Water Resources Systems Engg.

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What is a System ?

A System may be defined as an assemblage of elements or components interacting with one another and working towards a common objective

Water Resources Systems

- **Water Resources Systems consist of multiple units such as reservoirs, canals, power house, etc and serve multiple purpose such as irrigation, hydropower generation, flood control, M & I water supply, navigation, recreation etc**
- **Water Resources Systems are designed to serve several socio-economic objectives such as economic efficiency, income redistribution, enhancement of environmental quality etc.**

The basic purpose of water resources system is to modify the unreliable, naturally existing water supply from one which is inadequately distributed in both time and place to one which is reliably distributed in both time and place to accomplish many social and economic purpose /objectives

Water Resources System

- **Brings about large scale permanent changes in our environment such as creation of storages, canal systems, change in land use pattern, etc.,**
- **Brings changes in economy of the region**
- **Multidisciplinary efforts are required**
- **Requirement of reliable data on hydrology, economy, engineering, soil, agriculture, environment etc**
- **Susceptible to economic and hydrologic uncertainties**

Methods of Systems Analysis

- **Optimization – Maximization, Minimization**
- **Objective Function/(s)**
- **Set of Constraints**
- **Linear Models, Non Linear Models**
- **Dynamic Programming—multistage decision making or sequential decision problems**
- **Used as Screening Models**

Methods of Systems Analysis

- **Simulation Technique:**

  The plan developed by optimization is subjected to generated inflows, operating policy and the performance of the system is evaluated against a suitable performance criteria

- **MODSIM, RIBASIM, MIKEBASIN**

SUMMARY OF VERBAL INFORMATION

Sl.No.	Particulars	Units	Wheat	Jowar	Availability
1.	Land	(ha)	x_1	x_2	100 (b_1)
2.	Soil Erosion	(tons/ha)	15 (a_{11})	4 (a_{12})	Not to exceed 500 tones (b_2)
3	Fertilizer	(kg/ha)	200 (a_{21})	100 (a_{22})	
4	Water	(ha-m/ha)	0.60 (a_{31})	0.45 (a_{32})	50 ha-m (b_3)
5	Crop Yield	(Kg/ha)	1055 (a_{41})	800 (a_{42})	
6	Price of crops	(Rs/Kg)	5.00 (c_1)	4.25 (c_2)	
7	Water Cost	(Rs/ha-m)	125 (c_3)	125 (c_3)	
8	Fertilizer Cost	Rs./Kg	1 (c_4)	1 (c_4)	

TERMS USED IN LP

- **Objective functions [f(.)]**
- **Decision variables (x_1, x_2)**
- **Input variables (u_1, u_2, u_3, u_4)**
- **Output Variables (y_1, y_2, y_3, y_4)**
- **Exogenous variables (c_1, c_2, c_3, c_4)**
- **Technologies coefficients (Input / Output variables) (a_{ij})**

u_1 the total amount of water in ha-m applied for growing wheat = $a_{31}x_1$

u_2 the total amount of water in ha -m applied for growing jowar=$a_{32}x_2$

u_3 the total amount of fertilizer in Kg applied for growing wheat=$a_{21}x_1$

u_4 the total amount of fertilizer in Kg applied for growing jowar=$a_{22}x_2$

y_1 the total yield of wheat in Kg = $a_{41}x_1$

y_2 the total yield of jowar in Kg = $a_{42}x_2$

y_3 the total tons of topsoil eroded due to production of wheat = $a_{11}x_1$

y_4 the total tons of topsoil eroded due to production of jowar = $a_{12}x_2$

$$f(x_1x_2) = c_1 * y_1 + c_2 * y_2 - c_3 * (u_1 + u_2) - c_4 * (u_3 + u_4)$$

$$= (c_1 * a_{41} - c_3 * a_{31} - c_4 a_{21}) x_1 + (c_2 * a_{42} - c_3 * a_{32} - c_4 a_{22}) x_2$$

$$= C_1 x_1 + C_2 x_2$$

S.t.

$$x_1 + x_2 <= b_1$$

$$a11 * x1 + a12 * x2 <= b2$$

$$a_{31} * x_1 + a_{32} * x_2 <= b_3$$

$$x_1 >= 0$$

$$x_2 >= 0$$

$$f(.) = 5000\,X_1 + 3243.75\,X_2$$

S.T.

$$x_1 + x_2 \leq 100$$

$$15\,x_1 + 4\,x_2 \leq 500$$

$$0.6\,x_1 + 0.45\,x_2 \leq 50$$

$$x_1 \geq 0$$

$$x_2 \geq 0$$

- **Graphical Method**
- **Simplex Method**

Reference Books

1) **Water Resources Systems Planning & Analysis**
by
D. P. Loucks, Stedinger J.R., Haith D.A.
2) **Hierarchial Analysis of Water Resources System**
by
Haimes Y. Y.