Understanding economics of groundwater use

MG Chandrakanth, Professor and University Head, Dept of Agri Economics, UAS Bangalore

Dear RAWE 2013 students: First visit this site [https://waterforward.charitywater.org](https://waterforward.charitywater.org/et/wwHsVPO6?c=1)

to understand how important is water for every body, but how we do not realize this.

In the course of the first week of July 2013 when all of your RSK sub-batch leaders made a presentation in Ag Econ Rawe classes, more than 80% indicated one major problem, relating to groundwater scarcity. Pl give some time and heart of yours to understand, appreciate the complexity of groundwater extraction, recharge and utilization in hard rock areas. Remember Kolar district and surroundings including 65% of geological area of India are classified as Hard Rock Areas where the recharge of groundwater from rainfall is below 10%. For example observing rainfall from 1951 to 2007 in Bangalore, August receives rainfall of 137 mm but the range can be from 24 mm (as in 1984) to 274 mm (as in 1998). What is important for us is to find the rainfall per rainy day which can be around say 2 to 8 mm[[1]](#footnote-2), but most of the times, average rainfall per day lies between 2 and 5 mm. For instance if we receive a rainfall of say 5 mm, let us find out how much water is on one acre of land. Since 10 mm = 1 cm, 5 mm = 0.5 cm = 0.5/100cm = 0.005 meter. One acre of land = 4000 sq meters. Therefore, 0.005 m X 4000 Sq meters = 20 cubic meters. One cubic meter of space has 1000 litres of water. Therefore 20 M3 = 20,000 litres of water = 20,000/4.54 = 4405 gallons = 4405/22611 = 0.19 acre inch. What does this mean? Since Kolar farmers are using drip irrigation, one acre, with 200 feet X 200 feet area, with drip irrigation emitting point running every one foot, and so in every drip pipe, there is a drip discharge every 1 foot, there are 200X200 = 40,000 drip points. If, each drip point emits around 0.5 liter per hour, then this amounts to 40,000 X 0.5 liter per hour = 20,000 liters. Thus, rainfall of 5 mm in Kolar on a rainy day means the farmer receives around 20,000 litres of water, with which farmer can drip irrigate or flow irrigate his / her crops may just be sufficient to irrigate 1/10th acre of land = 4 guntas from drip irrigation or 2 guntas by flow irrigation depending upon the crop cultivated. In kolar, considering the data for 100 years, looking at the trend profile, the Jun- Jul- Aug- Sep rainfall is increasing, annual rainfall is also increasing, number of days with rainfall of 10 to 80 mm is increasing. You can get this detail for any village. Just go to an excellent website <http://www.test.knowyourclimate.org/>, type the village name , say Jangamkote or sulibele, you will get average rainfall, monthly, daily, including trend (you need to navigate this website).

How much rain water gets collected on your toop tops?

If your roof area is 20X 30 feet in 30 feet X 40 feet site = 600 sq feet = 600X0.0929 = 56 sq meters. If you receive 800 mm of rainfall (Bangalore approximate), you can collect around 32 cubic meters = 32000 litres per year. With a Per capita water is 50 litres per day X 365 X 4 persons (in a family) at home = 73000 litres. Hence at least 50% of our water needs can be harvested by rainfall roof top harvesting. Remaining 50% can be from cauvery if available. Ready recokner from CGWB GOI. Obviously 60X40 feet site gets collected 64000 litres and gives you the most water from rainfall which almost fills water needs of a family per year.



Note: one cubic meter = 1000 litres of water

Average rainfall pattern in RAWE villages of 2013 batch of students

I BATCH

<http://www.test.knowyourclimate.org/climateProfile> SULIBELE RAINFALL

<http://www.test.knowyourclimate.org/climateProfile> JANGAMKOTE RAINFALL

<http://www.test.knowyourclimate.org/climateProfile> NANDAGUDI

<http://www.test.knowyourclimate.org/climateProfile> JADIGENAHALLI

II BATCH

<http://www.test.knowyourclimate.org/climateProfile> BETHAMANGALA

<http://www.test.knowyourclimate.org/climateProfile> KAMASAMUDRA

<http://www.test.knowyourclimate.org/climateProfile> BUDIKOTE

III BATCH

<http://www.test.knowyourclimate.org/climateProfile> VEMGAL

<http://www.test.knowyourclimate.org/climateProfile> HOLUR

IV BATCH

<http://www.test.knowyourclimate.org/climateProfile> Narasapura

<http://www.test.knowyourclimate.org/climateProfile> Vokkaleri

<http://www.test.knowyourclimate.org/climateProfile> TEKAL

V BATCH

<http://www.test.knowyourclimate.org/climateProfile> Anugondanahalli

<http://www.test.knowyourclimate.org/climateProfile> Masti

<http://www.test.knowyourclimate.org/climateProfile> Lakkur

Want to know more technical details about groundwater?

1. Preliminaries of groundwater by IIT Kharagput <http://www.youtube.com/watch?v=yodHMzUx2V4>
2. In the following you tube videos you will appreciate how complicated is groundwater hydrogeology – it requires a lot of maths to understand and appreciate.

<http://www.youtube.com/watch?v=dlVyCMT6oxY&list=PL5CD1E81758EAE411> Part 1 :one hour video on Groundwater by IIT Kharagpur – highly technical on groundwater flow

1. Pl watch this video from the 45th minute, to find how much is the flow of groundwater and the formula to determine the same

<http://www.youtube.com/watch?v=NOnJ604RCe4> Groundwater flow Part 2: one hour video by IIT Kharagpur

<http://www.youtube.com/watch?v=sH8XmG1Bvz8> recharging groundwater, a simple video, very educative

<http://www.youtube.com/watch?v=25sWFuAYSVc> Understanding groundwater

1. borewell recharge in chamarajanagar 220 wells benefited drinking water supply : <http://www.youtube.com/watch?v=6dP9oNVLAyA>

<http://www.youtube.com/watch?v=5cR6hlXguIA>  
<http://www.youtube.com/watch?v=XHIudmFJThA>  roof top harvesting system

1. Endoscopy (how borewell looks inside)

<http://www.youtube.com/watch?v=6lVTPhsvp38>  how water exists in fissures and fractures in hard rock areas of Bangalore you can see groundwater percolating at 180 feet

<http://www.youtube.com/watch?v=wriPMjNKKIQ>  how drop by drop water collects in borewell,endoscopy of a borewell

<http://www.youtube.com/watch?v=QQLr-aXmq5s>  borehole inspection

<http://www.youtube.com/watch?v=23ElT84dZc8>  how borewell looks inside

<http://www.youtube.com/watch?v=N5fwgSgqatw> endoscopy of a borewell - you can see where groundwater is located

Saptapadi in understanding groundwater use for irrigation

     In this note, let us make a modest attempt to make our farmers and policy makers understand and appreciate how important our groundwater resource is, especially of interest of farmers / consumers in hard rock areas of  India, which form 65% of the country's area. In Karnataka, hard rock forms 99% of state area. What is important for the farmers is to note that the recharge to groundwater from rainfall is hardly 10% in hard rock areas. Specifically this means that if we receive a rainfall of 750 mm, only 75 mm is the natural recharge and the rest drains away. Let us attempt to analyze the complexity of groundwater recharge further using basic arithmetic.

One acre of land is 4000 square meters. Say this land receives a rainfall of around 750 mm per year which is roughly the rainfall in the Eastern dry agroclimatic zone. Let us now find how much of this rainfall actually contributes to groundwater in relation to how much we pump for our irrigation through the saptapadee lessons.

Step 1: Convert 750 mm to meter using 750 mm = 75 cms = 0.75 meter

Step 2: Multiply the rainfall of 0.75 meter with 4000 sq meters of land which received that rainfall = 0.75M X 4000 Sq M = 3000 cubic meters

Step 3: One cubic meter is = 1000 litres of water. Therefore 3000 cubic meters = 3000000 litres of water

Step 4: one gallon of water = 4.54 litres. Therefore 3000000 litres of water =  660793 gallons

Step 5: Therefore 660793/22611 = 29 acre inches given 1 acre inch = 22611 gallons of water

Step 6: Thus, 1 acre with 750 mm of rainfall will have received 29 acre inches of rainwater. But only 10% enters as groundwater = 2.9 acre inches

Step 7: One irrigation well roughly extracts around 100 acre inches of water. This irrigation well may be serving say 3 acres on an average.  Thus, for three acres, the total recharge is say 2.9 acre inches X 3 acres = 8.7 acre inches or approximately 9 acre inches. Thu, by contributing hardly 9 acre inches of water, towards recharge, farmer is pumping out 100 acre inches of water per well on an average every year leaving a gap of around 91 or say approximately 90 acre inches to be recharged by other areas consciously or unconsciously.

So what are the Spatha Padee measures  for our farmers and policy makers?

Step 1 .We need to educate that a farmer withdrawing around 100 acre inches of groundwater from one irrigation well, is in fact getting groundwater from at least another 30 acres of land, since each acre recharges only around 3 acre inches of water per year.

Step 2:  Unless groundwater recharge programs are undertaken on a massive scale, groundwater wells will face premature, / initial failures. And as these cannot be borne by small and marginal farmers, they continue to suffer due to lack of access to groundwater. Thus we need to educate and encourage the farmer to have groundwater recharge structure for his/her borewell on the farm by proper training and giving incentives. In addition, we can give benefits from different governmental programs to only such farmers who adopt groundwater recharge methods as given by experts in agricultural engineering.

Step 3: Draw lessons from the studies in the Dept of Agricultural Economics, UAS Bangalore funded by the Ford Foundation since 1995 till 2005. These  indicate that (1) probability of well failure in eastern dry zone is around 0.4; (2) open wells/dug wells have virtually vanished due to the advent of deeper  borewells over time (3) the amortized cost of groundwater per acre inch ranges from Rs. 300 to Rs. 400 without considering electricity cost (4) To lift one acre inch of groundwater, the electricity cost is around Rs. 100, which implies Rs. 10,000 per year per well for 100 acre inches (5) The total cost of groundwater inclusive of electricity ranges  Rs. 400 to Rs. 500 per acre inch or per ha cm. Usually an acre of paddy needs about 40 acre inches, vegetables need half of paddy 20 acre inches, ragi and millets need about 1/4th of paddy, 10 acre inches, if water is used as flow irrigation. For drip irrigation, savings are higher to the tune of say 30 to 35% depending upon whether we use subsurface or surface drip irrigation. Precise estimates however are still needed from research as it also depends upon the extent of evapotranspiration.

Step 4:  What are the implications? (1) Our farmers and our Government, if they are really concerned about the precious and scarce groundwater should first think whether it is ethical for them to cultivate paddy / sugarcane using groundwater? (2) If they still decide to cultivate, they should realize that they are in fact using (40 acre inches X Rs. 500 per acre inch =) Rs. 20,000 worth of groundwater for every acre of paddy they cultivate and double that = Rs. 40,000 worth of groundwater for every acre of sugarcane they cultivate. These costs may vary for other parts of Karnataka, but still they may not vary substantially, since 99 % of Karnataka's aquifers are hard rock aquifers and the situation is alarming. Thus, instead of cultivating paddy and sugarcane using groundwater, they should think of low water crops which are even more economically viable than these two water giant but low

profit crops.

Step 5:  What is the solution? Farmers should realize that they are drawing a precious resource more than gold (since gold cannot be consumed) and hence use the groundwater in such a way that they make a 'wise' use rather than 'beneficial' use (as Ciriacy-Wantrup puts it). This means, farmers can use groundwater not for paddy, not for sugarcane, but for other crops, but not through flood or furrow or surface irrigation, but through micro or drip or sprinkler irrigation.

Step 6: The Government has virtually no scheme or program towards Irrigation Extension. They only have agriculture extension by the Agri /Hort Departments. Even Agri Extension efforts are dwindling since 'Gramsevaks' have vanished from Karnataka. The Government can make use of our Agri Engineering graduates including Diploma in Agri Engineering graduates by offering them hands on training in groundwater, linking them with the Dept of Mines and Geology which handles Groundwater. The Government must offer benefits from Developmental programs to only those farmers who comply with disciplined groundwater use such as benefits from different Governmental programs such as subsidies from Agri Dept / Horti Dept, and all other schemes. The disciplined groundwater use needs to be certified by the Agri Engineering graduates / diploma holders who are certified as trained, and cross checked by Agri Dept officials including Dept of Mines and Geology.

Step 7: India is the largest pumper of groundwater in the world, pumping twice that of the USA and 6 times that of Western Europe. India has the largest number of irrigation wells being 25 million pumping around 75 acre inches of water per well. At present, groundwater resource is meeting 80% of the irrigation needs of India, while surface water meets the balance 20%. Even with the Dept of Mines and Geology, Irrigation Department, Minor Irrigation Department, BWSSB, Urban water supply Board, and all the laws such as Irrigation Act of 1965, Karnataka land reforms Rules of 1974, and the latest Groundwater Regulation and Control Act of 2011, groundwater resource has been treated as an 'orphan' since there is no agency to practically conserve (like Forest Department which exclusively deals with forestry). Dept of Mines and Geology is more concerned with Mines, since minerals are more 'valuable' than 'groundwater'. The state should develop a body (though it has initiated the Groundwater Regulatory Authority, with little teeth at ground level) to effectively address groundwater resource use similarly to how it addressed 'Agriculture' during the 'Green revolution', educating and creating awareness among farmers, measuring groundwater use using water meters (not electrical meters) and helping the farmer to understand the true value of groundwater so that s/he will use it efficiently, effectively, sustainably.

**Understanding Bangalore’s Climate – What’s with all the rain?** <http://www.chikyu.ac.jp/precip/> website from Japan has information on Bangalore rainfall !

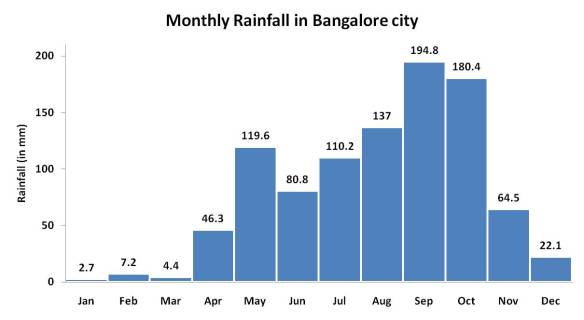
[**August 18, 2011**](http://greengovernance.wordpress.com/2011/08/18/understanding-bangalore-climate-1/) by [**Pavan Srinath**](http://greengovernance.wordpress.com/author/boregowda/)

This past week, Bangalore received copious amounts of rainfall on consecutive nights.  A heavy spell of rainfall with **76 mm** of precipitation was recorded in the city starting on August 15th night. There was more rain on the following day, with Bangalore receiving another **38 mm** of precipitation.  (You can take a look at the data yourself [here](http://www.imdaws.com/ViewAwsData.aspx).) On average, Bangalore receives **only 137 mm** **of rainfall in August**, which means that with the two days of rainfall, Bangalore has already exceeded the month’s quota of expected rainfall! (with 144mm).

What does this mean? Do we truly have a freak set of rainfall set on our hands? Or can this be normal even when it doesn’t agree with the average numbers? This post aims to make sense of rainfall and variability in Bangalore.

**Understanding the Basic Climate Profile**

Let’s start by trying to understand the basic rainfall profile of Bangalore. On average, Bangalore receives 970 mm of rainfall in a year.

[](http://greengovernance.wordpress.com/2011/08/18/understanding-bangalore-climate-1/monthly-rainfall-in-bangalore-city/)

The graph above shows the average monthly rainfall distribution for Bangalore city. ([source](http://mausam.gov.in/WEBIMD/ClimatologicalAction.do?function=getStationDetails&actionParam=1&param=2&station=Bangalore)). One can notice two “peaks” in rainfall received, a large peak around September: the primary monsoon season; and a secondary peak in May: which represents Bangalore’s summer showers.

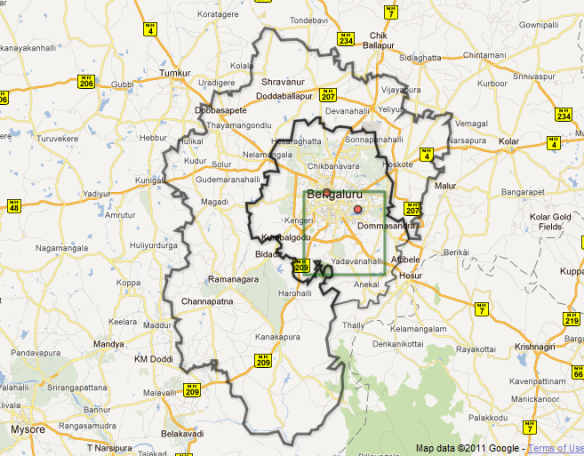
**Average rainfall doesn’t tell us much!**

Now all this is fine and factually quite accurate, but averages and monthly “expected” rainfall values tell a very incomplete story. The Indian Met Department loves to talk about “expected” rainfall quantities and  whether the actual rainfall received was in deficit or excess. Read any of their daily, weekly or monthly reports meant for direct government/news agency/public consumption, and the story is the same. The devil, as it happens, is in **climate variability**. Every year, in all parts of India, there is**natural and inevitable deviation from the average** rainfall quantities. Some months are higher, some lower, heavy showers happen in the first week of a month in one year, the last week in another. It is only when you see a weather event that goes beyond the expected range of variation that it becomes an “extreme” weather event.

Let’s explore this with the rainfall in Bangalore from last week: just how special was such a high rainfall event? To understand that, we first need to understand how monthly rainfall varies naturally year on year.

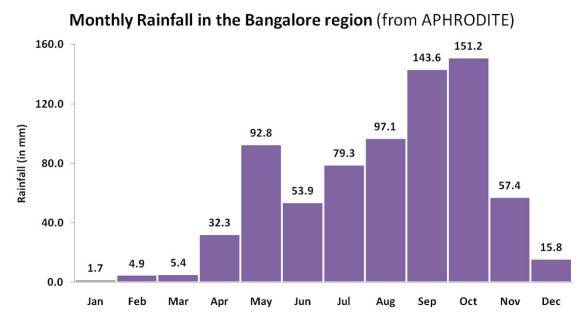
**Getting Data for Analysis**

The [Research Institute for Humanity and Nature](http://www.chikyu.ac.jp/index_e.html), Japan have developed an excellent[gridded database of 50 years of daily rainfall](http://www.chikyu.ac.jp/precip/) covering all of South Asia, called **APHRODITE**. (It’s available for free download, but be warned: file sizes are huge and you need programming skills to extract data out of it).

[](http://greengovernance.wordpress.com/2011/08/18/understanding-bangalore-climate-1/bangalore-weather-stations1/)

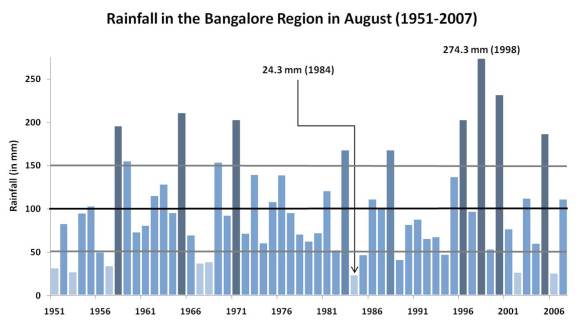
**So what do the numbers say?**

Before we can blindly trust all the results that this new source of data tells us, we need to check if the numbers match up to what we already know. Below is a graph of the monthly average rainfall values. APHRODITE provides data from 1951-2007, and below is the average of the first 30 years.

[](http://greengovernance.wordpress.com/2011/08/18/understanding-bangalore-climate-1/monthly-rainfall-in-bangalore-region-from-aphrodite/)

On comparison with the previous graph, the overall pattern of monthly rainfall seems unchanged, however: the rainfall amounts that APHRODITE gives us seem to be almost uniformly around ~70% of values obtained by the IMD. Thus, the average rainfall in August here is about **97mm** instead of 130mm. This is likely because APHRODITE data is “built” by processing rainfall numbers from several stations and not just Bangalore City, and hence will be a bit different. Let’s continue working with this, shall we?

Let’s take a look at how rainfall in August has been varying, over the past 50 years.

[](http://greengovernance.wordpress.com/2011/08/18/understanding-bangalore-climate-1/august-rainfall-in-bangalore-time-series/)

The graph above shows the amount of rainfall every August, from 1951 onwards, till 2007. The black horizontal line roughly indicates the average. But take a look at the variation! August, 1998 received a whopping 274.3 mm of rainfall, whereas the August of 1984 received a mere 24.3mm, not even 10% of the former. This is the extent of variation that exists naturally cannot get captured with a simple average value!

1. To understand the June 16th 2013 Kedarnath floods, Gandhi sarovar, upstream of Kedarnath where Mandakini river originates, received around 300 mm of rainfall on June 16th 2013. Imagine 5 mm per day in Kolar, and 300mm per day in Kedarnath, which is almost 50% of kolar’s annual rainfall received within a day (in fact within one hour). [↑](#footnote-ref-2)