in the basin varies from 1000 mm to 1400 mm. About 80% of annual rainfall occurs during monsoon period (15 June to 15 October). The air is highly humid during monsoon and decreases progressively in summer with average relative humidity 45% to 60%. Evaporation is as high as 175 mm in May and is very low during July to November. Rest of the year is moderate evaporation. Mean annual temperature varies from 26°C to 31°C. Evapo-transpiration varies from 9.5 mm/day (in May) to 3.3 mm/day (in December).
4. FORMULATION OF PROBLEM

4.1 Concept of Block

In this system study, computation of net return and net irrigation water requirement need some consideration. Net return for any crop is the product of yield per unit area and sell price of unit yield less expenses. Net irrigation water requirement is the difference of crop water requirement and effective rainfall. In a command area the values of yield per unit area, sell price per unit yield, expenses, crop water requirement and effective rainfall are influenced by agronomic, economic, climatic factors and rainfall factors. These factors are not likely to remain same over a command area. The block is an area within which agronomic, economic and climatic factors as well as rainfall remain unchanged. So for analysis the entire command area has been divided into a number of agronomic zone, economic zone, climatic zone and rainfall zone.

4.1.1 Agronomic Zone (AZ)

Agronomic factors are yield, type of crop sown and type of soil. If in a certain portion of command area same types of crop are sown and their yield value is same for a particular class of soil, then the portion of the command area lies in a particular agronomic zone.

4.1.2 Economic Zone (EZ)

A portion of the command area lies in a particular economic zone if economic factors like cost of labour, hire charges of agricultural implements, cost of seeds, fertilizers, insecticides and sale rate of main product and by product of a particular crop remain unchanged.

4.1.3 Climatic Zone (CZ)

If a certain area several climatic factors such as temperature, relative humidity, wind speed, sunshine hour remain unchanged everywhere at any time (day, week, month), the entire area will be identified as a single climatic zone. Evapo-transpiration of a particular crop at a particular time (day/week/month or period) is dependent on the abovementioned factors. As in a climatic zone those climatic factors remain unchanged in a particular period, so evapo-transpiration will remain unchanged for a particular crop in a particular period. In other words, the water requirement of a particular crop in a particular period will be same everywhere within a climatic zone.

4.1.4 Rainfall Zone (RZ)

Rainfall is not evenly distributed over space as well as time. Rainfall zone is that area within which rainfall values are assumed to be same in a particular period. In other words, effective rainfall is same everywhere in a rainfall zone in a particular period. So net irrigation requirement (which is the difference between consumptive use and effective rainfall), will be same everywhere in a particular rainfall zone.

Entire command area under consideration is not uniform with respect to agronomic, economic, climatic and rainfall factors. To avoid these difficulties, the entire command area has been divided into a number of blocks where each individual block has same agronomic, economic, climatic and rainfall factors. Each block has been further subdivided into three agricultural soil-classes: excellent, medium and poor respectively. It is assumed that yield in excellent and poor soil classes are 10% more and 10% less than medium soil-class respectively. If \( i, j, k, a, e \) notations are used to represent crop, soil-class, block, agronomic zone and economic zone respectively, then net return from a particular crop \((i - th)\) from a particular soil-class \((j - th)\) for a particular block \((k - th)\) per unit area \(R_{i,j,k}\) is
= [(Sale price of the \textit{main product} of \((i-th)\) crop in that \((k-th)\) block) $\times$ (yield of \textit{main product} of \((i-th)\) crop in \((j-th)\) soil-class in \((k-th)\) block)]

\[ + \]

(Sale price of the \textit{by-product} of \((i-th)\) crop in that \((k-th)\) block)) $\times$ (yield of \textit{by-product} of \((i-th)\) crop in \((j-th)\) soil-class in \((k-th)\) block)

(Expenses for that of \((i-th)\) crop in \((j-th)\) soil-class in \((k-th)\) block]

Sale price of main product and by-product of a particular crop from a particular block depends on the (a) type of crop and (b) economic zone where the block is located. Whereas yield of \textit{main product} and \textit{by-product} of that particular crop in that particular soil-class in that particular block depend on (a) type of crop (b) type of soil-class and (c) agronomic zone where the block is located. Expenses for production of crop is related to the cost of fertilizer, labour, water, seed, hire charges for agricultural implements, land-tax etc. Requirement of fertilizer depends on type of crop and agronomy of the area where the block located. Cost of the labour also depends on type of the crop and economic zone where the block is located. Other items of expenses like hire charges of agricultural implements cost of water and seed, land tax etc depend on agronomic zone and economic zone in which the block is located. So net return from a particular crop \((i-th)\) from a particular soil-class \((j-th)\) for a particular block \((k-th)\) per unit area \(R_{i,j,k}\) is;

\[
R_{i,j,k} = \left[ \left( SM_{i,e} \times YM_{i,j,a} \right) + \left( SB_{i,e} \times YB_{i,j,a} \right) - E_{i,a,e} \right] \ldots \ldots (1)
\]

Where, 
- \(e = EZ\) identification number of the \((k-th)\) block
- \(a = AZ\) identification number of the \((k-th)\) block
- \(SM_{i,e}\) = Sale price of \textit{main product} of \((i-th)\) crop in \((e-th)\) \(EZ\)
- \(SB_{i,e}\) = Sale price of \textit{by-product} of \((i-th)\) crop in \((e-th)\) \(EZ\)
- \(YM_{i,j,a}\) and \(YB_{i,j,a}\) = Yield of \textit{main product} and \textit{by-product} of \((i-th)\) crop \((j-th)\) soil-class in \((a-th)\) \(AZ\) respectively
- \(E_{i,a,e}\) = Expenses of \((i-th)\) crop in \((a-th)\) \(AZ\) \((e-th)\) \(EZ\)

4.2 Formulation of Objective Function (Z)

Eq.(1) represents the net return from \((i-th)\) crop, \((j-th)\) soil class and \((k-th)\) block per unit area. Therefore, total net return from the entire area under the \((i-th)\) crop, \((j-th)\) soil class and \((k-th)\) block

\[
= R_{i,j,k} \times A_{i,j,k} \\
= R_{i,j,k} \times A_{j,k} \times X_{i,j,k}
\]

Where \(A_{i,j,k}\) = area occupied by \((i-th)\) crop, \((j-th)\) soil class and \((k-th)\) block

\(A_{j,k}\) = total area of \((j-th)\) soil class in \((k-th)\) block

\[
X_{i,j,k} = \frac{A_{i,j,k}}{A_{j,k}}
\]

= fraction of area occupied by \((i-th)\) crop, \((j-th)\) soil class and \((k-th)\) block
If in the command area there are \( m \) number crops, \( n \) number soil-classes and \( m \) number blocks, then total net return from all the blocks from all the soil-classes and all the blocks is:

\[
Z = \sum_{k=1}^{b} \sum_{j=1}^{n} \sum_{j=1}^{n} (R_{i,j,k} \times A_{j,k}) \times X_{i,j,k} \quad \ldots \ldots \; (2)
\]

The present study deals with the allocation of area under each crop over entire command area to yield maximum net return considering land and water constraint. So we have to maximize eq.(2) subject to land and water constraint. Maximization of \( Z \) is our objective function.

4.3 Formulation of Land Constraint

Land constraint is area occupied by all crops in a particular soil-class in a particular block in a particular time should be always less than or equal to the total area of that particular soil-class in that particular block for that time period. For the purpose of analysis entire year has been divided into \( P \) number periods and subscript \( l \) is used to express period. Therefore land constraint can be expressed as follows;

\[
\sum_{i=1}^{m} A_{i,j,k} \times F_{i,l} \leq A_{j,k}
\]

\[
\sum_{i=1}^{m} \frac{A_{i,j,k}}{A_{j,k}} \times F_{i,l} \leq 1
\]

\[
\sum_{i=1}^{m} X_{i,j,k} \times F_{i,l} \leq 1 \quad \ldots \ldots \; (3)
\]

Where \( F_{i,l} \) = field occupancy of \( i-th \) crop, \( l-th \) period.

Field occupancy implies that whether the particular crop either physically present in the field or not. So number of in-equations to be handled is equal ton. \( b \cdot P \).

4.4 Formulation of Water Constraint

Irrigation water requirement (IWR) is the quantity of water required by a crop in duration of time (period or day/week/month) for its normal growth under field condition at a particular place. IWR will vary crop to crop, from period to period from one block to other (as blocks are located in different climatic zone) assuming IWR is independent on soil class. So IWR depends on (1) type of crop \( i \), (2) number of block \( k \) and (3) number of period \( l \).

Therefore, volume of irrigation water requirement (VIWR) for a \( i-th \) crop, \( k-th \) block and \( l-th \) period \( (VIWR_{i,k,l}) \) is equal to depth of irrigation water requirement (DIWR) \( i-th \) crop, \( k-th \) block and \( l-th \) period \( (DIWR_{i,k,l}) \) multiplied by total area occupied by all soil-class by \( i-th \) crop in \( k-th \) block at \( l-th \) period. Therefore,

\[
VIWR_{i,k,l} = DIWR_{i,k,l} \times \sum_{j=1}^{n} X_{i,j,k} \times A_{j,k}
\]

So total volume of water required by all the crops for all the blocks for all the periods is equal to;
The total volume of water will be supplied from Massanjore reservoir. If dependable inflow into the reservoir at \( t \)-th period (\( VIN_t \)), loss from the reservoir during \( t \)-th period (\( LS_t \)), volume of water released for irrigation from the reservoir just before the beginning of \( t \)-th period (\( VR_t \)) and initial volume present in the reservoir (\( VA_0 \)) then volume available for release during \( t \)-th period (\( VAR_t \)) is equal to

\[
VAR_t = VA_0 + \sum_{t=1}^{l} VIN_t - \sum_{t=1}^{l} LS_t - \sum_{t=1}^{l-1} VR_t
\]

So volume of irrigation water required during \( t \)-th period (\( VR_t \)) should be always less than or equal to the volume available for release during \( t \)-th period (\( VAR_t \)); i.e., \( VR_t \leq VAR_t \)

\[
\text{or, } VR_t \leq VA_0 + \sum_{t=1}^{l} VIN_t - \sum_{t=1}^{l} LS_t - \sum_{t=1}^{l-1} VR_t
\]

\[
\text{or, } VR_t + \sum_{t=1}^{l-1} VR_t \leq VA_0 + \sum_{t=1}^{l} VIN_t - \sum_{t=1}^{l} LS_t
\]

\[
\text{or, } \sum_{t=1}^{l} VR_t \leq VA_0 + \sum_{t=1}^{l} VIN_t - \sum_{t=1}^{l} LS_t 
\]

\[
\text{or, } \sum_{t=1}^{p} VR_t \leq VA_0 + \sum_{t=1}^{p} VIN_t - \sum_{t=1}^{p} LS_t \ldots \ldots (4b)
\]

So from eq. (4a) and eq. (4b);

\[
\sum_{t=1}^{p} \left[ \sum_{k=1}^{b} \sum_{i=1}^{m} DIWR_{i,k} \sum_{j=1}^{n} X_{i,j,k} A_{j,k} \right] \leq VA_0 + \sum_{t=1}^{p} VIN_t - \sum_{t=1}^{p} LS_t \ldots \ldots (4c)
\]

The above in-equation is water constraint. So number of in-equations to be handled is \( P \). The said in-equation has been formulated on the basis of the following assumptions.

(a). All the storage volume in the reservoir is the quantities above dead storage.
(b). Volume release of water from the reservoir is equal to volume required in the field
In order to apply Modified Simplex Algorithm eq.(2), eq.(3) and eq.(4c) can be represented in the following form

\[ \text{Maximize } Z = \sum_{k=1}^{b} \sum_{j=1}^{n} \sum_{i=1}^{m} C_r Y_r \ldots \ldots (5) \]

Subject to

\[ (1) \sum_{i=1}^{m} Y_r \times F_{r,i} \leq 1 \ldots \ldots (6) \]

\[ (2) \sum_{i=1}^{p} \left[ \sum_{k=1}^{b} \sum_{j=1}^{m} DIWR_{i,k,l} \sum_{j=1}^{n} Y_r A_{j,k} \right] \leq VA_0 + \sum_{i=1}^{p} VIN_t - \sum_{i=1}^{p} LS_t \ldots \ldots (7) \]

Where

\[ C_r = R_{r,i,k} A_{j,k} \text{ and } Y_r = X_{r,i,k} \]

\[ k = \frac{r-1}{m,n} + 1 \quad \& \quad k_1 = r - (k - 1)m.n \]

\[ j = \frac{k_1}{m} + 1 \quad \& \quad i = k_1 - (j - 1)m \]

The above formulation is a generalized formulation for optimal cropping pattern for maximization of net return considering land and water constraint. This formulation can be used for any number of crops, any number of soil-class and any number of blocks. On the basis of block identification number corresponding agronomic zone, economic zone, climatic zone and rainfall zone have to be determined. Using the Modified Simplex Algorithm, the above formulation has been run in FORTRAN 90.

### 5. COLLECTION AND PROCESSING OF DATA

The above generalized formulation has been run using the data of Mayurakshi Command Area in India. For analysis large number of data has been gathered. Data related with yield of crop, cost of main product, by-product, fertilizer, labour, have been collected from Ministry of Agriculture Marketing, Government of India (GOI). Area of agricultural land in a block in a particular soil class has been obtained from Land Revenue Department, GOI. Reservoir inflow and outflow, rainfall and other meteorological data collected from Ministry of Water Resources, GOI.

#### 5.1 Processing of Data for Land Constraint

In the expression of land constraint the term field occupancy \( F_{i,l} = \text{field occupancy of } i - \text{th crop, } l - \text{th period} \) indicate that whether the crop is physically present in field in that period or not. In this study, field occupancy is equal to 1 indicate the presence of the crop in the field and equal to 0 indicate the absence. In this study five number of crops: ‘Potato’, ‘Wheat’, ‘Boro(Hyv)’, ‘Aus(Hyv)’, and Aman(Hyv), have been considered.
Entire year has been divided into 36 number of period. First 10 days, second 10 days and rest of the days in month have been considered as 1st period, 2nd period and 3rd period respectively. The first 10 days of month of November is numbered as ‘Period-1’ and last 10 days of month of October is numbered as ‘Period-36’. As reservoir remain full at the beginning of November, that is why counting of period has been started from November.


The entire command area has been divided into five blocks and under each block there are three number of soil classes. So in this analysis total number of in-equation for land constraint is equal to $540 = 3 \times 5 \times 36$.

5.2 Processing of Data for Water Constraint
5.2.1 Computation of Dependable Rainfall

Distribution of rainfall is uneven over the command area. The rainfall show considerable variation from year to year, from one period to another. In order to assess the water available for any time interval it is necessary to ascertain the dependable rainfall for that time interval. In this study, the entire command area is divided into two rainfall zone. Here dependable rainfall has been computed for 36 periods (no. of periods) for each rainfall zone by four methods: (a) By Probability Ranking Method, (b) By Maximum Number of Occurrence, (c) By Taking Mean and (d) By Statistical Probability Method (value corresponding 0.2 cumulative probability). The lowest value among the four methods is taken as dependable rainfall for that period in that rainfall zone. In analysis historical rainfall data from 1974 to 2008 has been used for analysis. It is found that dependable rainfall in ‘Period-1’, ‘Period-18’ and ‘Period-36’ are 113.0, 0.0 and 135.0 mm in rainfall zone 1 and 85.0, 0.0 and 40.0 mm in rainfall zone 2 respectively. So total $2 \times 36 = 72$ number dependable rainfall data have been computed. [2 is number of rainfall zone and 36 number of period]

5.2.2 Computation of Effective Rainfall (ER)

Effective rainfall is a part of the rainfall that forms part of consumptive use. The FAO has brought out comprehensive review of effective rainfall [Dastane,1974]. As per recommendation of FAO publication No.24 [Revised, 1977] and by field Lysimeter test, in this study dependable rainfall up to 24mm/period has been neglected and dependable rainfall above 24mm/ period has been taken 60% effective. In this analysis 2 rainfall zone and 36 periods have been considered. So, total $2 \times 36 = 72$ rainfall data have been processed.

5.2.3 Computation of Dependable Inflow

As discussed in Section.3, the volume of water release from reservoir is distributed in the command area by two main canals on either side of Tilpara barrage. Rainfall in the catchment area of Massanjore reservoir is also not evenly distributed. In this analysis historical inflow data from 1985 to 2008 have been used. Dependable inflow has been computed by four methods as done for computation of dependable rainfall. Lowest value among all the four methods is taken as dependable inflow. So here total 36 number data have been processed.

5.2.4 Computation of Evapo-Transpiration (ETo) and Crop Co-efficient (KC)

Evapo-transpiration may be different for same crop at different time and places. In fact, ETo of a given crop at a given place may vary throughout the day, throughout the month and throughout the crop period. In the study area there is no data available for ETo, measured directly by soil
moisture depletion studies. So ETo (in mm/day) has been computed by Modified Penman Formula using climatic factors like temperature, wind velocity, relative humidity, sunshine hour and radiation etc. In this analysis two climatic zones have been considered. So for 36 number periods total $2 \times 36 = 72$ number evapotranspiration values have been computed.

Crop co-efficient (KC) is the ratio of evapo-transpiration of a particular crop in a particular period to the evaporation of standard crop in that particular period. So value of KC depends on the crop (i-th) and period (p-th) for which it is computed. In this study 5 crops and 36 periods are considered. So total $5 \times 36 = 180$ have been computed.

5.2.5 Computation of Depth of Irrigation Water Requirement (DIWR)

Crop water requirement is the total water required at the field head to mature a crop. It is the sum of Consumptive use ($C_u$) of the crop, application losses and special needs. In this analysis application losses and special needs are assumed to zero. Consumptive use of a crop is the product of KC of the particular crop in that particular period and ETo at the particular period in that particular area. In section 5.2.4, it is discussed about the computation of ETo (in mm/day) and KC. It is also known to us that entire effective rainfall (as discussed in 5.2.2) is used by the crop to satisfy its consumptive use. So depth of irrigation water requirement will vary from crop to crop, from period to period, from block to block (one climatic zone to other). Depth of crop water requirement for i-th crop, in k-th block and l-th period can be expressed as follows;

\[ DIWR_{i,k,l} = KC_{i,p} \times ETo_{p,c} \times NOD_{p} - ER_{p,g} \ldots \ldots (8) \]

Where, $NOD_{p} = No.\ of\ days\ in\ a\ period$. From the above expression for a particular block, corresponding climatic zone and rainfall zone are known, so for a particular crop, for a particular block in particular period depth of irrigation water can be computed.

5.2.6 Computation of Loss from Reservoir

Due to high temperature, humidity and wind speed almost 50 percent of the total evaporation takes place during March to June. On the basis of land pans, mean annual evaporation losses from the reservoir is almost 990 mm. Evaporation for every period can be computed from storage capacity versus surface area plot.

6. RESULTS AND DISCUSSION

The results in Table.1 indicate that in order to get optimum net return, Potato has to be cultivated almost entire command area. Cultivation of Boro(Hyv) is holding the second highest position where as Aus(Hyv) is in lowest position. Wheat and Aman(Hyv) have been eliminated from the optimal cropping pattern.

Cultivation of Potato and Wheat start at same time. Sale price of main product and by product of Wheat is more than that of Potato whereas expenditure for Potato is more than Wheat. As yield of Potato is very high in compare to Wheat, net return per unit area of Potato is very high compareto Wheat. More over field occupancy for Potato is only nine periods whereas Wheat requires twelve periods. Again depth of irrigation water per unit area is less for Potato than Wheat. For all this reasons in optimal cropping pattern Wheat has been eliminated. Due to same reason Aman(Hyv) has been eliminated by Aus(Hyv).

To get a place in optimal cropping pattern Boro(Hyv) has no competitor as its field occupancy does not overlap with other crops under consideration. Yet optimum cropping pattern in Table.1 shows that Boro(Hyv) cannot be cultivated over the entire command area due to non-availability water.
7. CONCLUSION

In this study optimum cropping pattern skewed towards Potato. So to get maximum net return, potato has to be cultivated over entire command area. In order to cultivate the entire command area a large number of labours are required. But it is very difficult to get that huge number of labour at time. So for sustainable agricultural development farmers have to take the advantage of mechanized cultivation system. In the recommended cropping pattern wheat is absent. If it is essential to produce certain amount of wheat, then certain compromise have to be made with the optimum cropping pattern. Expenditure for Boro (Hyv) is very high so poor farmers unable to spend the high expenditure, hand over their land to rich farmers. So rich farmer become richer and poor farmer become poorer which creates social tension. In order to implement the optimum cropping pattern government participation to provide loan to the poor farmer or formation of co-operative among the farmers are essential.
REFERENCE


