INDIAN INSTITUTE OF SCIENCE

Water Resources Systems:

Modeling Techniques and Analysis

Lecture - 18

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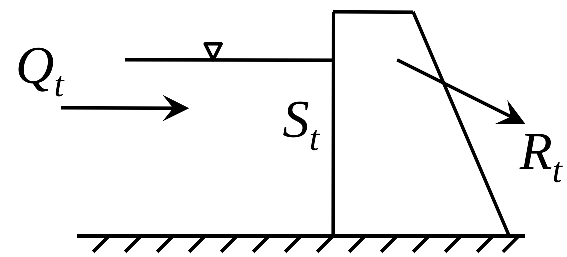
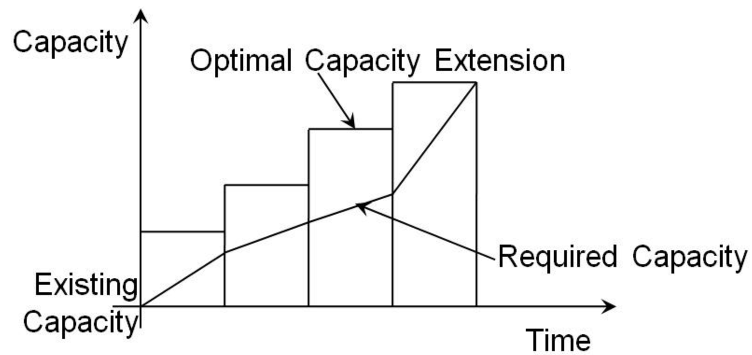
Summary of the previous lecture

Dynamic programming:

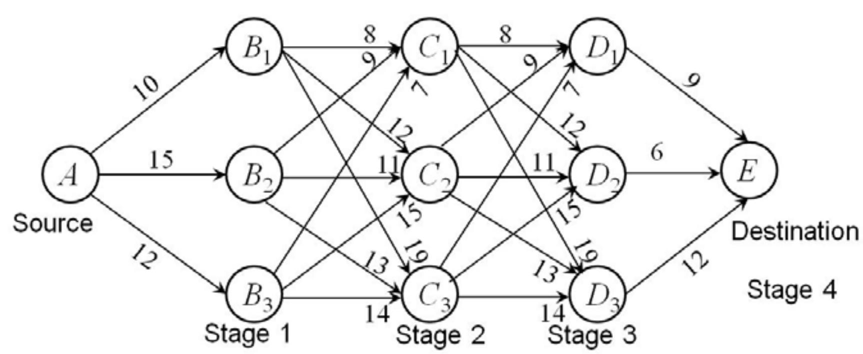
- Reservoir operation problem



- Capacity expansion problem



- Shortest route problem

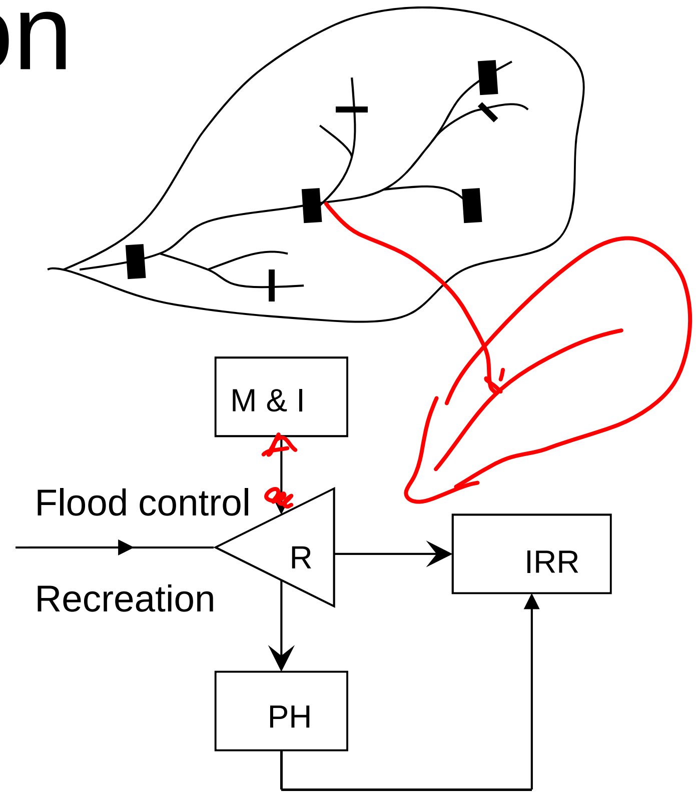


SIMULATION

Simulation

Necessity :

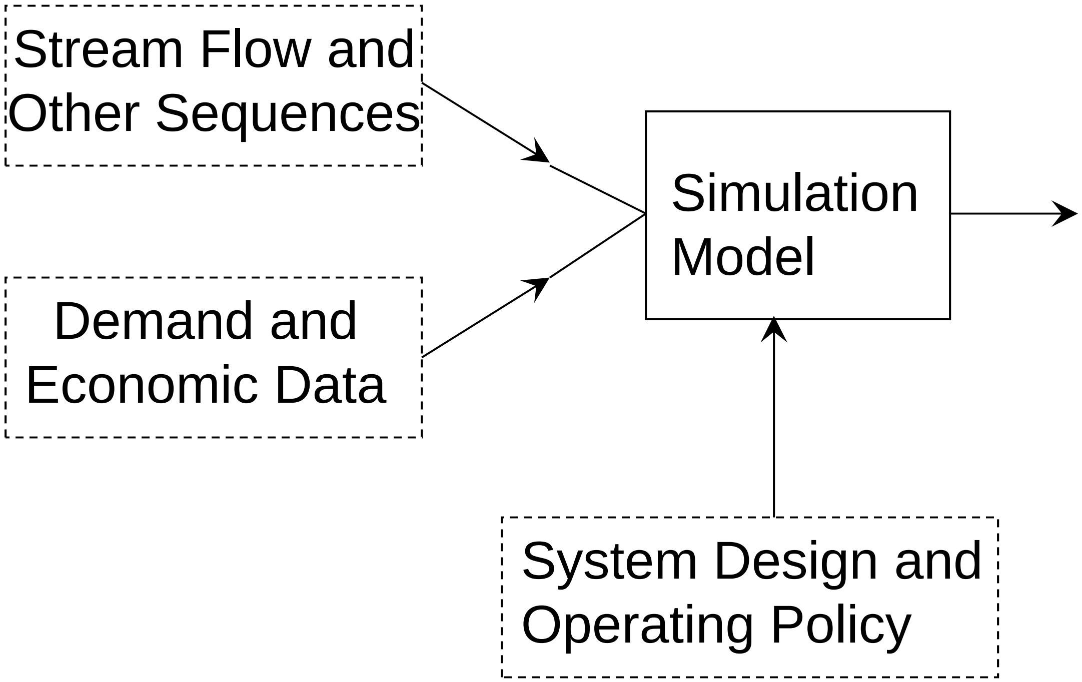
- Modeling of complex water resource systems.
- Screening of large number of alternatives.
- Detailing to any desired level



Features of Simulation:

- No optimal solution.
- Specified operating policy; Detailing to any degree possible.
- Even very large simulation programs handled with ease on computers

Simulation

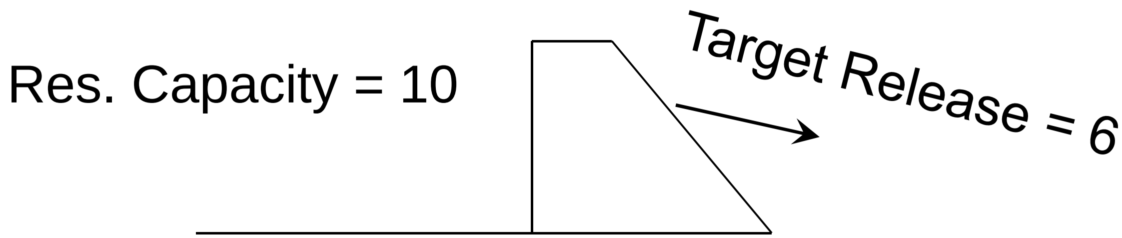


System Performance Measure

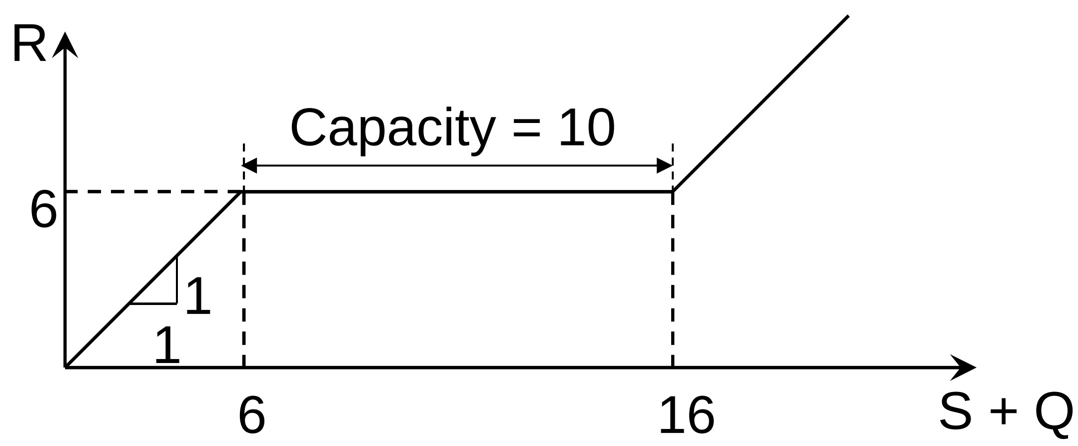
- Expected net benefits.
- Costs
- Costs subject to minimum benefits.
- Sum of deficit releases.
- Crop production.
- Power production, (s.t. Irrigation)

Simulation

A simple simulation example:



Reservoir Operating Policy: [SOP]



Simulation

given: Target release = 6

Period t	Initial Storage S_t	Inflow Q_t	Release R_t	Final Storage S_{t+1}	Deficit
1	9	12	11	10	0
2	10	11	11	10	0
3	10	12	12	10	0
4	10	5	6	9	0
5	9	4	6	7	0
6	7	2	6	3	0
7	3	1	4	0	2
8	0	3	3	0	3
9	0	5	5	0	1
10	0	8	6	2	0
.	.	.	.	.	.
.	.	.	.	.	.
20	1	11	6	6	0

$Q_{11 \text{ to } 20}$: 5, 4, 5, 7, 8, 2, 2, 1, 7, 11

Total → 18

Total Deficit = 18

Simulation

Performance measures :

a. Total deficit = 18

b. Proportion of periods in which target is met = 12/ 20 = 0.6

Parameters that may be varied (for a design exercise) :

a. Reservoir capacity

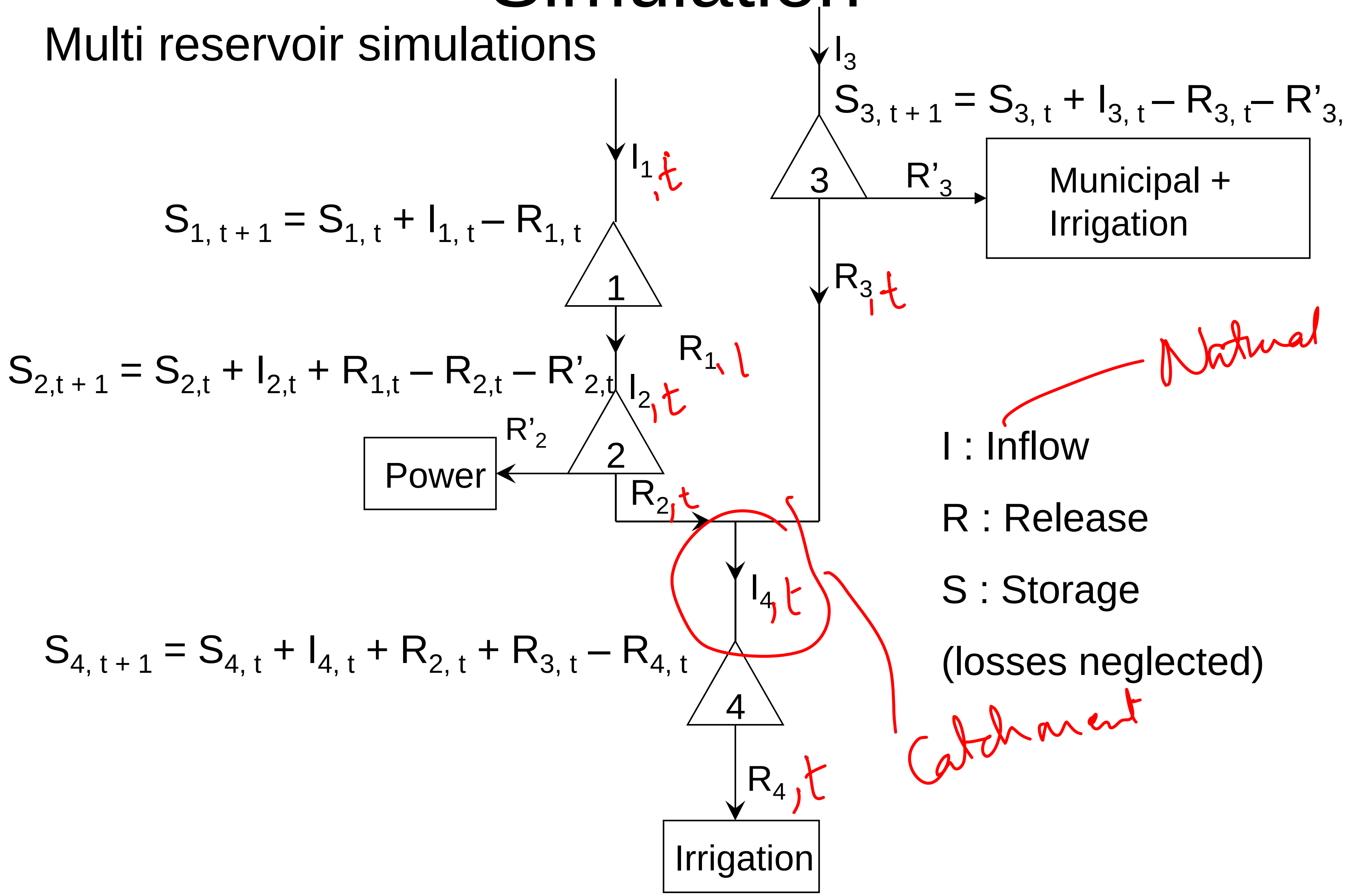
b. Reservoir operating policy

c. Target release

Also, the study may be carried out for different generated sequences of Inflows, to account for stochasticity of Inflows.

Simulation

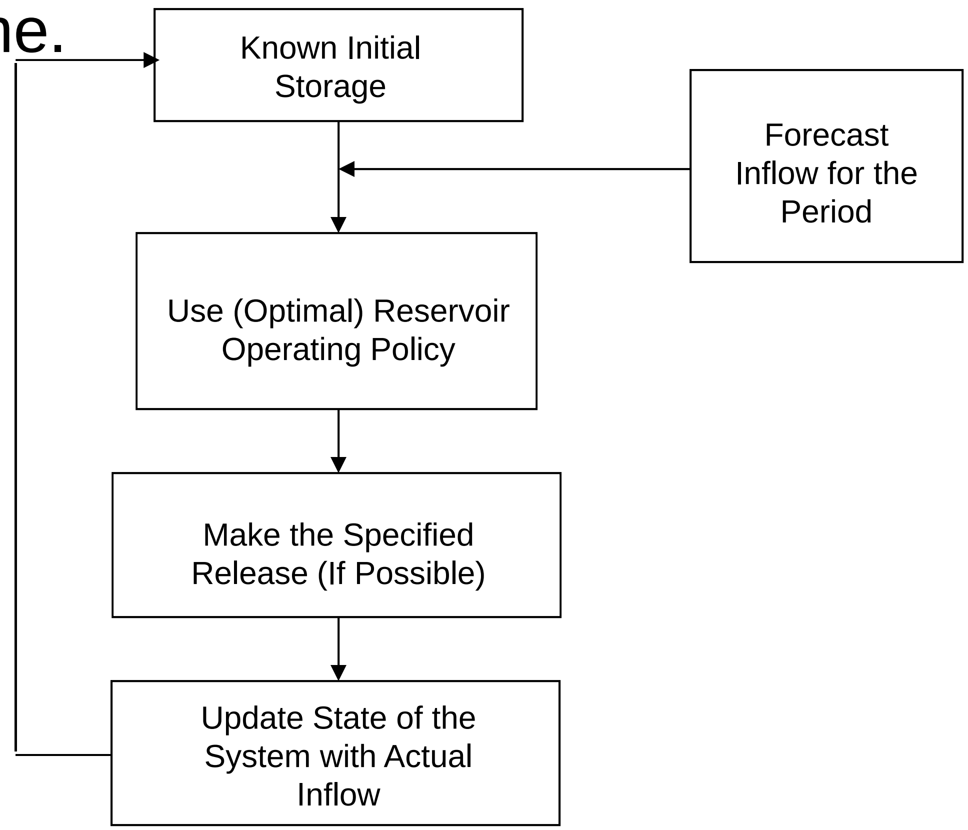
Multi reservoir simulations



Simulation

Simulation of real time reservoir operation

- Acts as a decision support system.
- Useful to evaluate performance of reservoir operating policies, in real time.



MULTI-OBJECTIVE PLANNING

Multi-objective Planning

- Water resource planning is a complex and interdisciplinary problem in which we may have to consider multiple objectives.

- Some objectives may conflict each other.

  For example, a reservoir project intended to satisfy irrigation, hydropower and recreation.

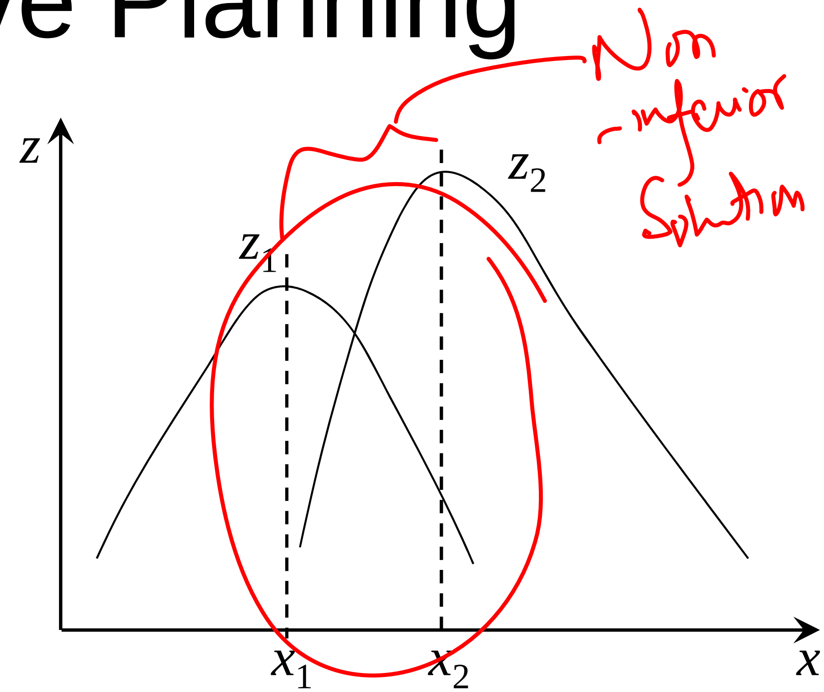
- The concept of noninferior (or Pareto optimal) solutions is basic to the mathematical framework for multi-objective planning.

Multi-objective Planning

- A noninferior solution is one in which no increase in any objective is possible without simultaneous decrease in at least one of the other objectives.
- No optimal solution to a multi-objective problem.
- Determine the noninferior set and get the best solution out of this. (best compromise solution or the perfect solution)

Multi-objective Planning

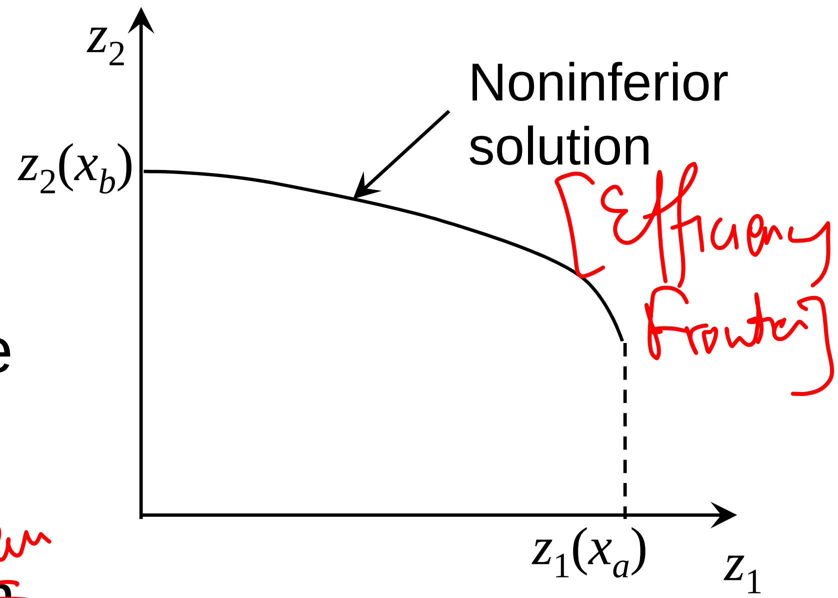
- Consider a problem in which two objectives z_1 and z_2 are to be maximized.
- Let both be functions of decision variable x .



- Solutions with $x < x_1$ and $x > x_2$ can be eliminated.
- The range $x_1 \leq x \leq x_2$ is the noninferior range.
- In this range, it is not possible to increase the value of one OF without decreasing that of the other.

Multi-objective Planning

- Let X be a vector of decision variables, $X = (x_1, x_2, x_3, \ldots, x_n)$
- $Z_j(X), j = 1, 2, \ldots, p$ denote p objectives, each of which is to be maximized.
- The multi-objective ~~function~~ Problem is written as



$$\text{Maximize} \quad [Z_1(X), Z_2(X), \ldots\ldots\ldots, Z_p(X)]$$

s.t.

$$g_i(X) \le b_i \qquad i = 1, 2, \ldots\ldots, m.$$

Multi-objective Planning

Plan formulation:

- Generates a set of noninferior solutions.
- Two common approaches in formulating a MOP problem
  - Weighting method
  - Constraint method