This article is the fifth in the series of posts from the Data Capacity Project collaboration with Keystone Foundation.

In a continuation of our look at data use for non profits and some of the tools and methods for better data management, we are looking at why data is so important to the Keystone Foundation and what are the types of things you can use it for.

The Nilgiris has undergone an incredible amount of change in the last 10 years and it is important for NGOs like Keystone to understand how these changes impact resources available to communities, and how they can assist them to make better decisions regarding those resources. In this article, we look at their experience of using computer based simulation as a tool that uses primary and secondary data to improve their understanding of the water resources in a region.

Context

Coonoor town in the Nilgiris is the second largest tourist destination in the Nilgiris. It is an area well endowed with natural resources such as forests and water sources. However, over the last year (2012-13), the town has been reeling under a water crisis[1]. The town had a population of nearly 45,000 according to the 2011 census. Apart from the local population, the town also has a floating population that could be as high as 15,000 persons per day[2]. The drying up of local water sources including the Raliah dam, which is the main source of water for the town, has meant that water supply has been erratic[3]. People have had to depend on purchasing water through tankers, tapping springs and open wells etc. The hydrogeology of the region is such that it does not support the digging of borewells to exploit groundwater as is being done in the plains.

In this context, Keystone Foundation was interested to better understand the various factors affecting the availability of water and its quality then advocate for mainstreaming conservation action in district public policy. While the focus was on Coonoor town, a larger area was taken up for the study. This was done by keeping in mind the main stream flowing through the town, the catchment area of that stream and covering the downstream area as well.

Computer Simulation

In order to really showcase the impact of poor water management and conservation it was important for Keystone to be able to show various examples of what could occur if a change in approach was not undergone.

In order to present these alternative "futures" the decision was made to undertake a computer simulation exercise. A computer model is a computer program that is designed to simulate what might or what did happen in a situation[4]. Computer Simulation is a cost-effective tool for addressing a cross section of stakeholders and developing a shared understanding of a system. Simulation of various policy options enables stakeholders to understand the possible implications of their proposed actions. It is also able to incorporate the effects of feedback loops in the system and demonstrate the effects over a long period of time of various actions. Last, but not the least, the simulations can be refined as our understanding of the system improves over time and/or we identify a part of the system to examine in depth. The key to simulation is good data that is granular so that the simulations can be tested and proven to be somewhat accurate.

Computer models to understand water situation have been around since the 1960s. From scales as big as the earth to a small square of soil, scientists use models for different purposes. For relevance to the community being served so that they can make decisions, the area of a river basin is suitable to understand better the interlinkages on where the water is coming from, how it is used and what happens to it as it flows past.

For Coonoor, Keystone felt a similar intervention was necessary. We wanted to look at two specific questions:

a) What was the level of water deficit in the region, if any - to understand whether or not there is sufficient water available in the region to meet the needs of various sectors.

b) What was the level of nitrates in the stream - to look at the level of chemical and biological pollution in the streams. The level of nitrates is an indicator of chemical pollution in the stream and they are easy and economical to measure as well. The presence of coliform was also measured to check for biological pollution of water.

Data Collection

The Nilgiris simulations took into account the population, land use, rainfall, geology, tourist flow etc. Secondary data was collected for these parameters from various sources such as scientific literature, research institutions in the area, government departments etc. Given that the objective of the project was to understand broad trends in water availability and not accurate measurement of quantities, we chose to use secondary data as the main inputs into the simulation. The process of simulation would also point out gaps in the data and if desired we could collect data at a later time.

We collected secondary data from various institutions such as Coonoor Municipality, Center for Soil Water Conservation Research and Training Institute (CSWCRTI), Ooty, private tea estates. CSWCRTI has worked extensively on soil and water in the Nilgiris, as well as the impact of land use changes on the local hydrology. These were invaluable in making the simulations reflect the local conditions.

We also used data collected by Keystone over the years for different projects in this scenario building exercise. For instance, rainfall data had been collected from different sources for different periods of time and the frequency of data (daily, monthly, annual) also varied from one source to another. All these datasets were cleaned up as part of the Data Capacity Initiative with IWP, so that a separate simulation could be used to generate a typical daily rainfall pattern for the region for a 20 year period.

The primary data we collected were pertaining to water quality and household water use patterns. In the former, we used basic lab kits which could measure nitrate levels up to 50 ppm only, as these are readily available and relatively easy to use. However, when we ran the simulations, we realised that the predicted nitrate levels were many times this limit. Therefore, on hindsight this choice was not appropriate. For biological pollution, we used a test that could tell us whether or not a sample was polluted. It could not measure the extent of this pollution.

For understanding the household level dynamics, we developed a schedule that covered aspects such as family composition, occupation and its impact on water, water usage for all purposes, waste management, sanitation practices, water sources – access and availability across seasons etc. We covered around 150 households from across the region with the schedule and this helped us make realistic assumptions in the simulations. We did not aim for statistical accuracy with this sample, but aimed to cover a cross section across the region. We stratified the sampling across the landscape by including villages in the upstream, midstream and downstream areas as well as across communities.

One of the key inputs into the simulation was landuse. This data is normally available through village level officials or at the Panchayat level as aggregate information. In the case of the Coonoor region the challenge was that the boundary of the region was not coinciding with any administrative units and as such using secondary data was not feasible. Also, such data even if available does not have a spatial component. We decided that for the purpose of the simulation it was sufficient to distinguish area under agriculture from area under tea cultivation and other land uses. Moreover there are large areas under tea that can be easily distinguished visually from other farming. We therefore used satellite imagery of the region to derive a land use layer. We also verified samples of the layer with on the ground observations. Again this layer is not meant to be accurate spatially at the farm plot level, but meant to represent the land use pattern of the region.

The region was subdivided into smaller sub-regions based on the catchment area of smaller streams. This was done to be able to look at the results in different land use regimes.

Table: Land use in the sub regions of Coonoor region

Region	Builtup	Farming	Grasslands	Open space	Rock-outcrop	Tea	Tree cover	Water body	Grand Total
Region 1	**31%**	1%	3%	0%	0%	**27%**	**39%**	0%	100%
Region 2	14%	7%	6%	0%	0%	**53%**	**20%**	0%	100%
Region 3	18%	5%	1%	0%	0%	**50%**	**26%**	0%	100%
Region 4	6%	**26%**	1%	0%	0%	**57%**	10%	0%	100%
Region 5	3%	**25%**	1%	0%	0%	**66%**	4%	1%	100%
Region 6	7%	1%	1%	0%	0%	**83%**	8%	0%	100%
Region 7	5%	0%	0%	0%	0%	**23%**	**72%**	0%	100%
	10%	**7%**	**2%**	**0%**	**0%**	**51%**	**30%**	**0%**	**100%**

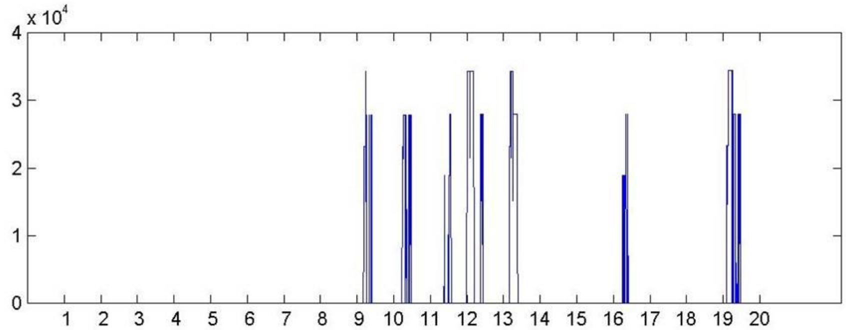
Note: Figures in bold show major land uses for each subregion.

The Baseline and scenarios

A detailed description of the assumptions made in the simulation as well as the actual code is documented in the annexure. The code was written in Matlab and ported to Freemat, a free and open source software, to enable anyone to run it without the need for expensive software licenses. The simulation is run for a 20 year period with calculations at daily intervals.

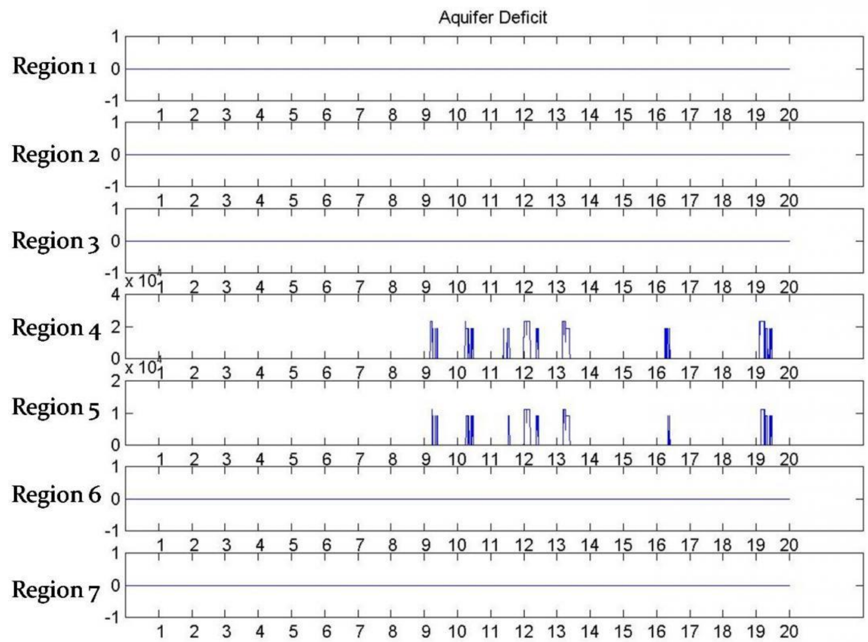
In the baseline scenario, the population was assumed to grow at 1.5% per year and tourist population at 5% per year. In this case, there is water deficit in seven out of the 20 years, starting nine years from now (Pic1). Among the sub-regions there is water deficit in sub-regions 4 and 5 due to more area under farming there (Pic 2). Nitrates are always more than four times the safe limit for drinking, which is 40 ppm (Pic 3). It is also more than 300 ppm in sub-region 1 which has Coonoor town and crosses 300 ppm mark in a few years in sub-regions 4 & 5 (Pic 4). This shows that if the current trends continue then, there will be a major water crisis in the coming years both in terms of quantity and quality. If we add uncertainty due to climate change as well as the issues related to distribution of water into the mix, then the crisis is much more immediate. Last year's experience in Coonoor town is an example of this type of crisis.

Pic 1: Water deficit in the Coonoor Region



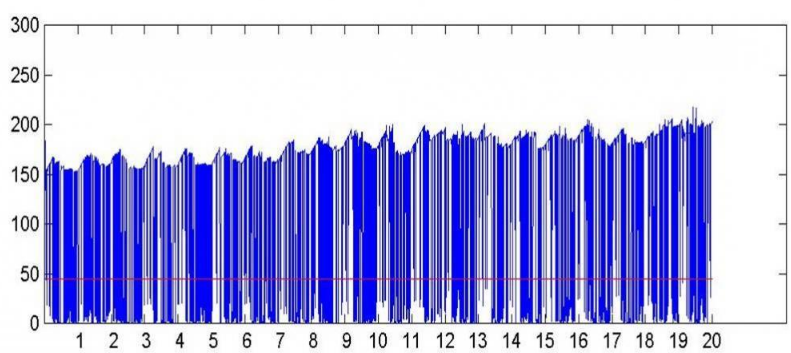
Note: X-axis – Year, Y axis – cu.m per day

Pic 2: : Water deficit in the different sub-regions



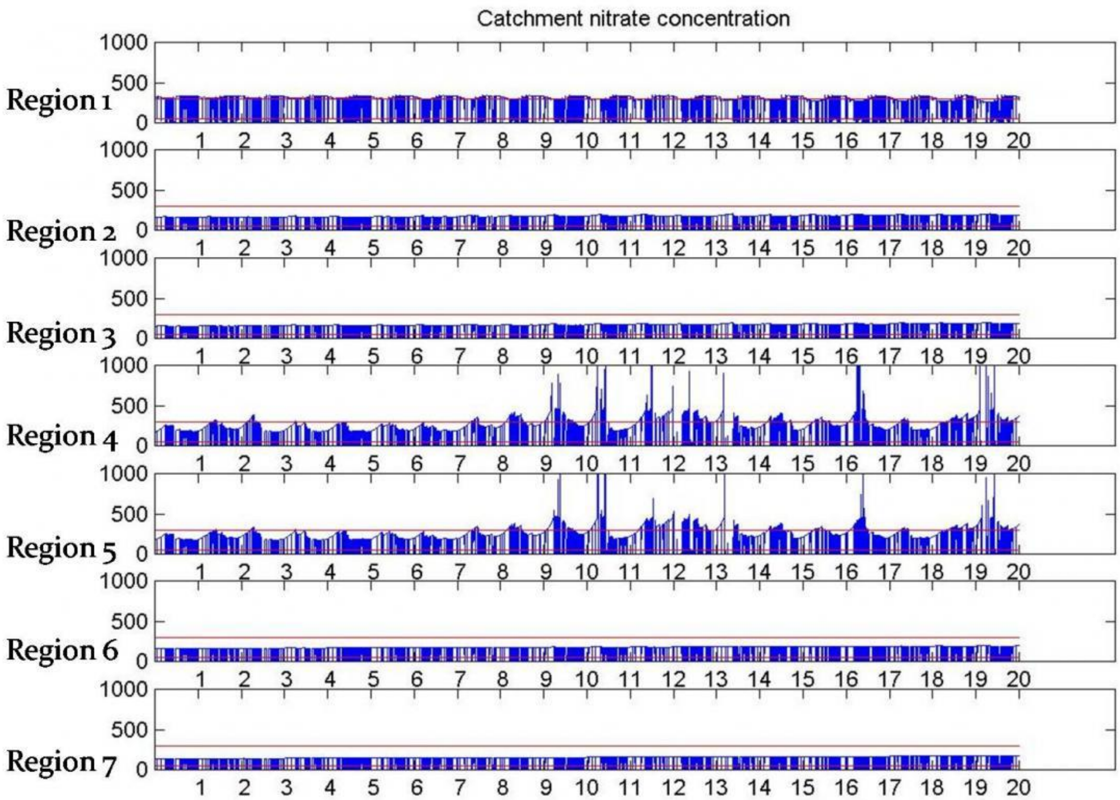
Note: X-axis – Year, Y axis – cu.m per day

Pic 3: Overall nitrate in the region



Note: X-axis – Year, Y axis – ppm

Pic 4: Nitrate levels in different sub-regions

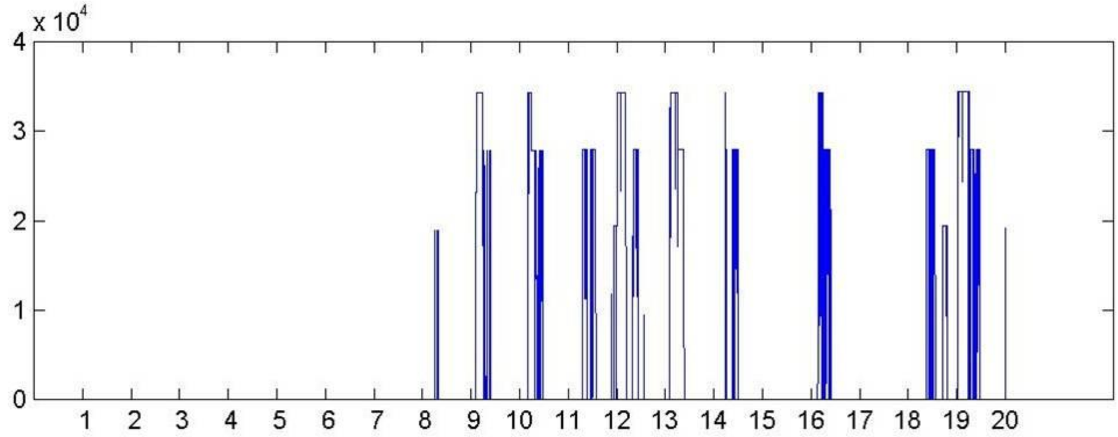


Note: X-axis – Year, Y axis – ppm

In order to illustrate some of the possible response measures to tackle the situation, a few additional scenarios were simulated.

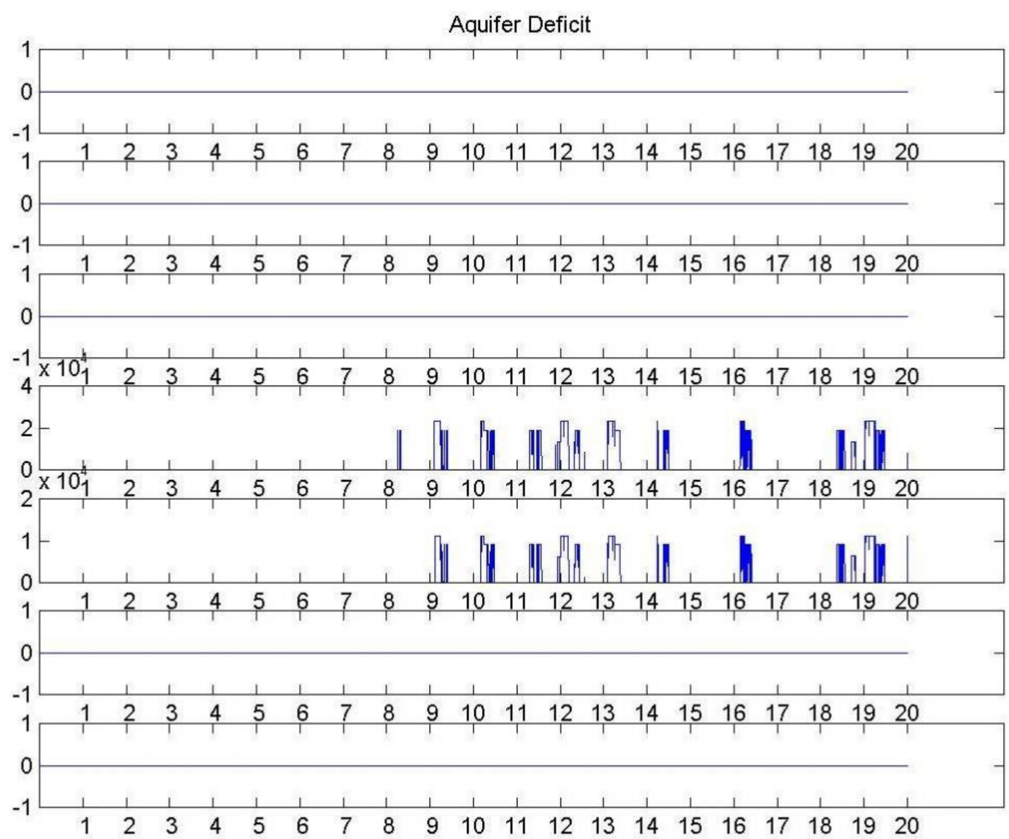
- In one case, the urbanisation trend in the Nilgiris was highlighted, by considering that 2% of land under tea (arbitrarily taken) was converted into builtup area. This results in significant reduction in base flow, increase in flood peaks, reduction in aquifer storage and there is deficit in regions four and five in more number of years. This is due to higher demand for water for agriculture in these two regions.

Pic 5: Water deficit in the Coonoor Region



Note: X-axis – Year, Y axis – cu.m per day

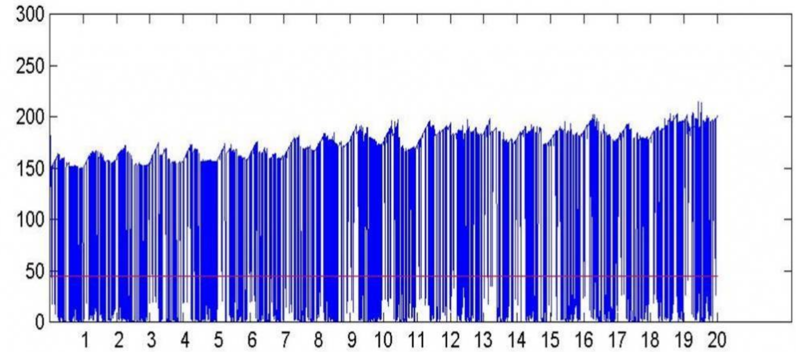
Pic 6: : Water deficit in the different sub-regions



Note: X-axis – Year, Y axis – cu.m per day

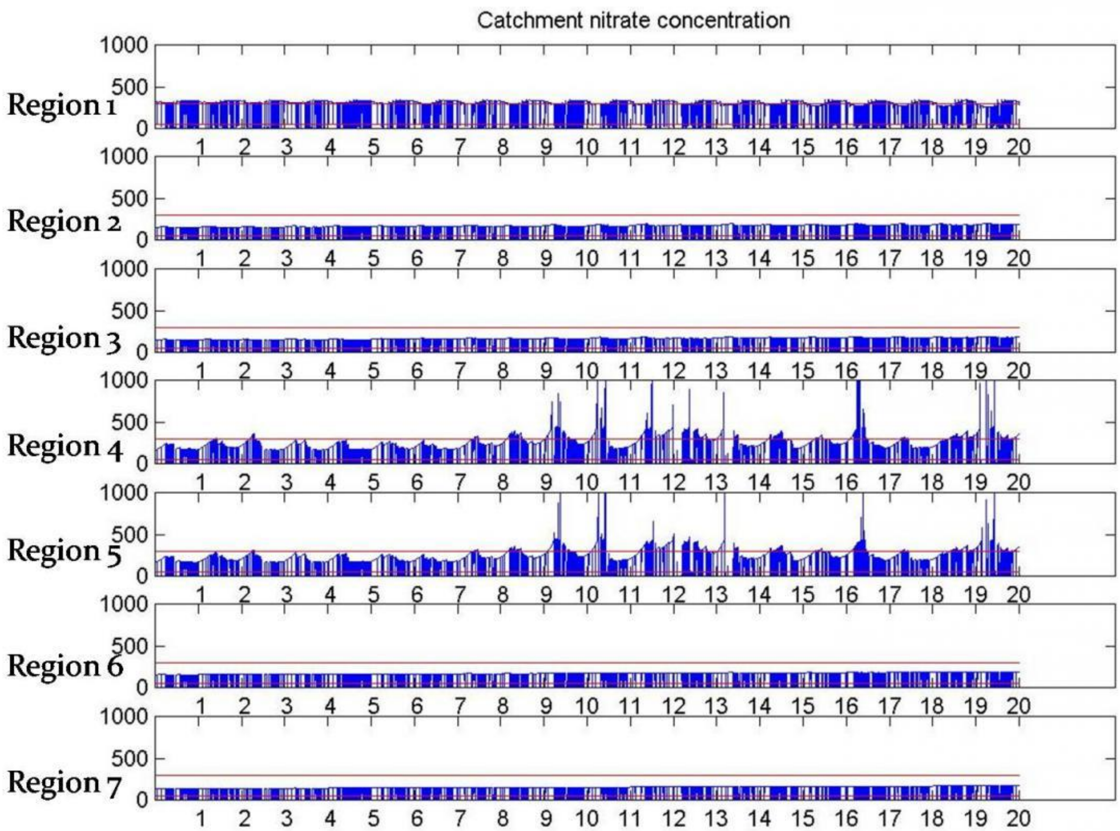
- In another case, the adoption of organic agriculture was simulated, by reducing the agricultural chemical use by 25% (arbitrary level). In this case, the water deficit scenario is unchanged and the overall nitrate level remains the same, although the peaks do reduce somewhat.

Pic 7: Overall nitrate in the region



Note: X-axis – Year, Y axis – ppm

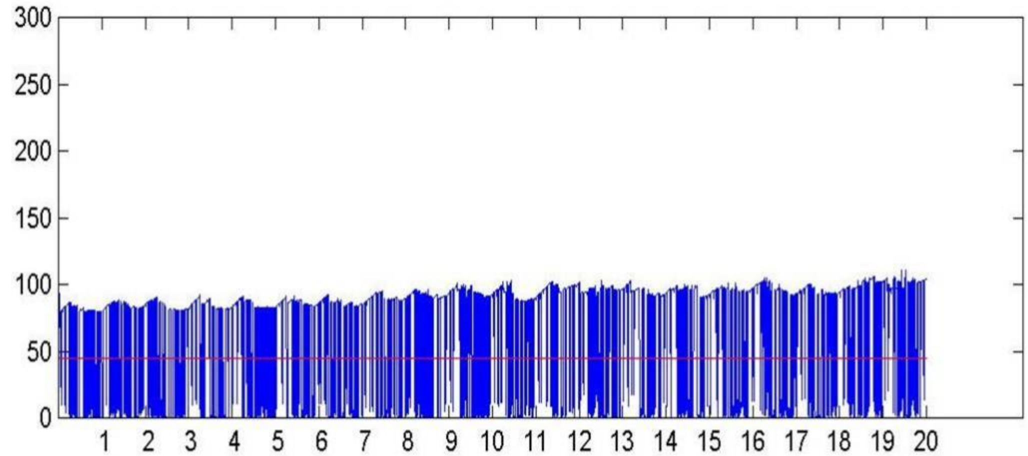
Pic 8: Nitrate levels in different sub-regions



Note: X-axis – Year, Y axis – ppm

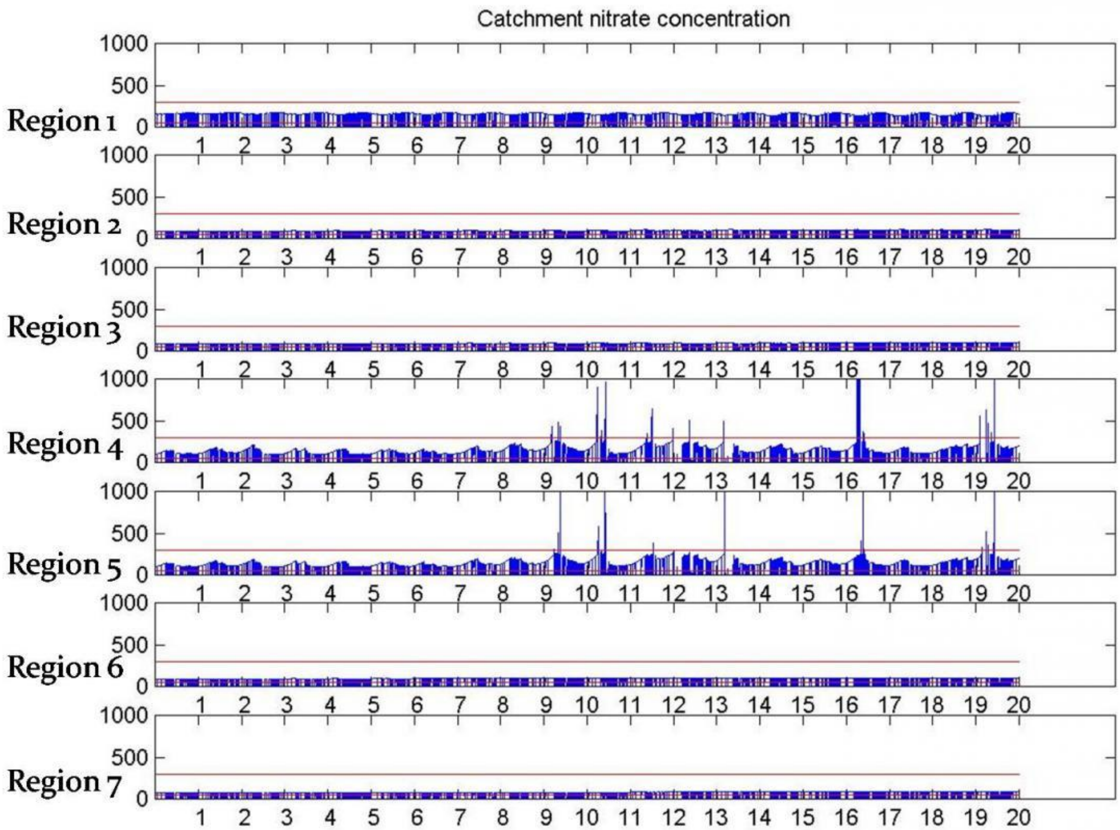
- Solid waste management is a major issue in the Nilgiris and this is a major contributor to the Nitrate load in the streams. Simulating a 50% reduction in waste from local and tourist populations (arbitrary levels), there is a significant reduction in nitrate levels in the streams.

Pic 9: Overall nitrate in the region



Note: X-axis – Year, Y axis – ppm

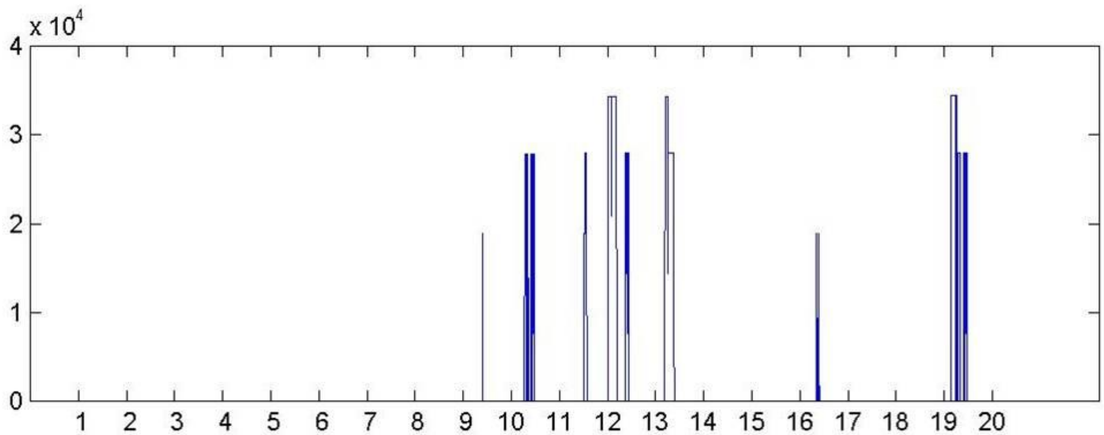
Pic 10: Nitrate levels in different sub-regions



Note: X-axis – Year, Y axis – ppm

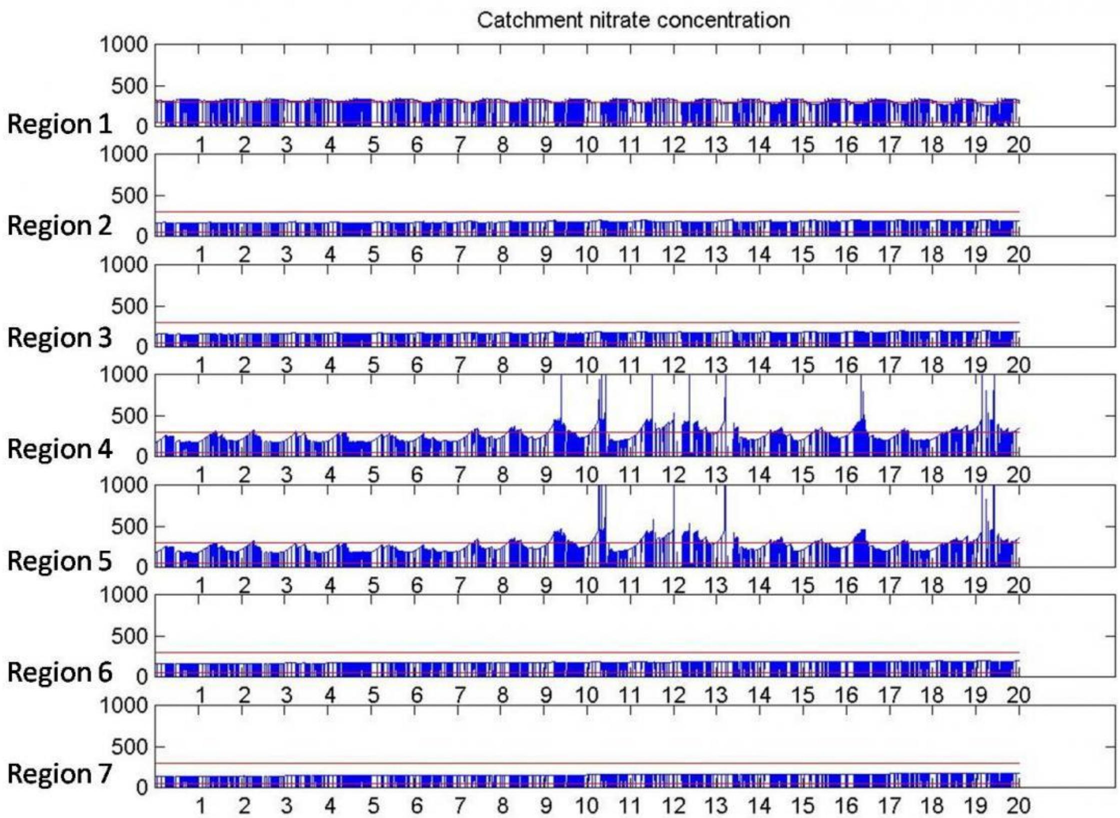
- As mentioned earlier, much of the forest cover in the region consists of exotic species. Simulating the replacement of 25% of these exotics with native species and grasslands (arbitrary level), shows an increase in baseflows and decrease in water deficit.

Pic 11: Water deficit in the Coonoor Region



Note: X-axis – Year, Y axis – cu.m per day

Pic 12: : Water deficit in the different sub-regions



Note: X-axis – Year, Y axis – cu.m per day

The simulations show the importance of land use pattern in the quantity and quality of water available in the region. The simulation also predicts a high level of nitrates in the stream water which indicates that the problem of waste management in the region is being pushed downstream to people who depend on the stream water for agriculture, drinking etc. Locally the villages mainly depend on springs for water supply and these are not contaminated as yet. Therefore the low dependence on streams has meant that direct impact to people is low from a drinking water point of view. The pollution is being sent downstream out of the Nilgiris where the communities living next to the river have to deal with the consequences. The study of these effects was beyond the scope of this project.

Dissemination and follow up

By using computer simulations, it was possible to demonstrate the cumulative impact of various sectors on the water resource situation in the region and generate a consensus on the need to act on the same. The simulations were presented in June 2013 to a group of stakeholders in the region including the District

Collector, line departments, Wellington Cantontment Board, CSWCRTI, UPASI, other NGOs etc. Though the simulation is a technical output, we were able to communicate the purpose of simulation and the results it threw up. The simulation was able to show what happens to the water due to the combined effects of different 'sectors' – domestic, tourism, plantation, sanitation, agriculture etc. which normally operate independent of each other. This is something novel that cannot be easily communicated otherwise. The experience in sharing this with a group of laypersons was also good as they were able to quickly grasp the significant messages regarding land use and waste management.

Thus, Keystone found that computer simulation is an effective tool to get across a technical subject to a lay audience or one consisting of people with different levels of technical expertise. To communicate at a community level, this has been supplemented with specific examples that reflect larger trends. Keystone plans to focus on the water supply and demand situation of Coonoor town and modify the simulation accordingly. A Payment for Ecosystem Services approach will be tried out to come up with a possible solution to the water crisis. This is the focus of a new project from 2013-15.

The simulation of nitrate levels highlights the need for good waste management and sanitation practices. Keystone is also planning to work on a village scale on waste management and sanitation issues with youth from the villages by partnering with other agencies involved in this work.

[1] http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/acute-water-shortage-in-coonoor/article4616168.ece;

http://www.thehindubusinessline.com/news/states/coonoor-faces-acute-water-shortage/article5097333.ece;

http://www.downtoearth.org.in/content/coonoor-hill-station-without-water

[2] http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/acute-water-shortage-in-coonoor/article4616168.ece

[3] http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/acute-water-shortage-in-coonoor/article4616168.ece

[4] https://simple.wikipedia.org/wiki/Computer_model

[5] https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0B3T_OundzgYHNjM3NzExMGQtYTE3Yy00ZTJlLWEwNzEtNGNkOGI2ZGFkMjli&hl=en_US