PROCEEDINGS OF THE TRAINING CUM CONSULTATION ON THE USE OF HYDROLOGICAL MODELLING AT THE SUB-BASIN LEVEL

BY

SOCIETY FOR PROMOTION OF WASTELANDS DEVELOPMENT, NEW DELHI

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R.R. FUNCTIONAL HALL, MADANAPALLE

1. Welcome by Nandgopal, Krushi Samstha

Nandgopal, Krushi Samstha welcomed everyone with a brief introduction of Rayalseema region and the existing water scenario. He stated that though various watershed programmes had been implemented in the region, including in Chittoor district during the last ten years, still there was a lack of an understanding as to how to assess water availability at a watershed or a sub-basin level. It was in this context that Krushi Samstha was trying to develop an understanding on the Pennar basin, with a particular focus on the Bahuda river sub-basin, when. SPWD came forward with support to jointly conduct a study on the Bahuda sub-basin in order to make interventions for ensuring equitable distribution of water through participatory water governance. He informed that field level work has already been initiated and the workshop is to share the model being followed and to get feed back on the same from participants having different experiences in their respective areas.

2. Background of the Consultation by Hardeep Singh, SPWD, New Delhi

Hardeep Singh, SPWD, initiated with a brief description on SPWD's involvement in the region. SPWD started working on tank- renovation in early 1990s in collaboration with partner organizations focussing on both the technical and the institutional aspects. The experience led to a better understanding on both the aspects but still there were number of unresolved issues especially on sustainability, equity and replicability. In the area where rainfall is erratic and the land-use in the catchment depends among other things on the rainfall, the management options need to be worked out based on rainfall dependability and a realistic understanding of land-use. Furthermore unit for the analysis has to be chosen carefully. Sub-basin of 20,000 to 50,000 hectare seems to be appropriate as it captures all the complexities of interconnected tank system alongwith groundwater issues, canal systems, and small watersheds etc. and is also not too big to handle. Moreover, there is a critical need to have some forum to discuss water governance issues at the intermediate (sub-basin including tank/canal command) level that can provide a much desired link between village and district level institutions. .

Hardeep Singh then discussed the conceptual framework behind the project. He said that various disciplines focus on different aspects of water management; engineers stress more on hydraulics and engineering design; economists on issues like cost-benefit analysis or rent seeking, maximizing profit etc. and management professionals on the performance of the WUAs. There is a need to work out a framework to develop an integrated understanding of the issues. It is important to understand how the characteristics of technology and the social organization determine each other. Understanding of a social structure and its interaction with human agency is a key to conceptualize capacity building aspect of the project.

He concluded by emphasising on the need and the importance of the project. He said that the idea was to bring technical and social relations together and there is a need to

conceptualise structure and agency so that our own understanding of these issues is good enough before talking to the people in various Departments. He added that the project has come up at a right time as even the tank management programme is going on and many of the organizations being part of it can help in establishing a forum. He hoped that based on a continuous information from the field, we should be able to come up with a concrete understanding of what is required to be done.

3. Presentation on Groundwater Modelling by Ramamohan, Center for World Solidarity (CWS), Hyderabad

Ramamohan started by referring to traditional neerganti system of water distribution and expressed his concern on the shift in the control of water distribution from people's hand to the irrigation department that eventually turned out to be inefficient and incapable of coping with complexities of water distribution.

Expressing his feelings on the situation of farmers he said that farmers cannot convey anything except for their demand. They cannot say about the quantity of water available, uses and wastage of water in the structure and hence are not in a position to talk on these terms. He wished that Society for Promotion of Wastelands Development (SPWD) and the local partners would take the understanding on water modelling and water distribution to the people, so that people get to know some basic technical know how on the use and distribution of water and can demand for better quality, scheduling, distribution and allocation of water. He introduced a tool related to groundwater monitoring emphasising on its importance but cautioning at the same time that the tool by itself does not help in solving any problem. The tool was in the form of a Microsoft Excel sheet. The first sheet was on the basics of the tool describing as to who can adopt it, in what situation one can use it, what is its applicability, what are the various assumptions etc. On its application, he mentioned that the tool can be effectively used for hard rock areas, pre-dominant groundwater areas, irrigated areas, but only for smaller areas between 500 to 1000 hectares. For calculation and specification on the tool, he explained that the only data required is the static water level and there is no need to measure rainfall or acquire data on cropping pattern, forests, topography etc. He stated that the output is in the form of groundwater budget (for monsoon, non- monsoon and the entire year), using two values: recharge and extraction.

On the social application of the tool, he said that it can be understood by all and stressed that it has to be used with some purpose to realize its value. He then focused on the use and emphasized that it can be used for understanding the status of the resources, plan the resource use in a better way and map the resources geology to find locations of structures to be made. Another point was to generate systematic information and the issues of equity, inequality, efficient and allocation. The tool also helps in decision making as it gives sufficient background of the natural resources and socio-economic conditions. He added that it can also be useful in conflict resolution over water issues with some technical information on groundwater availability.

The major application of the tool is to build awareness. People get to know how much groundwater is there. He cited an example of a project going on in Andhra Pradesh on social regulation in 4 villages of Rayalseema where people are measuring the groundwater availability and decide on the sharing of water. Many of the farmers not having well are supplied water by sharing of the existing wells and various small groups have been formed for water conservation. Another example on the application of the tool was to assess the claim from the competing demands of the urban areas from the available water of the Palar river (which originates in Karnataka and flows through Chittoor and then enters Chennai). Palar river in Tamil Nadu is a highly exploited basin. A lot of serious issues like industrial pollution, sand mining, pumping to towns and cities and excessive sand mining has killed the ecology of the river. There are series of wells in the bed of the river and pumping water to Chennai city. Because of this many nearby villages are facing serious problems such as drying up of wells. Often complaints have been made to the authorities but they have been ignored citing facts that Palar river has enough water. In the given circumstances he concluded that there is a need to have an understanding of the quantity of water available and the optimum duration of external pumping that would have no impact on local groundwater needs. This can be answered in a more scientific way and used by affected people.

Discussion

In the post presentation session, there were several questions and suggestions on the issue of groundwater model. Gangi Reddy came forward with a view that only one activity is not sufficient to improve water conditions. Retaining moisture in the sub soil is a major pre-requisite.. He raised questions on the nature of conflicts that have arisen among the farmers and asked the way to widely replicate the model. He also sought to integrate all other components of water management as a part of a solution to enhance groundwater scenario. Rama Mohan explained that the focus was on increasing access to groundwater without drilling wells. So, sharing of groundwater was considered as the best option. In this case, the recipient benefited but what benefit would the owner of the well get? If his neighbouring farmer comes with another well, then there is a danger to his well too and hence he allows water to be lifted from his own well. These are the crisis issues that have emerged among the group of farmers. As far as the issue of replicability is concerned, the whole package has become a very heavy one with lots of inputs required in the form of capacity building, attention, trainings etc. But because of the intervention of CWS, there are incidences of monitoring and measurement levels for groundwater resource; though it is a very recent phenomena.

Hardeep Singh queried on the applicability of the model at the sub-basin level and also enquired about the level of assurance with which one can state the percentage of rainfall that gets recharged? Rama Mohan replied that the model is not appropriate for application on a larger basin, but what could be done is that larger basins can be divided into small watersheds and then proceed with this methodology. He further stated that about 10-12% of the rainfall becomes recharge.

4. Presentation on Papagni River Uplands Project by Johnson and Diwakar, Foundation for Ecological Security (FES), Madanapalle

The presentation started with an overview of the river basin and FES' profile as an organization and as a facilitator. The second part dealt with the study that had been taken on the upper part of the basin at a place called Chintamani in Karnataka. FES studied groundwater scenario and based on that some case studies on watersheds have been conducted. The presentation dealt with a study whose focus was to develop a watershed as a model. The study was carried out in collaboration with the Advanced Centre for Water Resource Development and Management (ACWADAM), Pune.

Johnson, FES, started with the general description of the river basin. He elaborated that the Papagni river originates at the Nandi hills in Karnataka and the basin is spread over an area of 4.400 square kilometres. FES' foremost emphasis is on the environment, followed by institutions and communities and then the economy. FES' learning over two decades have been on the dynamic interaction that goes on between three major parameters: economy, ecology and social. He added that FES started its work with the commons as it believed that these constitute the physical, institutional and political space of the poor. FES believes that conservation and poverty alleviation goes side by side.

The study undertaken by FES on 'Mapping and Analysing the Development Context of the Papagni basin' was then dealt by Diwakar Reddy. He started with the scenario of water resources in the river basin mentioning that the average rainfall was highest in Kolar, Malur and Mulbagal talukas, whereas the dryland talukas in the north recorded the lowest rainfall. The study has analysed the spatio-temporal aspects of groundwater resources by monitoring the average water levels in wells, change in average water levels in wells, contribution of bore wells to irrigated area and contribution of open wells to the total irrigated area.

Diwakar then described the overall scenario of groundwater. There was a huge drop in the water table as inferred from the well-readings and the rate of fall in water table has accelerated over the period. Though the percentage net irrigated area is increasing, the other sources of irrigation are deteriorating. The tank irrigation is falling steadily because of siltation and encroachment. The open wells are drying up and as a consequence there is a massive rise in bore well irrigation. He attributed the causes of this trend to be both physical and socio-cultural. There had been no rainfall since 2002 and thus the tanks have been empty during the same period. Further, the presence of granitic rocks has accentuated the problem as recharge is very slow. The shift to water intensive crops like paddy and sugarcane, lesser time for water storage, domestic water demands from rural and urban areas and the industrial requirements of water in the basin has further intensified the problem. He suggested that drip irrigation, tank desiltation and rainwater harvesting could be crucial to prevent groundwater disasters.

Diwakar then gave the details of the areas where the study was conducted: Saragundlapalli and Gundlapalli. Both the areas have undulated topography and the average annual rainfall is 650 mm. As far the local geology, the main rocks in the study

area are the peninsular gneisses that are very old and hard with very less porosity. The basement rocks are also very hard but in some areas covered by clay or shallow hard rocks. There are cases where certain areas are good for recharge as there are dykes and intrusions which are excellent medium of recharge of water in the deeper aquifers.

The local geo-hydrology is influenced by the degree of weathering and occurrences of joints and fractures. The gaps formed by these features play an important role in the accumulation and movement of water in the sub-surface. The soils play an equally important role in the moisture holding potential.. The thickness and nature of soil changes from upstream to downstream, with dominance of clay in the downstream that is very suitable for paddy cultivation. But, the yield of wells located within this zone is very low as compared to that of wells in the red loamy soil.

Drainage analysis is very important as it gives an idea of permeable and impermeable zones and hence the infiltration capacity of the soils and the rocks. While conducting drainage analysis, the significant parameters are the number of streams, bifurcation ratio (which determines whether a stream is structurally controlled or not, i.e presence of more joints and fractures), basin area, total length of the streams and drainage density (to determine the texture of a drainage basin).

The study has also taken into account the land characterization of both the watersheds through analysing recharge and discharge zones. The middle portions and upper slopes of the watershed, where there were traces of joints and fractures, were recommended for recharge structures. The ground water balance has been worked out wherein input and output to the system have been equated by taking annual rainfall and water from external sources as inputs and groundwater pumped from wells, aquifer throughflow, recharge to deeper aquifers, evapo-transpiration and base flow contribution to streams as outputs. .

Finally, it was stressed that a hydro-geological audit is required to assess the impact of watershed on the water resource system as physical recharge measures may lead to increased water use and therefore to over exploitation. Most of the watershed projects have become useless because of absence of hydro-geological audit, check dams are constructed but there are no harvesting structures in recharge zones and recharge structures in harvesting zones. So, before beginning the work on watersheds, deep understanding of the hydro-geology of the area is required. This was suggested to be done through a systematic and long term monitoring of the water resources.

Discussion on Pani Panchayats: Diwakar then shared his views on Pani Panchayats, existent in Pune district of Maharashtra. It was started with the efforts of Vilasrao Salunkhe, the reasons mainly being the extreme drought conditions in Pune district during the 1970s, particularly in Pondhe area, which is very similar to the Rayalseema area of Andhra Pradesh. Though, the area is geologically suitable but rainfall is very less and the problem is further aggregated by the over exploitation of groundwater resources. So, a solution was sought by the government of Maharashtra and this was provided in the form of Pani Panchayats.

According to the Pani Panchayat principles, water is allocated on the basis of the family rather than on the basis of land holdings. He cited an example that a family unit of five members is given water right for the irrigation of one hectare of land, i.e. 1000 cum water per capita. Cropping pattern is also restricted to the less water intensive crops. All the beneficiaries of the irrigation scheme are required to bear 20% of the total cost of the scheme. This creates a condition where even a landless person can acquire some land for cultivation as water rights are for all. This proves the inclusiveness and equity in the Pani Panchayat principles. He reflected his vision of the replication of the similar activities in the Rayalseema area as the physiographic and socio-economic conditions are almost the same.

In the concluding remarks of the presentation, Johnson added that in the two watersheds undertaken by FES, the land characterization has taken into account the recharge and discharge zones. He explained that usually in a watershed programme, lots of construction activities take place, but it should be also ensured that informed decisions are taken on the construction of structures in the suitable zones. The integration of people's involvement should get the preference and only then can the social regulations come into the picture for better maintenance and conservation of water resources. He further clarified that with the experiences of Pani Panchayats, FES is progressing to implement its programmes in similar ways in its study areas.

Discussion

During the post presentation round, Gangi Reddy clarified some of the notions of the present times. He stressed on the fact that tank irrigation was falling steadily, and critically mentioned that earlier there were only one sluice gate on a tank but now, there are so many bore wells which act as the sluice gates of the tank. He alarmed that in future all the tanks would remain dead as has been witnessed in the last four or five decades, tanks have filled only once in a period of six to seven years. The lesser inflows cannot be attributed to low rainfall, rather degradation, maximization of evaporation and groundwater exploitation are the real reasons. He urged that unless we minimize groundwater exploitation and ensure the moisture content of the sub soil, the scenario is bound to worsen. Johnson further added that encroachment issue is also relevant because of water scarcity in the command areas of the tank.

Terming tanks as the 'lifeline' of the villages of Telangana and Rayalseema belt, Jilani said that generally tanks are very old structures, already silted and with less storage capacity. But as surface water is one major source and if it is not available above the ground, then what will be the source of recharge to groundwater? Secondly, he argued for the careful selection of watersheds for treatment as it is difficult if some unsuitable geological features are found on the recharge and discharge sites after spending lots of money and manpower. Diwakar clarified that these features should be studied only after selecting the watershed, the zones suitable for recharge and discharge. He mentioned that siltation is a big problem as silt is mainly clay and it does not allow groundwater to infiltrate. So, simultaneously the evaporation rate has been increasing, and storage

capacity of the tank and infiltration rate. He suggested that if desiltation is carried on, the problem will definitely ease.

Rama Mohan had a query on the concept of bifurcation index. He sought the differentiation between the higher and lower values of the index and their respective importance. He expressed his view so as to integrate this scientific aspect with the social exercises conducted for better results and cost-benefit ratios. Diwakar explained that with the help of toposheets, drainage analysis can be made which gives the groundwater recharge potential. Bifurcation ratio is a significant indicator of the drainage analysis. He then explained the various orders of the drainage basin and explained that the low bifurcation ratio reflects the lesser tectonically affected areas or not so suitable zones for infiltration i.e. these areas are suitable for constructing harvesting structures. Higher value of bifurcation ratio (usually more than 5) reflects that the area is affected by structural disturbances and contains more joints and fractures, i.e. suitable for recharge structures. He further added that a high drainage density reflects that the zone is not permeable and the surface streams are flowing over it whereas a low drainage density shows that the zone is permeable. So, accordingly they form suitable areas for recharge and discharge.

5. Training on Hydrological Modeling: SCS model and Haan's model by Amita Bhaduri and Hardeep Singh, Society for Promotion of Wastelands Development (SPWD), New Delhi

The training on hydrological modelling was conducted by Amita Bhaduri and Hardeep Singh of SPWD, New Delhi. The worsening scenario of water management and the ways to control it were highlighted in the backdrop of a complete absence of active institutions at the intermediate level. The need for developing forums at sub-basin level for evolving comprehensive understanding on both the technical and social aspects of the problem with a focus on finding practicable solutions to the problems was emphasised for making some contribution to the ongoing programmes and policy debates. The hydrological model developed by SOPPECOM 1 for this project based on its experiences was presented.

The presentation gave a basic introduction to the models in the Water Governance Project. For the hydrological analysis at the sub-basin level, the basic models are the SCS (Soil Conservation Society) model and the Haan's model and the purpose is to make the model an instrument of participative governance. In the note by Suhas Paranjape on "Robust Hydrological Modelling Options", it has been mentioned that there is a lack in the baseline regarding hydrology before the start of the watershed programme or even after its evaluation and it was in this context that the negative externalities of watershed treatment are talked about. The aim is to do a post facto analysis with the data (upto last 20 years) available from various departments: daily rainfall data from irrigation, revenue or meteorological departments. The other data required are slope, soil, land cover and cropping pattern. The data needs are simple and the exercise is amenable to advanced tools like remote sensing and GIS and mathematical modelling.

The hydrological cycle was discussed and it was noted that the project would rely on Tideman and on SOPPECOM's earlier work based on Datye's modified models of Haan which have been used in the, Jaisamand catchment/sub-basin study as well as in the Sabarmati study.

The following watershed related models were discussed under the first day of the training. The details of the models can be referred to in the Paper by SOPPECOM on "*Robust Modeling Options for Watershed Hydrology*".

i) Model I - SCS based runoff model for Indian conditions

A popular and simple model with low data needs was developed in the US and has been adapted to Indian conditions by Tideman through a modification of its parameters. This model can be very well used in small watersheds of about 500 hectares. The SCS model is based on a simple assumption that –

Actual retention/ Potential Maximum Retention = Actual Runoff/ Maximum Runoff

From here, the following relation can be derived –

$Q = (R-I_a)^2/[(R-I_a)+S\}$

Where Q is actual runoff, R is rainfall, I_a is initial abstraction during the period between the beginning of rainfall and beginning of runoff. All values are in mm. The relationship between I_a and S (maximum retention or storage) is $I_a = 0.2$ S [for US conditions]. Tideman modified this relationship according to Antecedent Meteorological Conditions (AMC) in Indian conditions – AMC I, AMC II and AMC III.

Relation of Ia and S for Indian conditions

Black soils region [AMC II and III) Ia = 0.1S

Black soils region [AMC I]	Ia = 0.3S
All other regions	Ia = 0.3S

The Antecedent Moisture Conditions (AMC) are classified by hydrologists based on 5 day total antecedent moisture condition which leads to different runoff producing conditions – low, moderate and high.

S is derived from CN (Curve Number), which in turn is tabulated on the basis of land-use and hydrologic soil-group. The Curve Numbers derived from the table (for AMC II condition) can be corrected for AMC I and III conditions (check Tideman for the table). The hydrologic soil groups A, B, C and D have been defined by Tideman based on infiltration rates. Gore's notes give an account of the simple soil testing methods, which can be employed in the field. Since different areas of the watershed have different curve numbers, a weighted average of the curve number is used.

S = 254 (100 – CN) / CN where CN = curve number; S = maximum retention or storage in mm depth.

ii) Model II - Haan Model

This is a four-parameter model for water yield from small watersheds. Here the soil moisture zone is considered to be composed of two sub-zones, the upper and the lower zone. The upper zone is the zone with moisture holding capacity of 25 mm. Evapotranspiration, infiltration, surface runoff and deep seepage are worked out accordingly as follows:

Infiltration
I = Im when R >= Im and Mu < 25 or Ml < Mc
I = R when R < Im and Mu < 25 or Ml < Mc
I = 0 when Mu = 25 or Ml = Mc
Where I = Infiltration rate; Im = Maximum infiltration rate; R = Rainfall; Mu = Soil Moisture in upper zone; Ml = Soil moisture in lower zone; Mc = Soil moisture capacity of lower zone

Evapotranspiration
Ea = Ep when R <= 25 and Mu <= 25
Ea = Ep(Ml/Mc) when R <= 25 and Mu = 0
Ea = 0.5Ep when R > 25 and Mu > 0
Ea = 0.5Ep(Ml/Mc) when R > 25 and Mu = 0
Where Ea = actual evapotranspiration and Ep = potential evapotranspiration (as worked by one of the standard methods). Evapotranspiration has been reduced by half on a rainy day because of cloud cover and low solar radiation.

Surface run off
Rus = R – I [where Rus is the direct surface runoff]

Deep seepage
Sd = Sm (Ml/Mc) [where Sd = deep seepage and Sm = maximum deep seepage]

Return flow
Rur = alpha.Sd [where Rur = return flow contribution to run off; alpha = parameter controlling fraction of deep seepage that returns as run off]

The model was developed considering the availability of daily rainfall figures. These can then be converted to a hypothetical hourly or even 6-minute rainfall figures based on standard storm distributions. This has been done for Type I and Type II storms in the US. There is a need to replace these with relevant patterns in Indian conditions.

Discussion

Post presentation, there were a number of queries and comments on the working of the models. Rama Mohan had a query on the value of 'S' and whether it changes every season. It was informed that the values of Curve Number (CN) and S will remain the same but initial abstraction will change. The project should not limit itself to mechanical calculation of all the aspects of the model but should focus on understanding concepts like initial abstraction (Ia).

Nandgopal further queried on the significance and reason of using this model. It was clarified that the model is used for assessing the run-off in the watershed. It is very important to know the water availability before constructing a harvesting structure. Further, understanding this basic model was quite significant to get a clear meaning of other models.

Diwakar Reddy had a query on the estimation of the upper and lower root zones in the Haan's model. Since the model has been developed taking into account the US conditions, where the technology is far more advanced and they can monitor these different root zones through sophisticated instruments, but for Indian conditions it is not possible to measure the daily variations in the root zones. This is one of the flaws of the model but with some modifications, the model has been run on Indian conditions also.

K.Sridhar further asked whether infiltration capacity varies according to soil types and land use types. The response was in affirmative and further it was added that it will depend upon the agricultural practices and rainfall also. Jilani then queried on the inclusion of slope aspect in the model, to which the response was that it would be taken into consideration in the other models to be followed in the training.

Rama Mohan wanted to know how the precipitation aspect is dealt with and if is it the base flow that is contributing to the return flow? It was clarified that the model takes into account only the rainfall and no other form of precipitation. Further, it is the interflow which contributes as the return flow. A further query was whether the modelling application is trying to find the present run-off or past run-off through the modelling application? The reply was that it is basically done to estimate the past inflows based on dependability and assurance. The interest is on yield and it would be interesting to see the day by day moisture content in the soil. This could be further matched with the scheduling of irrigation. Here, Rama Mohan suggested that irrigation scheduling does not depend upon the storage level of a reservoir. It was agreed that dams act as buffer storage. He further enquired if the tool involves community participation. The community participation and the level at which it was proposed for certain components of the study was clarified. Jilani responded that in some cases participation should be avoided for certain time to have a clear understanding.

6. Knowledge Sharing Discussion on Model of Farming by M.C.V. Prasad, President of Madanapalle Farmers Association, Madanapalle

The presentation was on an innovative method to sustain moisture in the top soil. Prasad informed that the model was innovated by Mr. Subhash Palekar of Amravati district in Maharashtra. He emphasized that the modern agricultural inputs, especially the chemical fertilizers has taken its toll on agriculture and particularly the top soil. All the organic content of the soil has been diminished. Soil is being transformed into a lifeless object.

He then elaborated that all the organic matter available in the nature can be used to enhance the humus content of the soil. He stressed that the Carbon-Nitrogen ratio (C-N ratio) is significant for better management of the soil. The C-N ratio in agricultural crops is 1:56. He further mentioned on the relevance of humus to enhance the water content in the soil. One unit of humus can hold almost 6 units of water and to make one unit humus, the nitrogen-carbon composition should be 1:10 units.

He further mentioned that mulching has the capacity of attracting moisture from the atmosphere and a farmer can relax freely if he practices mulching in his field even if the irrigation is not provided. He cited an example from Amravati district of Maharashtra, where sugarcane cultivation is commonly practiced. Wherever humus was given, the quality and production of sugarcane was very high in those patches. The reason being that moisture in the top soil comes from the atmosphere just above it. Thus, this model of farming works nearest to the nature. Another interesting fact was that livestock in the surrounding were reared because of dung and not for milk production.

7. Presentation on Experiences related to PIM in Karnataka by Dr. B.S. Bhawani Shankar, SAHAYOGA, Bangaluru, Karnataka

Bhawani Shankar began the session with a brief introduction to the history of participatory irrigation management and related issues in Karnataka. He began with the note that in the 1970s, at the initiative of the Central Government, state governments started establishing CADAs (Command Area Development Authorities) to improve utilization of potential created under the projects. This was the beginning of participatory irrigation management (PIM) in Karnataka. But soon after, the results were not satisfactory.

He discussed on his suggestion to the Karnataka Government as an advisor that the era of department's involvement in each irrigation project should come to an end. After retiring from the government services, he was interested more in working with the people, empower them, aware them of their responsibilities and rights and from here he started an NGO called SAHAYOGA, which was for people's empowerment in management of natural resources. Sahayoga held talks with various water user associations (WUAs) to find out reasons for their becoming defunct. It was noticed that under the co-operative act, the members were required to put shares and then some grants were given to the WUAs from the government. So, it became the business of the rich to influence water

distribution and access and ultimately it collapsed as there was no scope of equity. Later on, a seminar was organized that was attended by the Irrigation minister and farmers and all the issues were discussed in detail. It was recommended that unless the farmers are empowered adequately, there is no chance of survival and sustenance and not through the grants given by the government. Bhawani Shankar then mentioned that as a consequence, there were amendments in the Irrigation Act of 1876 and a law was made. It empowered the WUA to manage the distribution of water in the distributaries and minors of an irrigation system and freedom of cropping pattern was introduced. The WUA should decide on the cropping pattern with the quantum of water available. Citing example for varying tax rates for different cropping pattern like maize and sugarcane as their water requirements and values are different, he also added that the rate fixation can be done by the WUA as it may vary according to the prevalent cropping pattern.
He further elaborated on how an irrigation project is planned. Land surveys, land classification, crop suitability for the particular agro-climatic zone is found, crop water requirements are estimated through modified Penman's method (which takes into account the evapo-transpiration) are conducted and based on this, the cropping pattern is decided for all the distributary canals. So, water can be allocated for the entire command for different seasons.

He then stressed on the volumetric distribution of water mentioning that agriculture uses 70-80% of water but there is still no measurement of volume. This varies with individual farming practices and many of the irrigation projects do not give benefit to the farmers and are discredited. In 1986, Maharashtra set up the system of measurement of water on volumetric basis through V-notch on the distributaries. This enabled to measure the rate of discharge. It was not required so much during the rainy season as for the availability of water. In Karnataka also, the Irrigation Act specified for the volumetric distribution but has still not been implemented. Instead, the complete turn-over of the area under WUA was promoted rather than PIM that was to give full freedom to distribution of water, cropping pattern and fixing water rates. He then talked about the *Warabandi* system of irrigation in north India, where the topography is plain and the same system cannot be applied in south India because of the rugged terrain. On the issue of volumetric supply, he cited an example of Maharashtra which follows the *Shejpali* system and where the WUA has huge income by collecting money on volumetric basis and is hence financially secured. This system has been introduced in Karnataka also

He further dealt with the constitution of a minor irrigation committee. The committee reported for *Jal Samvardhana Yojana Sangha,* a registered Government society constituted to take up restoration of 2000 tanks in Karnataka and financially supported by the World Bank. So, with their involvement, all the WUAs under tank irrigation were under Societies Act, 1960. The reason being that under the Societies Act, the members are only to pay some nominal fees rather than putting shares as in Co-operative Societies Act. This enabled the inclusion of poor, landless and many other users of water under a tank system as the idea was to bring in a sense of ownership and belongingness to the facility.

Further, he shared the experiments in Karnataka and how the system developed. His view was that the programme should lead to turnover of the system itself. He mentioned that even though Andhra Pradesh started in a big way, it could not do this. Within 2-3 years it mushroomed all over and ultimately collapsed. Only Maharashtra has done very well. He then suggested to visit Waghad Project in Nasik district of Maharashtra where even the main canal is being managed by the farmers. He stressed that the farmers fill up the water during the monsoon and use the least when it is required in the rabi season. They have a community well in the village and no farmer is allowed to take the water from it as this belongs to the community. So, this way they conserve a lot of water in the Waghad project area. The impact is such that there are a number of associations on volumetric basis, then there are federations, from branch canals group of association which take and distribute water themselves and since they pay to the government on volumetric basis, they are more careful on the water use efficiency and in their area, they conserve the rainwater for various uses. They collect the water and circulate locally.

He further discussed the Groundwater bill. He mentioned that recently the government of India has introduced a draft Groundwater bill. The bill says that groundwater belongs to the community because aquifers spread beyond the boundary of the land. So, water below the land does not belong to anybody, rather it belongs to everybody. But, many of the states have not adopted this. He stressed that the maximum care should be taken to use the water and leave sufficient for the environment, and gave the case of uses in agriculture and industries emphasising on the water use efficiency. He also informed that the efficiency of irrigation is about 25-30% in our country, which could be raised to 60% through better practices and is being successfully done in Maharashtra. As a result, water availability for agriculture has increased.

Finally, he elaborated on the case of Maharashtra where the measurements are taken by the WUA during the irrigation season and based on the quantity of water used, the money is paid to the irrigation department.

Discussion

During the round of discussion, Gangi Reddy informed that the JSYS is a farmers-owned project and none of the political parties are interested in the Groundwater bill. Bhawani Shankar commented that the success of any project depends on the commitment of the officials heading the departments and units. He also urged to follow a bottom-up approach and emphasized on the concept of ‘think globally, act locally’.

Jilani further commented that in Maharashtra, the government is not allowing well and electricity in the command area. Bhawani Shankar replied that there is a huge wastage of electricity and all such are mainly the vote bank issues.

Hardeep Singh added that the intermittent flow with modular off take in Warabandi system in north India cannot be replicated in south India because of the difference in soils and water demands in both the regions. Bhawani Shankar added that Warabandi was

demanded everywhere as everybody wanted enough water through all means. This was promoted by the World Bank.

Further Eswara Reddy maintained that since a long time, good irrigation systems have been maintained by the people themselves. But political dynamics in the current era has changed the whole situation. Though water is released to the canals every year, tanks get water once in three-four years. So, how to go as a technician to revive the existing conditions. Bhawani Shankar replied that in no irrigation project, operation plan is taken into consideration. The advancements of agricultural technology and various inputs in the same are not understood by the farmers. This has created a big mismatch.

8. Presentation on Community Groundwater Management under APFAMGS Project by K.Sridhar, APFAMGS

The presentation began with an introduction that the Andhra Pradesh Farmer Managed Groundwater Systems has taken a Nationally Executed (NEX) Project of FAO in 2003. This has been implemented in the state of Andhra Pradesh, operational in those areas which are characterized by continued decline in groundwater levels and which has left impacts on the people's life, agricultural practices and environment. The implementation is done through a federation of nine NGOs.

He further elaborated on the effects of depleting groundwater by stressing that groundwater depletion has serious consequences far beyond science and technology issues. Social, economic, livelihoods, environment, quality parameters are equally affected, whereas women and children become the silent victims. This project is an enabling intervention for reinforcing the internal strength and coping mechanism of farmers to explore and find out stable solution to the issues of ground water depletion and its adverse consequences.

The project approach was then clarified saying that the project integrates scientific technology with social transformation, women's economic empowerment through institutional change. He then specified on the people's institution where institutional intervention is integrated with technical component for managing groundwater depletion. A multi layer inclusive institution that is vertically integrated has been thought of in the project. Further, Ground water Management Committee (GMC) has been conceived to be a village level institution of the farmers-men and women. Several GMCs within a given hydrological boundary join together to form a Hydrological Unit Network (HUN). Regarding the methodological aspect, he mentioned that institution building is to be done at the habitation and hydrological basin. Participatory hydrological monitoring would be done through the GMCs. Then for crop water budgeting, farmer field schools would be emphasised and non formal education techniques for demystifying groundwater science. Gender mainstreaming would be another major component of the methodology.

The presentation then shifted its focus to various components of the project. Access to data placed the powerful scientific information in the hands of users who appreciate the

utility and take corrective actions to ensure sustained water use. He stressed that the idea of involving farmers in generating technical data solved the problem of extrapolating non representative data for understanding the local system. In a similar fashion, Crop Water Budget exercises are being carried out annually. CWB has been completed for 3 hydrologic cycle in 10 HUs, twice in 38 and once in 59 HUs. Again, Farmer Field Schools approach has been adopted for promoting group learning aimed at improving skills and knowledge amongst the farmers. Farmers meet once every 15 days [June–May] to discuss groundwater resource availability, appropriate cropping system matching water availability, organic farming, water use efficiency, using the people's institution to act as pressure group, gender role in water sharing, crop planning and issues on HIV/AID's affecting the farming sector.

He further informed on the skilled human resources that the APFAMGS Project could create a huge skilled human resource in 650 habitations, covering 62 Hydrological Units (HUs), in seven drought prone districts of Andhra Pradesh. The community based institutions organized for the purpose are now geared to take on the task of groundwater management. The project also has strong gender interface, keeping the practical and strategic gender needs at the core as gender in the project, occupies a cross cutting space encompassing all the components and processes.

Later on in the presentation he discussed the impacts of the project in the area in the form of integration of scientific technology with social transformation and general change issues (non technology), change in the perception of groundwater, introduction of scientific literacy to farmers, internalizing all learning's to apply in decision making, reduction of losses from failure in irrigated crops, increased profits from diversified cropping, change in cropping pattern from water intensive to water efficient crops, increased efficiency of water application, reduced migration and emerging leadership amongst women.

Finally, he concluded by expressing his views on the project while stating the various crucial outcomes like integration of the project learning's with new programmes, strategies interface and alliances, enhancement of gender role and sharpening of the institutional framework, dissemination of the project learning's to larger audience-national and global, interface with global level civil society, synthesizing documentation for different audiences, in-depth economic and income analysis and marketing agriculture produce through linkages with emerging markets.

Discussion

During the post presentation session, Rama Mohan asked on the process through which the pumping efficiency is being enhanced through this project. He mentioned that the initial calculation of the pumping efficiency is done through the data collected by the farmers. The bore wells were very deep during the initial period and high power pumps were required but gradually there was increase in the water level and this has enhanced the pumping efficiency in the area. Farmers are being encouraged to chose crops that need lesser water, so that groundwater pumping is reduced. For e.g. in many areas,

farmers have stopped paddy cultivation in rabi season and so with sugarcane as these are highly water intensive crops. And as an input, farmers are adopting water conservation practices of farming like mulching etc. Earlier, the bore well owners did not have the idea on water levels but now with the awareness level, they are more cautious in water use.

Nandgopal asked on the equity issue that is being dealt in the project. It was informed that majority of the medium and small farmers are involved in generating the data and later on using them, they are collectively conserving the groundwater. Gangi Reddy then asked if there is any plan to retain the impact after the completion of the project. Sridhar mentioned that farmers have been taken by various government departments as resource persons in their programmes. The project aims to be self regulatory and self sufficiency in future.

9. Knowledge sharing discussion on Soil Moisture Conservation by Gangi Reddy, CHAITANYA

Gangi Reddy stressed on the events and situation of the environment in a comparative way through this discussion. He admitted that man has done enough damage to the environment. He stressed that though we cannot remake the lost rivers, tanks and forests but we can reverse the process of desertification.

He raised a question to the audience if we can afford to sustain with the yearly rainfall that takes place and whether it is enough or not? He said that around thirty years ago, it was enough because of the situation of the soil moisture. The sub soil moisture was saturated and every drop of excess water used to flow adequately in the hydrological cycle. There were practices like mixed cropping pattern, use of manures and other organic products etc to minimize the evaporation. He emphasized that nature functions in a very self sustained way. With tree roots in the moisture saturated zone, evapo-transpiration was high resulting into higher humidity and cooler climate. So, even in the rabi season, crops like jowar, coriander, grams etc sustained through the atmospheric humidity. Contrary to that situation, the present time shows the opposite trends. There is lesser moisture in the soil, wells have dried up, water level has decreased and other crucial aspects like loss of trees etc. As a result, there is lesser humidity, no rhythmic rainfall and reduced flows to the rivers.

He showed the rainfall trends from 1960 to 2000 and pointed out that though there is not much variation, why is there a change in the moisture level of the soil? He answered that it was because of the increasing level of dryness in the soil. He criticized various programmes on watersheds as the basic cause i.e. how to create water in the watershed is not being looked after. He then suggested two immediate remedial measures for changing the present scenario of reduced soil moisture level in any hydrological unit: decrease the rate of evaporation and decrease in the groundwater use.

Finally, in his presentation he urged on protecting the moisture of the top soil by practices like mixed farming so that some crop cover is there even during the summer months to retain moisture and efficient ways of using groundwater. He emphasized that this is a

better solution while dealing with the problems of climate change, global warming, water loss or even the suicides by the farmers and this can make dryland agriculture successful.

10. Presentation on Promoting Livelihood Improvements in Dryland Farming on the Deccan Plateau by Ram Prasad, AMEF, Madanapalle

AMEF started the presentation with a brief introduction to the project and the study area. It was informed that the project operated in eleven mandals of the Chittoor district. The rainfall pattern, soil, crops, and irrigation facility was then described. With this background, the work profile in the project area was mentioned which included the cluster villages and the influence of rainfall on sustainable agriculture (SA) promotion.

The presentation then focused on the methods and techniques of the land use practices for better natural resource management particularly in case of groundnuts and tomatoes. After this, the focus of the presentation shifted to the capacity building aspect of the staff and the farmers. The major highlights of these were cropping systems and IPM methods. Involvement of farmer facilitators (FFS owner ship), sharing and solving of problems among themselves, trying out different experiments in other crops (e.g. Azolla in paddy, raised beds in cabbage, spot application & INM-IPM-Tomato), skills up gradation (like facilitation, observation, analytical decision making) and collective action on rabi groundnut seed production and biomass nursery were some of the highlights of the capacity building exercise.

It was revealed that the varietal trials on groundnut, paddy, and tomato revealed some specific learning on each of the variety and an outcome was expected from these. This was followed by a case of a tomato farmer where the cost implications of an eco farmer and a control farmer were compared. The finding suggested that an eco farmer spends much less money and inputs for the same quantity of agricultural produce and hence makes a lot of savings in his investments, apart from being very sustainable.

The presentation then dealt with the activities to sensitize the community that include cluster villages at EFB, field days, sharing events, SA orientation to farmers, SA exhibition, village interactions, training to NGO network farmers and observing world food days. He then described how various departments have been engaged in the multi faceted programme by involving themselves in seed production, fodder varieties, watersheds, bio fertilizers, trainings etc. Further, at the end it was mentioned that the whole programme has been documented in a variety of ways like quarterly periodical reports, training manuals, workshop proceeding and training reports, field boards etc and through which this is being disseminated.

11. Training on Hydrological Modeling: Datye Sabarmati model and Modified Haan's model with critical rainfall by Amita Bhaduri and Hardeep Singh, Society for Promotion of Wastelands Development (SPWD), New Delhi

Model III - Datye Sabarmati Model

The Haans model has been simplified on some accounts and enhanced on other accounts in by Datye under the Sabarmati study. The two zones have been eliminated and have been treated like a single zone. Average infiltration rate has been used instead of maximum infiltration rates. Infiltration takes place irrespective of the soil moisture in a sequential manner where deep seepage takes place only after soil moisture has reached its capacity in the root zone.

Infiltration
I = Iav when R >= Iav
I = R when R < Iav
Where I = Infiltration rate; Iav = Average infiltration rate and R = Rainfall

Evapotranspiration
Ea = [Ma/(1-p)Mca]Ep
where Ea = actual evapotranspiration; Ep = potential evapotranspiration = Kc.Eto; Kc = crop factor; Eto = Maximum evapotranspiration for theoretical crop; Ma = available soil moisture in the soil zone; Mca = maximum soil moisture available in the soil (at field capacity); P = parameter denoting fraction of available moisture required to be present for Ea to equal Ep and the rest are as defined earlier

Surface run off

Rus = R – I

Where Rus is the the direct surface runoff

Deep seepage
Sd = I – delta M
Where Sd = deep seepage; delta M = change in soil moisture storage in the root zone

Return flow
Sd = Rur + Gwr + Ia
Where Rur = return flow contribution to run off; Gwr = Groundwater recharge; Ia = Initial abstraction of moisture to compensate for loss of moisture from the entire soil during the non-crop period.

Model IV - Modified Haans model with critical rainfall

Analysis of hydrological aspects will be done by using the Modified Haans model with critical rainfall. This exercise will classify the outflows from a water balance domain into various categories to provide information on the quantity of water depleted by various uses, and the amount available for further use. The model is based on a modification of the Haans model by defining a critical daily rainfall parameter as a proxy to maximum or

average infiltration rates. The critical daily rainfall parameter combines the various watershed characteristics like relief, soil infiltration, vegetal cover and surface storage. The addition of the contributions gives us a coefficient that is utilised to estimate critical rainfall. The infiltration and evapotranspiration can then be calculated as:

Infiltration
Rc = 25 + 50 (1 – W/100);
where Rc + Critical rainfall; W = Composite Cook's factor. Infiltration takes the value of rainfall or critical rainfall whichever is less.

Evapotranspiration
*Ea = Ep * [Ma/ (1-p) Mca],* when R < Rc
Ea = 0.5 Ep [Ma/(1-p)Mca], when R >= Rc

Ea = actual evapotranspiration; Ep = potential evapotranspiration; Kc = crop factor; Eto = maximum evapotranspiration for theoretical crop; Ma = Available soil moisture in the soil zone); Mca = Maximum soil moisture available in the soil zone (at field capacity); p = parameter denoting fraction of available moisture required to be present for Ea to equal Ep

Surface runoff
Rus = R – I;
where Rus is the direct surface runoff

Deep Seepage
Sd = I – delta M;
where Sd is deep seepage and delta M is change in soil moisture storage in root zone.

Return flow
Sd = Rur + Gwr + Ia
where, Rur is return flow contribution to runoff; Gwr is groundwater recharge and Ia is initial abstraction of moisture to compensate for loss of moisture from the entire soil during the non-crop period.

Hardeep Singh clarified that the basic idea is of conducting a training where meaningful dialogue could take place. He said that the models can be discussed with all the participants and others interested during the period of the project and visits to the place. He then added that the general idea is to know and understand the different parameters of the project. It was said that handouts with examples and applications of the model will be circulated later on during the project period. Nandgopal suggested and encouraged everyone to share their ideas collectively for better advocacy as it is very difficult to influence people and bring immediate changes. Gangi Reddy suggested that government departments should be involved in such trainings which was well supported by Hardeep Singh.

List of Participants

Sl.No.	Name of the Participant	Organisation
01	N.Ram Prasad	AME Foundation, Madanapalle
02	K. Sridhar	APFAMGS, Hyderabad
03	G.Balaji	APFAMGS-GVS, Madanapalle
04	P.Gangi Reddy	Chaitanya, Lepakshi
05	P.Srujana	Chaitanya, Lepakshi
06	B.Chandramohan	Chaithanya, B.Kothakota
07	R.V.Rama Mohan	CWS, Hyderabad
08	N.Eswara Reddy	DPU, Chittoor
09	Ravi Niwash	FES, Madanapalle
10	Santosh Kumar Patnaik	FES, Madanapalle
11	P.Diwakar Reddy	FES, Madanapalle
12	Johnson Topno	FES, Madanapalle
13	S.Nagaraja	Gandhian Organisation for Rural Development, Chittoor
14	S.Balaji	Krushi Samstha, Madanapalle
15	K.Venkatesh	Krushi Samstha, Madanapalle
16	U.Sudhakar	Krushi Samstha, Madanapalle
17	V.Nandgopal	Krushi Samstha, Madanapalle
18	Jayalakshmi	Krushi Samstha, Madanapalle
19	M.C.V.Prasad	Madanapalle Farmers Association, Madanapalle
20	S.Jilani	MARI, Warangal
21	N. Sreedhar	Movement for Rural Emancipation (MORE)
22	D.V.Sagar	Movement for Rural Emancipation (MORE)
23	B.Ramamurthi	Movement for Rural Emancipation (MORE)
24	A. Swarna Kumari	Movement for Rural Emancipation (MORE)
25	A.Prasad	Movement for Rural Emancipation (MORE)
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27	K.Ramesh	Movement for Rural Emancipation (MORE), Madanapalle
28	A.Narayana Reddy	Rural Integrated and Social Education Society (RISES), Anantapur
29	S.S.Ramanatha Rao	Sahayoga, Bangalore
30	B.S.Bhawani Shankar	Sahayoga, Bangalore
31	Hardeep Singh	SPWD, New Delhi
32	Amita Bhaduri	SPWD, New Delhi
33	Surya Prakash Rai	SPWD, New Delhi
34	Alisha Vasudev	SPWD, New Delhi