RAIN WATER MANAGEMENT

I. Introduction

In the current parlance our most conspicuous failure is our stagnant rice productivity, which happens to be the lowest in the country. It is said to be due to state's 80% dependence on rain fed agriculture, which is said to be highly erratic. Therefore, in the context of Odisha, improving dependability on whatever rain we get appears to be our first priority. In the context of providing year round livelihood to the majority of households, who depend upon agriculture, raising cropping intensity substantially becomes highly relevant, which can come only if rain water is managed well.

Flow Irrigation advancement in the state has not been able to fully meet the requirement of the State's agricultural needs. Apart from a substantial gap between declared and achieved irrigation potential, the projects have problems like tapering and uncertain supplies, tail end scarcity as well as water logging. Lift Irrigation Projects have their own management problems.

The classification of land quality by Revenue Department and recorded in Record of Rights is not based on size, shape or land levels. It is fixed on the basis of the duration for which moisture is retained in the soil. The land revenue is higher for lands having capacity to support crops of longer duration or for having the capacity to support more than one crop. What does it indicate? Mere increase in plot size by leveling and bunding is not real land development. It must also improve the moisture status of the land.

Rain falls in every farmer's land. Traditionally over the past several generations the farmers have developed the infrastructure to do at least Kharif cropping over 65 lakh ha. One cannot say that the people who have performed this feat, apparently without any Government help, are either a lazy lot or are devoid of any wisdom. The social, economic and administrative changes that have taken place after independence have somehow taken away the very initiative from them and have made them unnecessarily dependant on the sources out of their control. It is time to reignite in people the lost initiative and empower them to manage the rain that falls in their land.

Therefore, *improving dependability* of whatever rain we get appears to be our first priority. Further, in the context of providing year round livelihood activity to the majority of households, who depend upon agriculture, *raising cropping intensity* substantially becomes highly relevant as the second priority. Both the priorities demand storage of adequate quantity of water out of the annual precipitation. The third priority is to *improve the field condition* of the small and marginal farmers, who constitute 83% of State's farming population. If one wants to fulfil the plan target of raising agricultural production by 4%, it cannot be achieved without productive participation of this large group of small &marginal farmers. In this context it is necessary to undertake some program under which all category of farmer will be benefited. Agriculture department has taken up a massive program of providing shallow bore wells to the people. But where is the water to lift unless the sources are charged? If one goes for searching water sources both lead and lift increase requiring relatively high energy input. If we look to the reasons of failure of Govt initiated lift points operated by OLIC, one will find the high energy cost at its root.

There could be no better program than Rain water management , which is in principle based on mass land development, to provide solution to all these. A way out was yet to be identified by the Government. Rain water management concept has evolved out of such a need. It is however an uphill task to replace the current perceptions of providing irrigation as well as that of meeting other water needs. It is, however, not impossible either. This task involves all the farmers and farmland of the village, which can be best performed by personnel having engineering background with experience in agriculture extension. The efficacy of the Rain Water Management concept has been established as observed from the large number of pioneering works done inside the state.

II. Management Concept

Ultimate source of all water we see in rivers, tanks and wells is the rain. Apart from its large quantum, the significant fact about it is that its home is the cloud which keeps floating overhead to cover every inch of land. It comes down during monsoon months and falls as droplets and does so everywhere without any discrimination. It falls on hilltops, roof tops as well as the crop fields. This is the basic advantage of trying to utilise it where it falls. In addition to minimising the chance of avoidable losses one saves the trouble of conveying the water from one place to other.

In its simplest sense, effective rainfall means useful or utilisable rainfall. Rainfall is not necessarily useful or desirable at the time, at the rate or amount in which it is received. Some of it may be unavoidably wasted while some may even be destructive. Just as total rainfall varies, so does the amount of effective rainfall. The useful portion of rainfall is stored and supplied to the user; the unwanted parts need be conveyed or removed speedily.

The term effective rainfall has been interpreted differently not only by specialists in different fields but also by different workers in the same field. To a canal engineer, the rain which reaches the storage reservoir directly and by surface runoff from the surrounding area indirectly is the effective portion. According to a hydro-electrical engineer, the rainfall which is useful for running the turbines that generate electricity is the effective portion of the total received. Geo-hydrologists would define as effective rainfall that portion of rainfall which contributes to the ground water storage; the extent of rise in the water table levels would be the effective rainfall. Agriculturists consider as effective that portion of the total rainfall which directly satisfies crop water needs and the surface runoff which can be used for crop water needs and also the surface runoff which can be used for crop production on their farms by being pumped from ponds or wells.

In the field of dry land agriculture, when the land is left fallow, effective rainfall is that which can be conserved for the following crop. An individual farmer considers that effective rainfall is that quantity which is useful in raising crops planted on his land, under his management. Water which moves out of the field by runoff or by deep percolation beyond the root zone of his crop is ineffective.

In our case, we will consider total precipitation falling in the watershed/village as useful. Earlier, there were no established method to store the entire precipitation and effectively utilise for cropping and other human uses. Thus whatever quantity could be used for cropping was considered as effective. But this method of Rain Water Management will utilise the precipitation not only for cropping, but also for drinking, washing and bathing, cattle growing, flood control and creating an off-season flow in the local streams and rivers. This takes care of requirements of Canal engineer, Hydro-electrical engineer, Geo-hydrologist, Agriculturist and individual farmer.

Bulk of the rain comes during monsoon months once a year. It has therefore to be stored so that it can be used during the dry months. The usual practice is to store water in surface reservoirs .Some of them are big spreading over several hundred sq. km. like that of Hirakud dam project while others are of medium size of few sq. km. However many more are small reservoirs of assorted size locally known as ponds or tanks. If we talk in the context of Odisha, which is located in the high rainfall zone, the aggregate volume of the created storage capacity cannot hold more than 10% of the total volume of precipitation received in the state. Thus currently 90% of the rainfall is being lost in various ways.

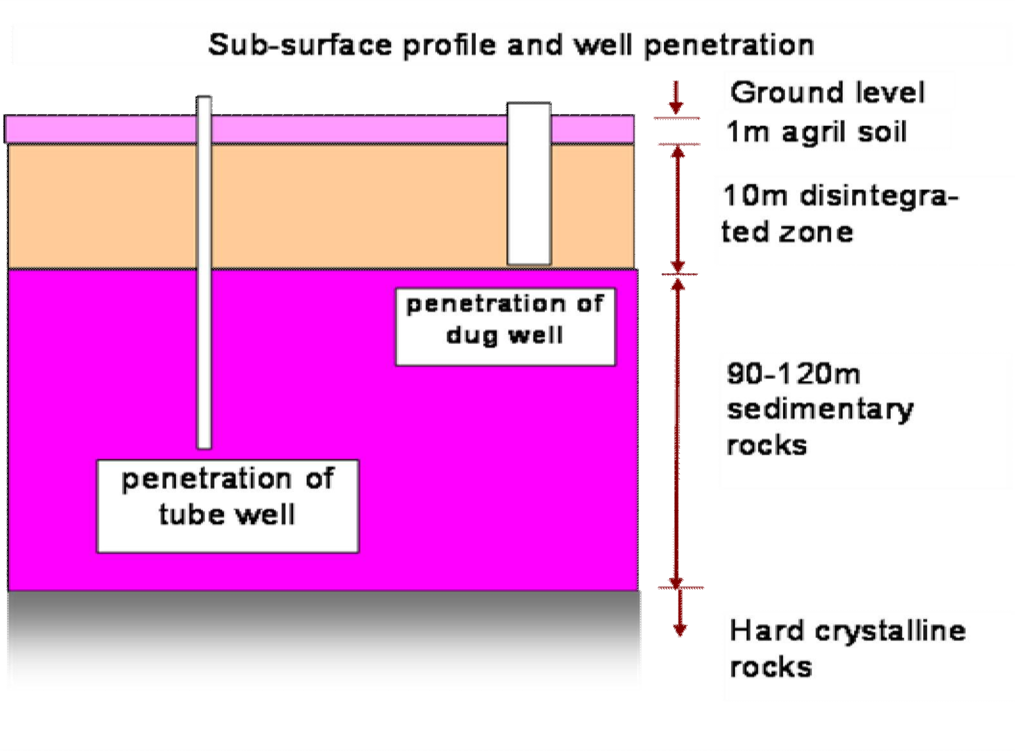
The most conspicuous manner of losing precipitation is through runoff (about 40%), Bulk of it is lost while it is still raining (call it quick runoff). This is the obstinate part. Not only it takes away water from the place of use, it also causes flood downstream. We would like to minimise it by enhancing infiltration into the soil, where it falls so that drought is prevented in the uplands of inland areas and thus minimises the incidence of flood in the coastal plains.
The second manner of loss is through unproductive evaporation (about 37%)
Natural retention is minimal (about 13%)
Manmade storage is still less (10%)

The soil mass, which happens to be a porous media, given adequate time, it can absorb the entire precipitation. The aggregate volume of porosity is 2-3 times the volume of precipitation received in a village. Thus storage space is more than adequate. The limiting factor is the time for in filtering the desired quantum. Under the current situation, it hardly stays for about 30 minutes. Not much can happen within such a short time because the rate of infiltration is only75mm per hour. Thus if we want 750mm, which is the volumetric water requirement of a 200% intensive cropping (50%) of Odisha's average rain fall, the quantity of runoff desired to be in filtered must stay within the village for at least 10hours. The current practice is to construct surface reservoirs, which have not been anywhere near achieving the objective. The highest ever cropping intensity in the most flourishing irrigation project is hardly 150 %. It is often associated with untimely and uncertainty of supply.

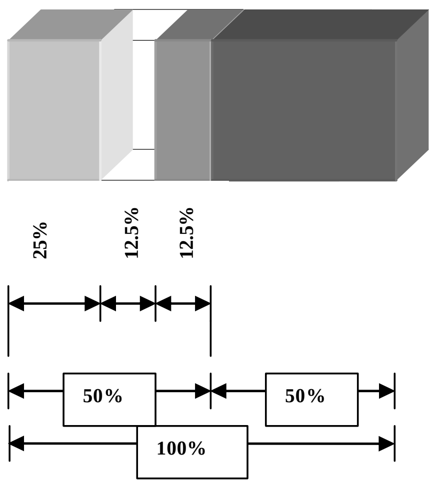
In order that we make use of the natural endowments as well as the traditional wisdom vis-à-vis the current demand, it appears to be a wise step to synthesise a way out. The inland areas of Odisha is hilly and used to be rich with intense forest cover, forests are a natural in filtering agent of rainfall. They used to store water and release it slowly. Throughout the year, every village in the inland areas had forest around it and enjoyed the benefit of spring flow from the forests. The traditional wisdom had laid out the entire area of the village land in every village and used to grow all kinds of crops including rice and sugarcane. They grew a variety of pulses and raised flourishing orchards. The coastal plains received the moderated floods (after infiltration) and their soil was regularly enriched with silt deposits by the flood water. What is more interesting is that water for cropping was no problem for them because of deep colluviums and high water table which maintained water within easy reach of the plant roots.

Over the time, population has raised thereby increasing pressure on land. Forests have been cleared so as to be converted to cultivable land. Soil mass is there alright but there is no water in it .The natural in filtering agency has vanished. But the original pattern of land lay out is still there with very insignificant change but it has not remained as productive as it once was. Therefore the need of the hour is to find an alternative agent to in filter rain water. Fortunately for us the vanishing forests have left huge land mass behind, which is still in the same shape as it was when forest was there. These can be reshaped to create an alternative flow path, which will be long enough to touch all uplands and flat enough to slow down the speed of water so as to gain the needed 10 hours to in filter at least 750mm of rainfall.

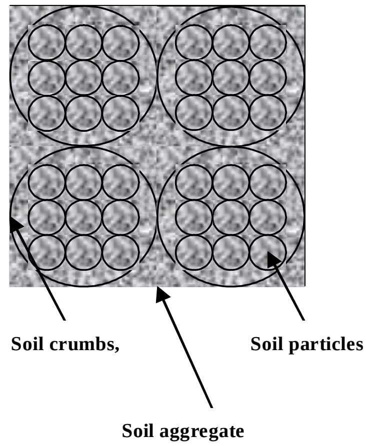
While providing for water, nature has created dense forest in apparently hostile terrain (hilly part) to help in filtering a substantial part of rainfall into the productive part of the soil, whose aggregate mass is large enough to absorb all the rain that falls on it/flows in to it. The soil is a porous media and can hold water up to 40-50% of its volume. Once water in filters into the soil not only runoff losses are eliminated proportionately, but unproductive evaporation is also cut down by transforming direct evaporation in to evapo- transpiration.



Soil is formed out of elementary particles which according to their size are divided into three types. The coarser ones having its size around 0.2mm are known as sand. Finer than this is silt having size around 0.02. The finest particles are clay, which have sizes around 0.002mm. When they come in contact with water they have the property of adhering to each other and form a crumby structure. If one visualises each elementary particle as a tiny sphere, there will be some space between them when they touch each other. These spaces are called micro pores. When water enters into them it gets so firmly held that even gravity cannot remove it. It can only be extracted by plant roots. Thus once in filtered, it stays in the micro pores for direct use of plant life. Therefore human intervention is needed only to in filter water into the soil. You don't need any other structure to hold it there till plant roots have removed it. This is the nature's design to store water for use by plants. The beauty of this design is that each of these crumbs now forms a lager sphere and can attach to each other as such leaving larger gaps between them. These gaps are called macro pores. Water can be stored in them as well. Difference is that it can be moved by gravity in the direction of the hydraulic gradient. Normally, nature fixes this direction in a given situation. Due to this property, water can move from an upper location to a lower one. If one finds the direction undesirable it can be changed by increasing the gradient in the direction required and by blocking the original path. If due to intensive cropping, the water stored in micro pores in any given location is used up, the micro pores can be refilled with water taken from macro pores of another location by appropriate redesign of the hydraulic gradient.



Variation in soil moisture regime



Schematic representation of soil structure

In order to design and regulate movement of water in macro pores, it is necessary to understand their configuration. For that, one may visualise that each macro pore is a sealed compartment with only one opening in the direction of the hydraulic gradient. It can move from one compartment to the next only if the next compartment is empty, it is akin to the movement of a queue through a narrow door through which one person can pass at a time Thus moving water from macro pores is as simple as opening a hydraulic gradient in the direction desired.

Knowledge of this helps us to plan opening of gradients either to move water within the subsurface from one location to the other or for taking out to the surface for pumping it out. Pumping is resorted to when gradient is exhausted. Where gradient is there, spring flow occurs. There are various ways of utilising springs.

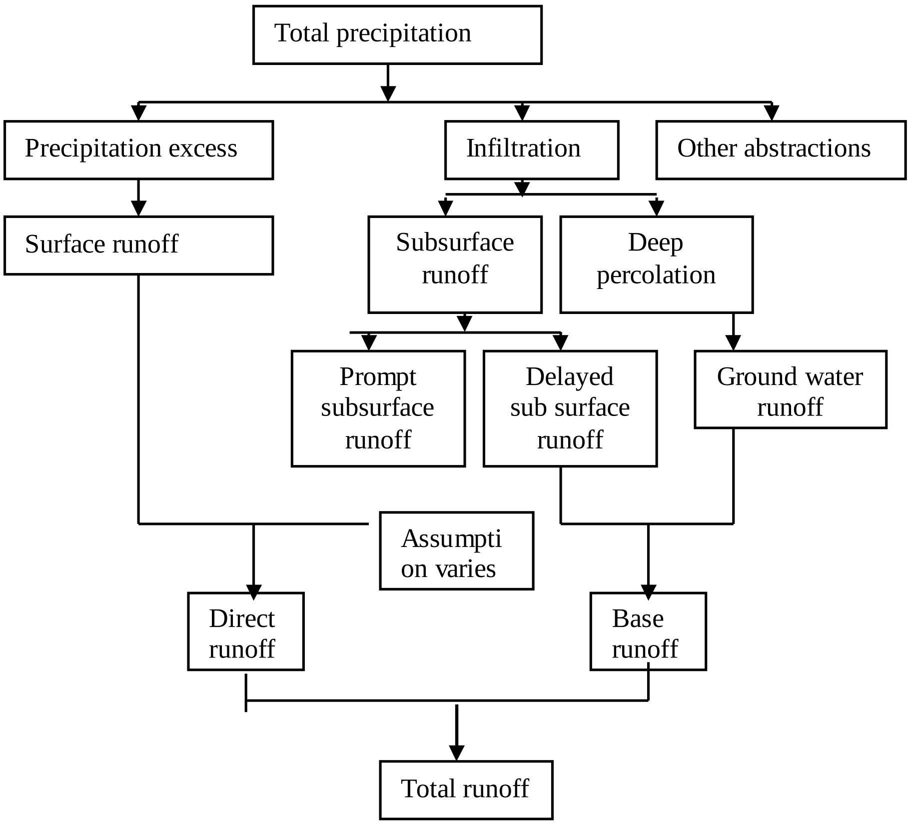
The gravitational water stored in macro pores is the source of all sub-surface water. Given sufficient time, it finds way to the low lying lands. While moving downwards the flow sometimes daylights on the surface in the form of springs. Where it does not daylight, it will still be available as aquifers in the relatively flat bottom lands where wells can be dug to reach the sub surface reservoirs. While springs can be tapped to flow in pipes to water scarcity area, in specific locations diaphragm walls can be used to lock the gradient in undesirable direction and open up one in the desired direction.

Because of the subsurface storage, water table would rise close to the surface of low lands. Water should be pumped out to remove the excess water from low lands to make them fit for cropping. This water will be used to irrigate crops within the command of a specific well. Such a command area will be provided with a buried delivery line which would be a pressure line all through and would be laid on a grade such that the head gained would be more than or equal to the static plus frictional head. This will amount to a zero friction pumping and will be close to a siphon in operation. This will cut down energy cost drastically. As the energy cost will be low, one can use pumping for unconventional use, such as irrigating upland for supporting a longer duration paddy crop. If the last irrigation is given for this purpose, the same irrigation can serve as pre sowing irrigation for a following Rabi crop. Medium lands which would be too wet for a pulse or oilseed crop can be put to SRI method of paddy cultivation.

The sub soil water moves almost at the same rate at which the rain water in filters into the soil i.e. 75 mm per hour. This speed is 30000 times slower than the average speed of surface runoff. At this speed it will travel 1.8 meters per day, which means it will remain inside the village for 556days to reach the outfall a kilometre away of an average village . It means, once in filtered it will take more than a year to leave the village. In other words the next year's rain would have arrived before the last rain water would have drained.

III. Hydrology

The precipitation divides itself in the following pattern before appearing as the total runoff.



The meaning of the terms used in this chart is as follows:

Total precipitation	Normal annual rainfall x Area of the village x 0.62 (Uniformity coefficient)
Precipitation excesses	The portion of the precipitation, which does not enter in to soil and becomes surface runoff.(About 45%)
Infiltration	The portion of the precipitation which enters into the soil pores (About 20%)

Other abstraction	Interception, Evaporation, Transpiration and Stored in depressions. (About 35%)
Deep percolation	The part which goes so deep that it can be taken out only through tube well
Sub surface run off	Water that enters the soil cannot stay at one place, it moves down inside the soil.
Prompt sub surface runoff	Sub surface water that joins the adjoining Nallah before end of rainy season
Delayed sub surface runoff	Subsurface water joining the adjoining Nallah after the rainy season
Direct runoff	Flow in adjoining Nallah during rainy season
Base run off	Flow in the adjoining Nallah after rainy season This comes from the water stored in the zone of aeration as well as the ground water.

The only usable water is the part that in filters into soil. The prompt sub surface runoff benefits the Kharif crop. The delayed sub surface runoff benefits Kharif crops in case there is drought as well as the Rabi crops. When we dig a well in low land and pump up for irrigation we are using the delayed sub-surface runoff.

IV. Water Balance Data

Rainfall, evaporation and runoff can be measured for a watershed. The method is simple and we can organize an indigenous set up to get this data with usable accuracy.

1. Rainfall

The rainfall figures pertain to recording at an observation point, once in 24 hours. Logically one should multiply this by the area of the basin to get the total precipitation occurring in basin during the selected period (day, month or year). In other words the logic assumes that the observed depth of precipitation to have occurred uniformly over the whole basin.

From common experience we observe that rain hardly occurs uniformly over an area. Therefore direct multiplication is likely to give a larger value for precipitated volume compared to what might have actually been received. The handbooks say that the smaller the duration of a storms (showers) and the larger the intended application area the lesser is the uniformity. Since we had not installed any continuous rainfall recorder we have no access to such information.

On the other hand, the standard studies in hydrology have been done with an intention of finding maximum runoff yields. Therefore the handbooks have mentioned the depth-area relationships for application of point rainfall data over an area in the shape of curves applicable to storms of different durations. Among the available curves, one of minimum 6-hour duration is usable for our purpose. Our interest is on the actual storm durations on daily basis over the entire rainy season. We would have got these figures had we installed a continuous stage recorder.

In the absence of that the coefficient for the minimum-recorded storm duration of 6 hours has been adopted. Since the major part of our rainfall is concentrated over 4 rainy months during which rains are fairly intense, errors of approximation will be fairly low. The chosen coefficient is 0.62. This means that the recorded rainfall depths have to be multiplied by this factor while assessing the volume of precipitation received over the entire basin.

2. Evaporation: Evaporation can be measured by installing a Pan-evaporimeter at the rain gauge station. Since the Pan-evaporation data recorded is from free water surface it is applied as such to the area occupied by water bodies. The bonded paddy lands are assumed to be *saturated* for 6 months in a year (July to December), where from evaporation (which essentially is transpiration responsible for all the Khariff cropping) is also equal to the pan evaporation rate. In rest of the land the nearest approximation used is 0.6 times pan-evaporation rate limited by 50% depth of rainfall received during the month. The figure 50% has been adopted due to the fact that evaporation from barren land takes place up to a depth of 30cms only. Any infiltration going below this depth remains in the soil.

3. Retention in water bodies: The average depth of the water bodies (mostly ponds and MIPs) has been assumed as 2m.Multiplying this by area of water bodies in square meter gives the retention volume. This is one time deductible starting from the first rainy month (July). In the over view month wise analysis this forms a part of the retention and therefore no separate presentation has been made at this point.

4. Infiltration: Unlike rainfall there is no method for determining the volume of infiltration for the entire basin. It can only be found indirectly. Once the other abstraction factors like evaporation, transpiration and retention by water bodies have been accounted for, what does not appear as direct runoff is credited to the account of infiltration.

As far as the characteristics of infiltration are concerned it is pretty rapid and high for the initial half an hour. In about 2 hours time the rate reduces and becomes constant, which equals the rate of subsurface transmission. The in filtered water will fill up the soil pores in the zone of aeration, and then move to build up the ground water table. If availability of water (rainfall) continues it may fill up all pores and then appear as base flow (fair weather flow).

Since there is hardly any **base flow** in villages the in filtered water does not appear to be enough to contribute to the stream flow. Therefore in case of a village the assumption that Infiltration equals (Precipitation-runoff- other abstractions) is fairly correct. Thus its quantum can be found after we have assessed the runoff.

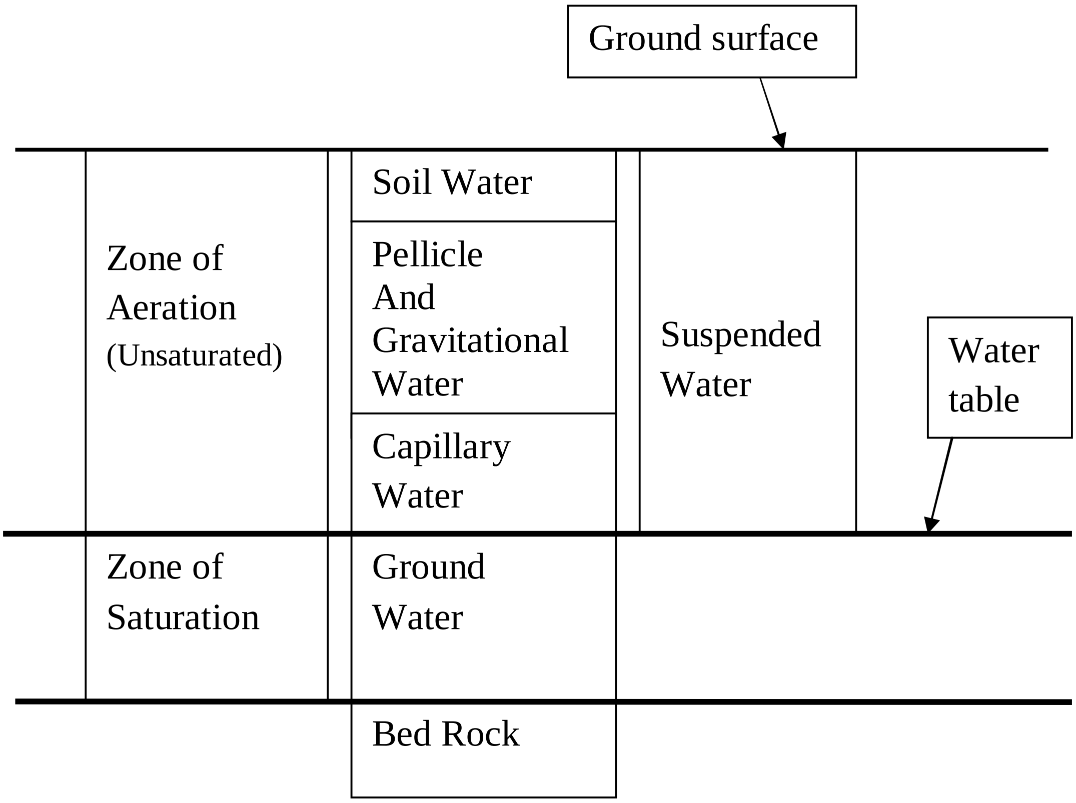
5. Runoff: Runoff from a watershed/village can be calculated from recording the discharge at different outlets by area-velocity (float) method from the village. To determine the velocity of water at the surface of the channel, the length of the trial section is divided by the average time taken by the float to cross it. Since the velocity of the float on the surface of the water will be greater than the average velocity of the stream, it is necessary to correct the measurement by a constant factor which is usually assumed to be 0.85. To obtain the rate of flow, this average velocity (measured velocity x coefficient) is multiplied by the average cross-sectional area of the stream.

Till we can do that, we can use figures from the nearest place, where they are measured and use the data.

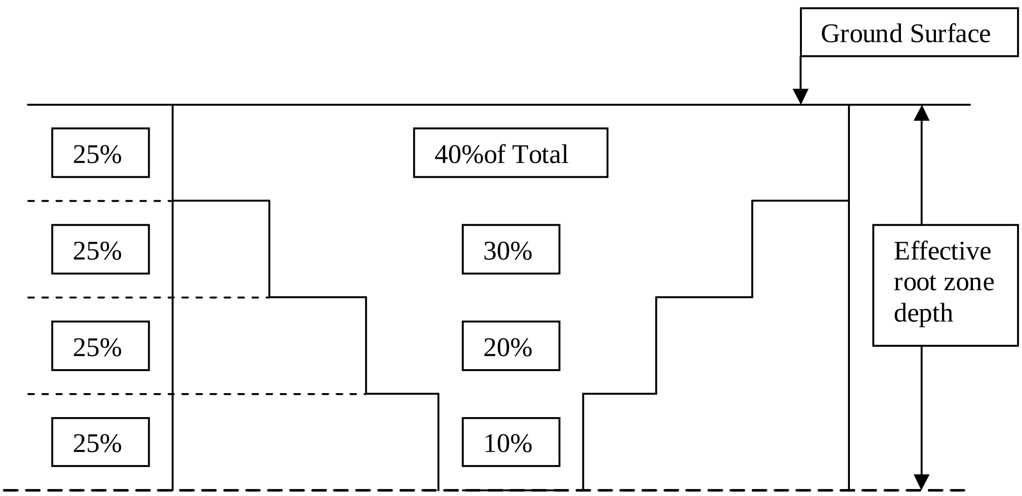
We will assess the need of the village and decide the extent up to which we should be enhancing the relevant factors.

The success of the treatment will be assessed on the basis of how much we have achieved the target we would have set for ourselves.
We can also make a ready and rough assessment from the nature of the physical terrain combined with observation of farmers during the past years.

V. Divisions of Soil water



Average moisture-extraction pattern of plants growing in a soil without restrictive layers and with an adequate supply of soil moisture



VI. The Application of Rainwater Management

The Kharif crop requirement is about 1m (96cm) of water. We normally receive 1.5m (1473mm) rainfall annually. Thus, as such, the rainfall is more than the crop requirement. Of course it is another thing that all of it is not available to the crop. A normal technologist is not sure if what is lost could be saved to meet the crop water requirement fully.

This topic is meant for introducing the participants to a modified view and convinces them the entire crop water requirement can be met relatively easily.

Normally the geographical area of a watershed is 500ha where as the arable area is around 150 ha. The scope lies in the fact that the precipitation over 500 ha is to be utilized only over 150 ha. Thus the excess available is more than four times.

The disintegrated zone below the arable land is around 10m and is 40% porous. Its aggregate volume is so large that it can store almost two years total precipitation

1. Rainwater management

Rainwater management is a unique concept because it talks of managing rain water instead of trying merely to store it.

Who says we are short of water, certainly not, at least in the eastern part of the country. In fact we are far surplus. Let us use the statistics of a typical Orissa village, which proves the point.

Normal Rainfall: 1400 mm (50 years average)
Geographical area: 500 ha
Kharif paddy area: 150 ha
Total precipitation: 500 ×10,000 × 1.4 × 0.62 = 43,40,000 cum
Irrigation Requirement of paddy: 150 ×10,000 × 0.960 =14,40,000 cum
Ratio of the two: 43,40,000 ÷ 14,40,000 = 3.01
Natural water resource endowment is about 3 times the basic livelihood need.

2. Surface & Subsurface Storage Potential

Hydrological observation in general indicates that an untreated catchment generally retains 20% of the rainfall and allows 80% to run off. In this ratio the quantitative picture of the village in the example emerges as follows:

- Natural retention@ 20% - 43,40,000 × 0.20 = 8,68,000 cum
- Runoff @ 80% - 43,40,000× 0.80 = 34,72,000 cum

Problem is in our inability to conserve and make use of the available resource.
The perception, we are used to, is the major hindrance

Surface storage capabilities: Let us make few simple calculations

- Let us say we muster space as well as funds for constructing 20 WHS of 1ha av. Size and 3m av. Depth**.**
- Enhanced storage capacity- 20x10, 000x3 = 6,00,000 cum
- Ratio of surface storage/Runoff (6,00,000÷34,72,000)x100= **17.28%**

Subsurface storage potential: The disintegrated zone is about 10m deep and porous. Porosity varies between 30-50%. If we exclude the hills and forest, the other part is quite retentive. Let us make some more calculations.

Subsurface storage potential of the village excluding 46% of hills and forest:

$$500 \text{ ha} \times 10{,}000 \times 54\% \times (10\text{m} \times 40\%) = 1{,}08{,}00{,}000 \text{ cum}$$

Ratio of subsurface storage potential to runoff:

$$(1{,}08{,}00{,}000 - 8{,}68{,}000\ ) \div 34{,}72{,}000 \times 100 = \mathbf{286\%}$$

Ratio of subsurface storage potential to precipitation:

$$1{,}08{,}00{,}000 \div 43{,}40{,}000 \times 100 = \mathbf{249\%}$$

The potential is so large that we can store more than two years' total rainfall and wipe out drought from the village.

In the context of river basins it may be said that individual micro watersheds aggregate to constitute a basin. Quantum may change but the ratio remains the same, i.e., 17.28% vs. 286%. Add few medium/ large projects, at best you may go up to 20-25% but never can equal 286%

A paradigm shift in the perception is necessary

- Small scale experiments have brought significant improvements.
- Large scale implementation is yet to be made.

Increasing Time of Concentration: Runoff generated during rainfall from the hills and forest above the village passes through rapidly to the stream or river below. Rain water hardly stays for an hour or half inside the forest. Rain Water does not infiltrate (hardly 10%) due to such short stay. This because, water infiltrates @ 50 to 75 mm per hour compared to over the ground speed of 2 kmph. To infiltrate a shower into the ground the water must stay 10 to 20 hours inside the forest. We need to have some mechanical measures to supplement the vegetative (plantation) measures to achieve this.

Time of Concentration is normally determined by

$$T_c = 0.01947 \quad L^{0.77} \quad S^{-0.385}$$

Where, T_c = Time of concentration (min)

L = Maximum length of travel of water (m)

S = Slope of drainage basin = H ÷ L

H = Difference in elevation between the most remote point of the basin and its outlet (m)

L = Maximum length of travel (m)

Time of concentration increases with the increase in length of travel and decrease in the slope.

VI. Management Technique

The logic of modern Rain Water Management technique has drawn considerable inspiration from our own tradition, which has been updated based on the findings of the modern knowledge in related aspects. The task is one of mass bunding in a specific design. The technology is based on traditional approach. Therefore farmers understand the proposal quickly. Bulk of the task involves earthwork and loose boulders; therefore labour intensive and cheap. It is briefly described as follows:

a) Replacement of the moderating role of the disappeared forest is sought in a mechanical measure called graded bund, which is used to create a safe alternate flow path for handling the entire runoff at an elevation permitted by the highest contour of a given location.
b) The damaging effect of flash floods is sought to be controlled through grading of the flow path limiting it to a maximum value of 0.5%. Since the original flow path through the cultivated lands is by and large higher and size of the guiding bunds (wherever available) much smaller such a path need fresh lay out and construction.
c) Since moderate flow is practically absent after disappearance of forests its role is sought to be replaced by saturating the sub-soil pores below the uplands. This task is partly accomplished by the guide bund described in item 'b' above. To complete the task a set of secondary bunds are required.
d) Secondary bunds recycle the runoff accumulating in the valley lands back to the uplands and are created by connecting and strengthening some specific existing bunds lying along a selected grade (0.2 – 0.5%)
e) Potential for Rabi cropping is considerably more compared to what was possible originally. The guide bunds (both primary and secondary ones) are quite effective in filling the soil pores during Khariff. The subsoil water move down slowly (@ 75mm/hour) and keep the soil moist in medium lands, which easily support a field crop during Rabi. The low lands maintain saturation right from the Khariff season till summer months and therefore can support a summer paddy crop.
f) During winter months there is no demand for water for low land paddy and therefore can be pumped up to medium lands for supporting vegetable cultivation. Easy availability of pump sets and competitive cost of pumping (because under the suggested situation the total head is low) Rabi/ summer cropping is made feasible.

Here is the details of RWM has been done by SACAL till January 2020.

RAIN WATER MANAGEMENT				
GP Name	Village Name	Area Covered in Acre	New Land in Acre	No. of House Hold Covered
Malasapadar	Padmapur	45	8	47
	Jhatikasahi	23	10	26
Karchabadi	Raldipanka	35	14	22
	Patulibandha	22	8	42
	Rajama	42	8	58
	B.Khajuripada	32	7	22