# HYDROLOGICAL INSTRUMENTATION PROBLEMS ASSOCIATED WITH RAINFED AGRICULTURE

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## 1. INTRODUCTION

The International Action Programme on Water and Sustainable Agricultural Development (IAP–WASAD) was developed by FAO in collaboration with the relevant UN organizations and member nations (1990). The motto of the International Action Programme was to establish a holistic approach to water resources for integrated development of irrigated and rainfed farming, livestock, fisheries and agroforestry and emphasizes the importance of water and soil conservation and environmental protection (FAO, 1992, 28). However, to make these efforts successful and revival particularly in terms of sustainable agriculture and rural development (SARD), it will be a wise step if common farmers can well realize the value of rational and judicious use of available water by various sources on the earth's surface. The importance of water resources can definitely be realized by those farmers where crop farming is rainfed. So, for the minimization of water crisis for irrigation in terraced crop fields in the Himalayan hills in particular, two most peculiar aspects are worth mentioning:

i. To generate baseline data in terms of crop hydrology for a considerable period, and

ii. To harvest rainwater in the seasons of its surplus and to recycle it for irrigating crops in seasons of drought or deficit rainfall.

For developing concrete solutions of the first aspect, it is essential to have modern scientific instruments with automation processes to derive data regarding the components of hydrology and meteorology which in combinnation influence rainfed agriculture. Moreover, for the second aspect a technique or a way is required through more and more investigations regarding the workmanship and feasibility of the art of rainwater harvesting techniques. But there are other so many hydrological instrumentation problems associated with rainfed agriculture. If these agro-hydro-meteorological instrumentations are taken care of with proper technical skills in different areas of today's water resources development, most of the problems of rainfed agriculture in particular will be solved. Although application of innovative and other technological inputs will go hand in hand in overcoming food shortages by way of increasing per acre yields even under rainfed agricultural conditions.

## 2. NEED OF HYDROLOGICAL INSTRUMENTATION

2.1 There are nine major river basins (i. e. , Indus, Ganga, Brahmaputra, Narmada, Mahanadi, Godavari, Krishna, Pennar and Cauvery) in the country. But amongst these the first three river systems of the Himalayan region have an important place from the point of view of both - their length and average annual runoff as is shown in Table 1.

**Table 1 Three major river systems of the Himalayan region.**

| Sl. No. | River Basin | Length of river (km) | Catchment Area Runoff ($km^2$) | Average Annual Capita ($m^3$) | Average Annual Runoff/ ($m^3$) |
|---|---|---|---|---|---|
| 1. | Indus | 2880 | 11,65,500 | 73305 | 2015 |
| 2. | Ganga | 2525 | 10,86,000 | 525023 | 1742 |
| 3. | Brahmaputra | 2900 | 5,80,000 | 537240 | 21060 |

Source: Theme paper on 'Water for Future', Water Resources Day- 1990, CWC, New Delhi, Water Resources of India, CWC, New Delhi, (Quoted from Water - Nature's Wonder - Hydrologic Cycle, NIH, Roorkee).

But most of the rivers of the Himalayan region, which are glacier fed and perennial, have also been found to have a decreasing trend in their discharge. A study of a typically Lesser Himalayan Gaula river showed that the yearly runoff at Jamrani dropped from an average of 8809 cumec/day during 1965-1981, i. e., a drop of 35 percent in only one and a half decades (Bartarya, 1988, 266).

2.2 Similarly if the three principal components of hydrology, i.e., precipitation, evaporation and surface runoff are taken into account in terms of all continents, it is found that out of a total average precipitation of 760 mm, 63.16 percent water is lost by evaporation whereas the remaining 36.84 percent water overflows through runoffs. When the Asian continent especially was taken into account, it was found that from the total average of 726 mm annual precipitation, 59.64 percent precipitation is evaporated and the rest overflows. So there very little availability of fresh water on our planet and its loss through evaporation and runoff urgently call for continuous recording and monitoring of data through inventions and discoveries of advanced hydrological instruments for making and implementing either sector-level or regional level developmental plans.

## 3. RAINFED AGRICULTURE AND HYDROLOGICAL INSTRUMENTS

3.1 Out of the total geographical area of India, about 35 percent is mountainous, of which about 58 percent area is accounted by the Himalayan lofty mountains. The practice of rainfed agriculture mainly extends over the Himalayan hills. However, even today the Himalayan region as a whole has hardly yet achieved a stabilized position in terms of its process of origin. The Himalayas are still considered to be rising along with the active erosional agents of denudation. Hence, these parts of our country are relatively more sensitive to the practice of any over developmental activity. Similarly, it is true that in years to come the practice of agriculture, particularly rainfed, would also have to become more critical owing to many reasons as follows:

(i) continuance of increasing anthropogenic pressures in a fragile natural system of the Himalayas,

(ii) encroachment on village panchayat and forest land for want of arable land,

(iii) degeneration and degradation of terraced fields in the upper reaches and low lying valley arable land in the wake of either 'cloud burst' or flooded rain water,

(iv) drying up of springs, lakes and decreasing trend of water volume even in glacier fed rivers,

(v) siltation in natural lakes and reservoirs,

(vi) declining per acre yield of crops and their overall efficiency,

(vii) inefficiency of techniques and technology for planning and implementing micro-level lift irrigation projects for watering crops from river valleys to terraced fields,

(viii) presence of traditional structures for harvesting rain water in every rainfed agroclimatic zone of the Himalayas,

(ix) insufficient information regarding precipitation, evaporation and runoff at relatively higher altitudes of different agroclimatic zones,

(x) non- availability of automated recording of agro-hydro-meteorological instruments, and

(xi) measurement problems regarding hydrological cum meteorological data at high elevations on a routine basis.

## 4. EXISTING STATUS OF AGRO-METEOROLOGICAL AND GEO-HYDROLOGICAL INSTRUMENTS

The first and foremost objective of real sense hydrological instruments is to record and/or measure base line data about aspects of crop geography is a routine form irrespective of diverse topographic, climatic and altitudinal variations within either a micro-watershed or a watershed or the whole of the geographical region. Hydrological instruments, as termed here, are the tools of research pertaining mainly to measurements of the components of hydrological cycle influences the growth of crop culture under hilly rainfed conditions of the Himalayan environment.

### 4.1 Temperature

Temperature is that component of the hydrological cycle around which every component has to rotate. Station temperature includes air temperature which is mainly measured inside a thermometer shelter (i.e., Stevenson's screen) at a height between 1.5m to 2m (Lohani and Seethapathi, 1984-85, 34). However, most of the thermometers do not require any shelter which are generally of the pocket type with the quality of automation. The major and common agro-meteorological thermometers are as follows:

- Thermometers: mercury in glass for wet/dry bulb temperatures.
- Bimetallic Thermograph: mercury in glass for chart recording.

- Remote Thermograph: range –15°C to +50°C, equipped with flexible capillary of 05 metres. Suitable for continuous recording of remote water, soil or air temperatures.
- Ground Surface Minimum Thermometer: measuring range –40°C to +40°C. For orchards it is much in use.
- Digital Thermometer: universal thermometer with measuring range –50°C to +150°C. Suitable for air, gases, liquids, plastic substances and surfaces.
- Portable Multiple Temperature Meter: measuring range –20°C up to +50°C. For accurate measurements of temperature of fields, soil, vegetation or in water.

## 4.2 Precipitation

Precipitation forms one of the most important parameters of the hydrological cycle. The main purpose of rainfall recording is to measure the depth and intensity of precipitation by various types of rain gauges and rainfall recorders. Precipitation is recorded in different forms such as, hail, mist, dew and snow, etc. The role of every constituent is very crucial when we talk about actual requirements and availability of precipitation for crops particularly where agriculture is rainfed. Except for rain and snow gauges there is non-availability of instruments to measure these forms of precipitation.

As far as the position of rainfall recorders is concerned, the most common are the tilting siphon, the tipping bucket and the weighing type. Moreover, for continuous recording of rainfall data for a long period, high capacity rain gauges (capacity 20 litres) are also used.

## 4.3 Evaporation

Evaporation measurement of water surface, wind surface and intercepted water has been recorded using open water pans for many years. Evaporimeters, water balance recorders, leaf wetness recorder and Piche evaporation pan meter are also in use. But Class A evaporation pan equipped with hook gauge evaporimeter is used most commonly nowadays. For estimating the evaporation power of air, atmometers are in frequent use. Water is constantly evaporated by a wet filter paper or thin porous ceramic disc which remains in contact with a water reservoir.

## 4.4 Surface Runoff

For studying geo-hydrologic characteristics of either rivers or crops, water sampling equipment, current meters, sediment sampling and water level recorders are generally needed. Catchment areas mainly characterized with rainfed agriculture in hilly environments have relatively greater significance for instruments which can be applied properly. However, there has not been any application of such instruments as may be able to measure continuously the gross quantum and volume of water for a given period of time especially from the outlet of terraced crop fields.There are certain types of current meters, such as, drain discharge recorder, floating drain discharge recorder, current measuring stick and current meter with propeller, etc.

## 4.5 Infiltration

Water loss through seepage is an essential ingredient to be taken into account for measurement under the hydrologic water budget. Infiltration of water is governed by factors of topography, aspects of slope, soil type and moisture availability of soils, and the existing land use pattern, etc. Infiltrometers are very commonly put into practice for measuring the quantum of water from precipitation and surface runoff. Instruments, directly or indirectly, pertaining to measurement of water seepage are as follows:

- Hydraulic conductivity test kit: it is mostly used in connection with the design of drainage systems in water logged land and in canal seepage investigations.
- Guelph insitu permeameter: its main purpose is to record data in fields to calculate (i) material flux potential, and (ii) soil absorption capacity.
- Mini rainfall simulator: it can be used in the field as well as in the laboratory to determine water infiltration and erosion characteristics of soils.
- The double ring infiltrometer : it is possible to determine threefold synchronic measurements of (i) water infiltration capacity of soils for irrigation and drainage purposes, (ii) erosion sensitivity of soils, and (iii) water permeability in non-saturated soil layers on or above the ground water level.

4.6 Other than these major elements already discussed under hydro-meteorological regimes, atmospheric pressure is measured with the help of barometers, altimeters and sensor pressures. While wind velocity and its speed is generally recorded by anemometers and wind vanes respectively. Moreover, the Anemograph is also in use for recording wind velocity and direction. Accordingly, data regarding air humidity is obtained by air hygrographs. Sunshine duration is measured by Campbell Stokes sunshine recorder, while its radiation by Bimetallic Actinograph, Bellani Pyranometer and Thermo-electric solarimeter, etc. Although for rough estimation of sun brightness, it can, usually be made by viewing the degree of cloud cover in the sky.

## 5. INSTRUMENTATION PROBLEMS

5.1 With the advent of hydrological instruments in the country, some of measurements of hydrologic parameters have been made possible. On account of the complete diversity in the prevalent physio-climatic conditions of the mountainous environment from that of the plains, the nature and type of instruments installed at field sites for collecting, retrieving and storage of hydro-meteorological base line data are also quite different in terms of their techniques of installations, repair and maintenance. Hence, to handle every type of instruments in the Himalayan context is typical and difficult. In accordance with the changing physio-climatic conditions from valley to hill tops along with sloping fields though with terraced features, require slightly distinct instruments in measuring agro-hydro-meteorological instruments which are lightweight, climate insensitive, water and wind proof, and cost reasonable.

5.2 Manual instruments can hardly prove economical, reliable and continuous sources of data which are fruitful for implementing long term real planning in the hands of academicians, engineers, scientists and policy makers. Under these conditions, the unavailability of accurate and authentic data regarding hydrological characteristics would lead to planning which would ultimately fail particularly when we wish to know water requirements of crops and to harvest rainwater and recycle it in crop fields in the seasons of drought and dryness.

5.3 Instruments more than one are generally installed to record a number of variables. Such a process of installing of several instruments for a definite purpose have limitations in measuring only one or two attributes of hydro-meteorology. So, alike instruments have usually to suffer from geographic suitability with alternate ones for recording hydrologic characteristics at a given time and given place.

5.4 The agro-meteorological instrumentation system, i.e., Automatic Weather Station (AWS) is being introduced in the country. Though Agro-Meteorological System (AMS) and Automatic Weather Station (AWS) work automatically, yet either of these cannot collectively generate data for all the elements of crop hydrologic regime at a time and at a place. AMS or AWS systems can only make available the data regarding precipitation, wind speed and direction, temperature, air humidity, etc. but at the same time fail to measure data regarding hydrology such as water discharge/ runoff, infiltration, interception, evapotranspiration and ground water flow, etc. So, there is need to develop a single system for both the aspects of hydrology and meterorology, i.e., Agro- Hydro-Meterorological System (AHMS).

## 6. CONCLUSIONS

6.1 The practice of agriculture particularly in high sloapy hills is greatly suffering primarily owing to inadequate irrigation water and erratic rainfall. There is complete absence of perennial sources of irrigation in and around the locations of terraced crop fields of rainfed agriculture.

6.2 The continual process of drying up of natural springs due to the spreading desertification over hilly rocks, ruthless cutting of forests and the gradual decreasing discharge of river water definitely symbolizes the future difficult situation of water resources.

6.3 Although the prevalent sources in the forms of rivers are glacier fed and hence perennial, yet they still need huge amounts of money, high levels of technology and relatively larger time to be tapped for irrigation schemes for terraced crop fields in the upper reaches of the valleys.

6.4 As an immediate preventive measure, rain water harvesting, after developing different suitable structures in accordance with the geographic suitability of different agro- climatic sub-zones within rainfed agriculture needs essentially to be stepped up and developed. This method may prove much more beneficial and reasonable than the method discussed under 6.3 in terms of deserving high potentiality and economy.

In a nutshell, to get regulated water and to find solutions of all the premises stated earlier, more and more sophisticated hydrological instruments with automation and environmental suitability even in mountainous topography are needed extensively for generating and collecting data on a routine basis. At the same time, manufacturers should confirm the availability of technical skills and punctuality in providing service to the users for repairs and maintenance of these hydrological instruments.

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