Vinay Kumar Koirala
Senior Divisional Engineer
Social, Environment & Climate Change Section
Department of Irrigation, Nepal
Review of Design of Medium & Small Scale Irrigation System including tube well & Micro Irrigation
Definition of Small & Medium Irrigation System

The Irrigation Policy 2013 (revised) of Nepal defines Medium Irrigation System as follows;

Medium Irrigation Project For Hill: 10 ha to 500 ha
Medium Irrigation Project For Terai: 100 ha to 2000 ha

The system having less than the mentioned command area have been categorized as small irrigation as systems

Contd…
With the Local Infrastructure Development Policy (2004) identifying small scale irrigation systems as local infrastructure, the responsibility for small-scale irrigation has moved from the Ministry of Irrigation (MoI) and the Department of Irrigation (DoI) to the Ministry of Federal Affairs and Local Development (MoFALD) and Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR).
Design Review of Irrigation Systems

Irrespective of the size of the projects following steps are followed after detail field investigation/survey (the detail TOR for the all kind of survey is being prepared in DOI that will be finalized & implemented by coming F.Y 2072/73)

First of all lay out the system on suitable base maps is prepared. The preparation of comprehensive base maps by ground control from aerial photograph is not economic or practical for medium level schemes; therefore other slightly less accurate methods must be used

Contd…. 
Design Review of Irrigation Systems

Contd…..

If available climate hazard maps should be used (DWIDP is preparing Hazard maps), so that the climate vulnerability of the project area is assessed.

Hydrological Analysis and Water Requirement Assessment

Flood Frequency Analysis
Most commonly used methods
- Gumbel’s distribution,
- Log Pearson Type III distribution, and
- 3 parameter Log Normal distribution

Contd…..
Design Review of Irrigation Systems

Contd…..

Regional Analysis
When the recorded hydrological data of the river is absent or too short a regional analysis is adopted to estimate the flood flow, and low flow of required return periods. In Nepal following methods are used to estimate the flood flow:

- WECS/DHM (1990) Method- based on regression analysis,
- Sharma and Adhikari (2004) – based on regression analysis

Contd…..
Design Review of Irrigation Systems

Contd…..

Water Availability for Irrigation
80% reliability of full supply
For gauged river the reliability assessment is carried out by frequency analysis while for ungauged river regional regression analysis for long term mean flow is adopted in Nepal

Irrigation Water Requirement & Water Balance

Calculation of Irrigation Water Requirement should follow the steps mentioned in the chapter 5 of revised Planning and Design Manual Volume I

Contd…..
Design Review of Irrigation Systems

Contd…..

The diversion requirement should be evaluated based on above mentioned water balance
Design of canal & related structures should be carried out based on bottom up approach; hence the pond level is fixed

Selection of type of head work/intake and design is carried out using standard hydraulic & structural engineering concepts

Contd…..
Review of Design of Tube Well

The design of shallow tube well involves the siting of the well, design of well, selection and design of distribution system, selection of appropriate pumps, and cost estimate of the shallow tube well construction.

Design Procedure:
Data required:
Topographical maps, Cadastral maps, Soil infiltration test results, Drilling results (log sheets), Type of distribution system and Power source for pump

Contd…..
Review of Design of Tube Well

Contd…..

Design Steps:
- Assessment of hydro-geology of the area and suitability of STW development including
- Quantity and quality of water;
- Assessment of well yield;
- Determination of well parameters such as screen type, screen length, and length of casing;
- Assessment of land suitability for STW irrigation;
- Design of cropping patterns with and without project conditions;

Contd…..
Review of Design of Tube Well

Contd…..

**Design Steps:**
- Calculation of crop water requirement based on proposed cropping pattern,
- Preparation of distribution layout based on topography.
- Siting of well and access to the field;
- Selection of power supply options or availability of electric supply;
- Selection of type and technology of distribution system such as lined canal versus unlined
- Canal, open channel versus piped channel;
- Design of channel size or pipe size;
- Selection of standard control, distribution, and outlet structures;

Contd…..
Design Review of Irrigation Systems

Contd.....

Review of Design of Micro Irrigation System

Pond Irrigation
Design Concept
The design of pond irrigation involves the design and assessment of the following components:

- Water availability assessment for the proposed site of pond;
- Irrigation water requirement assessment-based on cropping pattern, irrigation methods;
- Design of intake and conveyance canal or piped system-collection chamber, washout chamber, flow regulating chamber;

Contd....
Design Review of Irrigation Systems

Contd.....

Review of Design of Micro Irrigation System

Pond Irrigation
Design Concept

- Design of pond capacity or water storage reservoir; and
- Water application methods- drip irrigation, sprinkle irrigation and or free flooding method;

The design of water intake shall involve the design of spring intake structure as adopted in drinking water supply schemes:

Contd...
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

- Measurement of discharge with bucket and watch method,
- Design of overflow weir,
- Design of inlet chamber, and
- Sizing of conveyance pipe

The capacity of pond shall be fixed on the basis of the following:
- Available water at the source,
- Water requirement per day for the proposed crops, and
- Agreed pond operation rules with the farmers

Contd..
Design Review of Irrigation Systems

Contd.....

Review of Design of Micro Irrigation System

Sprinkler Irrigation
The main components of a typical sprinkle irrigation system can be broadly divided into the following:
- Pressurized Water Source
- Pipe Networks (Main Line, Lateral, Riser)
- Sprinkler Heads

Contd...
Sprinkler Irrigation
For small and medium size sprinklers the operating head varies between 10 to 30m. Depending on the water source, the various methods are used to obtain the desired pressure of water at the inlet of the unit. The most common methods are:

- Installation of pumping unit
- Gravitational energy (Water source / tank located at higher elevation) and
- Direct connecting from the supply line

Contd…
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Sprinkler Irrigation

Pipe Networks

The pipe network of a sprinkler system consists of the following pipes:

- **Main Line:** conveys water from source and distributes to the sub main.
- **Lateral:** delivers water from the mainline to the sprinklers.
- **Risers:** The vertical pipe connecting laterals with the sprinkler head is called riser pipe.

Contd…
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Sprinkler Irrigation

Sprinklers

Various types of sprinklers are commercially available. Depending on the mode of operation, sprinklers are can be classified in the following two types.

- Fixed Head Type
- Rotating type

Contd…
Design Review of Irrigation Systems

Contd.....

Review of Design of Micro Irrigation System

Sprinkler Irrigation

Micro Sprinkler

Micro Sprinkler is smaller version of sprinkler, which operates on much less head and flow than normal sprinkler. It can be operated in 10 to 15 m head.
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Sprinkler Irrigation
Micro Sprinkler
A complete package of Micro-sprinkler system has following parts:

- Main Pipe Line
- Riser Pipe
- Base
- Tee
- Lock
- Stake
- In-line Filter
- MS Head
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
Components of Drip System
The typical unit of drip irrigation system consists of mainly following four components:
- Pressurized Water Source,
- Head Unit (Control Head),
- Pipe Networks, and
- Emitters
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
Pressurized Water Source
The operating head of a drip system can vary between 5m to 12 m which is mainly governed by the topography and size of the plot to be irrigated. The desired pressure at the inlet of the drip system is achieved through the following methods:
- Installation of Pumping Unit,
- Direct connecting from the piped supply line, if available pressure is adequate.
- Use of booster pump if the pressure in the supply line is not adequate.
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
In all cases the water may be supplied either through an elevated tank or without it. Pressure regulation is essential in the case of the direct connection systems.

Head Unit (Control Head)
The head unit essentially consists of valves to control discharge and pressure in the entire system. Filters are also integral part of the head unit. Depending on the quality of water one or more types of filters have to be used in the drip system.
Design Review of Irrigation Systems

Contd.....

Review of Design of Micro Irrigation System

Drip Irrigation
Pipe Networks
Pipe network is the water distribution system up to the root zone of the plant. In practice two types of pipe are used for water distribution.
➢ Pipe without emitters and
➢ Pipe with emitters

Contd...
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
Pipe Networks
Water from the filters is supplied to the sub-mains by means of main pipe line. They are usually buried below ground, as a permanent setup. Sub-main consists of number of bifurcations to connect laterals pipe or drip pipe. Sub main distributes waters to all laterals fitted to it. Usually the diameter of the sub main ranges between 25 to 50 mm. Laterals are laid along the crop rows on the ground and hold emitters or drippers at a definite spacing. The diameter of pipes used for lateral is usually 9, 12 and 15 mm

Contd….
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
Emitters / Drippers
Drippers are small dispensing devices and are affixed to the laterals. The main function of the dripper is to discharge consistent amount of water near the plant in form of drops. Drippers burn off pressure energy to the atmospheric pressure or to create a great head loss. They are so spaced such that the emitting point is close to the plant. Sometimes more than one dripper is provided for one crop—especially for the matured fruit trees. For vegetables with small spacing, drippers may be closely spaced to get a continuous wetting pattern.

Contd…
Design Review of Irrigation Systems

Contd…..

Review of Design of Micro Irrigation System

Drip Irrigation
Simple Drip System in Nepal
Simple Drip System (SDI) is suitable for porous soil where seepage loss is very high and flood irrigation is very inefficient. SDI consists of a 50/200-litre tank placed at one meter elevated platform or pedestal made of bamboo/wooden logs. An outlet pipe connects this tank with a fine filter at the bottom of the pipe to avoid blockage in the drip pipe. The outlet is connected with a 14 mm diameter main line pipe, which is joined to the drip pipe with fittings and an adjustment pipe
Climate Change Threat Increasing Temperature

Dolakha District

Temp increase from $2^\circ-3^\circ$C

CONtributes to higher evapotranspiration rates & irrigation demand
Climate Change Threat
Reduced Rainfall in Winter

Sundarijal monthly daily averages

GREATER STRESS TO WINTER CROPS AND MORE IRRIGATION WATER REQUIRED

Rainfall Reducing
Climate Change Threat Increasing Rainfall Intensity

INTENSE RAINFALL INCREASES SOIL EROSION AND SEDIMENT ENTRY INTO CANALS
Climate Change Threat
Increase in River Flood Flows

Chitwan District

BIGGER FLOOD EVENTS DAMAGE IRRIGATION INTAKES AND LARGE AMOUNTS OF DEBRIS ENTER SYSTEM
Some Benefits Expected from Climate Change

The District threat profiles indicated benefits from:

- Increased Minimum Temperature in Winter
  - Extends Crop Growth Period

- Increased Rainfall Pre-Monsoon
  - Reduces Irrigation Requirement

- Increased Dependable River Flows
  - More Water being Available for Irrigation
Suggestions for Developing Modified Vulnerability Assessment Tools

A possible specific vulnerability assessment matrix to be used when assessing a component of an irrigation system to EXPOSURE:

<table>
<thead>
<tr>
<th>CONVEYANCE STRUCTURE</th>
<th>CLIMATE THREAT</th>
<th>PARAMETER</th>
<th>STRESS ON ASSET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>Pre–Monsoon</td>
</tr>
<tr>
<td>Landslide along canal alignment (due to storm intensity increase)</td>
<td>0–50%</td>
<td>Medium (1)</td>
<td>Low (2)</td>
</tr>
<tr>
<td></td>
<td>50–100%</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>&gt;100%</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Cross drainage flash flood increase (due to high intensity storm)</td>
<td>0–50%</td>
<td>Low (4)</td>
<td>Very Low (5)</td>
</tr>
<tr>
<td></td>
<td>50–100%</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>&gt;100%</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

- Landslide threat possible as still high water table
- Landslide threat minimal as water table lower
- Landslide threat greater as soil already saturated
- River flows already low
- River flows at their minimum values
- River flows already high and sediment transport increases
Suggestions for Developing Modified Vulnerability Assessment Tools

A possible specific vulnerability assessment matrix to be used when assessing a component of an irrigation system to its SENSITIVITY:

**CONVEYANCE STRUCTURE**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>STATUS</th>
<th>MAIN CLIMATE THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Increased temperatures</td>
</tr>
<tr>
<td>Main Canal Alignment</td>
<td>Earth Lined</td>
<td>High¹</td>
</tr>
<tr>
<td>Brick Lining</td>
<td>Medium⁴</td>
<td>Low⁵</td>
</tr>
<tr>
<td>Concrete Lining</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Pipelines</td>
<td>Medium⁷</td>
<td>Medium⁸</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aqueduct over cross drain</td>
<td>Piers in CD</td>
<td>Low</td>
</tr>
<tr>
<td>Side Abutment</td>
<td>Low</td>
<td>High¹²</td>
</tr>
<tr>
<td>Free Span Structure</td>
<td>Medium¹⁴</td>
<td>Medium¹⁵</td>
</tr>
<tr>
<td>Super passage under cross drain</td>
<td>With open channel</td>
<td>Very Low¹⁶</td>
</tr>
<tr>
<td></td>
<td>With covered canal</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>With Siphon</td>
<td>Low¹⁹</td>
</tr>
</tbody>
</table>
Seepage losses are higher associated with increased irrigation requirements

Scouring of channel if floods enter main canal

Saturated up slopes to canal could encourage soil erosion and land slips

Seepage losses reduced when associated with increased irrigation requirements

Main canal section protected against scouring if floods enter

Debris falling into canal section blocking it as well as landslip hazard

Exposed pipelines more susceptible to thermal degradation

Debris blocking pipe if floods enter main canal

Flexibility in replacement if damaged by landslip

Scouring around base of piers

Little effect

Scouring around base of abutments

Cross drain side slopes sliding near abutment

Long spans susceptible to increased thermal expansion

Depends on free clearance above cross drain

Little effect

Easy for flood water to enter canal depositing sediment

Flood water could still enter canal if structure not wide enough

Bigger structure may be more susceptible to thermal expansion

Problem with sediment blocking syphon if flood water enters
Suggestions for Developing Modified Vulnerability Assessment Tools

A possible specific vulnerability assessment matrix to be used when assessing the ADAPTIVE CAPACITY matrix score:

<table>
<thead>
<tr>
<th>STATUS</th>
<th>COMPONENT AVAILABILITY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absent</td>
<td>Partial</td>
</tr>
<tr>
<td>Availability of materials</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Access to technical resources</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Institutional policies and procedures in place</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Water user group commitment</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Access to financial resources</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**ADAPTIVE CAPACITY MATRIX SCORE**

Adaptive Capacity classified according to the following total scoring from the above table:

<table>
<thead>
<tr>
<th>TOTAL SCORE</th>
<th>ADAPTIVE CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very Low</td>
</tr>
<tr>
<td>6 – 8</td>
<td>Low</td>
</tr>
<tr>
<td>9 – 11</td>
<td>Medium</td>
</tr>
<tr>
<td>12 – 14</td>
<td>High</td>
</tr>
<tr>
<td>15</td>
<td>Very High</td>
</tr>
</tbody>
</table>

1. Necessary for implementing any remedial works
2. Necessary to design any remedial works
3. Needed to guide correct application of works
4. Required to show they want to improve and maintain works
5. Necessary budgets have to be in place
More than 60% of the land in the South Asian Region is considered prone to shaking of intensity 7 and above.

**Resonance**

The many systems have natural frequencies by changing the system one can change its natural frequency.

The system oscillate most when driven at this natural frequency, the natural frequency of the structures may be less apparent, which determines if it will or will not fall down during an earthquake
### Table 1: Seismic factors

<table>
<thead>
<tr>
<th>Class of Building</th>
<th>Area of violent earthquakes</th>
<th>Area of strong earthquakes</th>
<th>Area of weak earthquakes</th>
<th>Area of rare earthquakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.15g</td>
<td>0.10g</td>
<td>0.05g</td>
<td>Nil</td>
</tr>
<tr>
<td>B</td>
<td>0.10g</td>
<td>0.075g</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Type A: Monumental Building

Type B: All others
Earthquake or Seismic load on a structure depends upon its geographical location, lateral stiffness and mass.

However, wind loads and earthquake loads are assumed not to act simultaneously. A structure may be analyzed either by seismic coefficient method or response spectrum method.

The first step in seismic analysis is to determine the horizontal shear:

\[ V_B = a_h W \]

\[ a_h = \text{Design Seismic coefficient} \]
$W =$ Total dead load plus appropriate reduced live load on the structure

$$a_h = bICa_o$$

$a_o =$ Basic horizontal Seismic coefficient specified for various seismic zones

$b =$ A factor depending on the soil foundation system

### Table 2: Seismic zones and coefficients

<table>
<thead>
<tr>
<th>Zone no.</th>
<th>Basic Seismic Coefficient $\alpha_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>0.08</td>
</tr>
<tr>
<td>IV</td>
<td>0.05</td>
</tr>
<tr>
<td>III</td>
<td>0.04</td>
</tr>
<tr>
<td>II</td>
<td>0.02</td>
</tr>
<tr>
<td>I</td>
<td>0.01</td>
</tr>
</tbody>
</table>
### Table 3: Soil foundation factor $\beta$

<table>
<thead>
<tr>
<th>Types of soil mainly constituting the foundation</th>
<th>Value of factor $\beta$ for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Piles resting on soil type I or raft foundation</td>
</tr>
<tr>
<td>Type I Rock or hard soil</td>
<td>1</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
</tr>
<tr>
<td>Medium soil</td>
<td>1</td>
</tr>
<tr>
<td>Type III Soft soil</td>
<td>1</td>
</tr>
</tbody>
</table>
I = Importance factor depending on the life and function of the structures. Its value 1.0 for ordinary structures; 1.5 for importance services and community structures e.g. hospitals, water works, water towers, schools, major bridges etc.; 2.0 for containers of inflammable or poisonous gases

C = flexibility factor evaluated from the graph
Flexible Geomembrane

Articulated concrete blocks attached to the geotextile

Geotextile

Geomembrane

Portion of geomembrane exposed

Cobble wedge

Gabion

Portion of geomembrane exposed
Thank You for Your Attention