# AGENDA AND AGENDA NOTES FOR THE 30TH MEETING OF THE NIH WORKING GROUP

8-9 APRIL, 2009

~~17-18 MARCH, 2009~~

**AT 1100 HRS.**

**IN NIH SOCIETY ROOM**

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**NATIONAL INSTITUTE OF HYDROLOGY**

**ROORKEE-247667**

# AGENDA AND AGENDA NOTES FOR THE 30TH MEETING OF THE NIH WORKING GROUP

## AGENDA ITEMS

**ITEM NO. 30.1** Opening remarks by the Chairman

**ITEM NO. 30.2** Confirmation of the minutes of 29th meeting of the Working Group

**ITEM NO. 30.3** Presentation and discussion on the progress of the work programme of the five divisions for the year 2008-09 including the actions taken on the recommendations/decisions of the previous meeting and presentation and finalization of new proposed work programme of the five divisions for the year 2009-2010

**ITEM NO. 30.4** Any other item with permission of the Chair.

ITEM NO. 30.1 OPENING REMARKS BY THE CHAIRMAN

## ITEM NO. 30.2 Confirmation of the minutes of 29th meeting of the Working Group

The 29th meeting of the Working Group was held during 30 September - 01 October, 2008. The minutes of the meeting were circulated to all the members and invitees vide letter No. RCMU/WG-29/NIH-08 dated 20th October 2008. No comments have been received on the circulated minutes.

The Working Group may please confirm the minutes.

## ITEM NO. 30.3 PRESENTATION AND DISCUSSION ON THE PROGRESS OF THE WORK PROGRAMME OF THE FIVE DIVISIONS FOR THE YEAR 2008-09 INCLUDING THE ACTIONS TAKEN ON THE RECOMMENDATIONS/DECISIONS OF THE PREVIOUS MEETING AND PRESENTATION AND FINALIZATION OF NEW PROPOSED WORK PROGRAMME OF THE FIVE DIVISIONS FOR THE YEAR 2009-2010

The Work Programme of the Five Divisions of the Institute for the year 2008-09 was considered by the 29th meeting of the Working Group and the recommended programme was approved by the TAC.

During the present meeting the status of current year's (2008-09) work programme is being presented division wise. Some new project proposals/studies are also being presented for consideration of the Working Group.

This item has been organized in the following order:

1) **Environmental Hydrology Division**
2) **Ground Water Hydrology Division**
3) **Hydrological Investigation Division**
4) **Surface Water Hydrology Division**
5) **Water Resources System Division**

The Working Group may please consider the progress of the current year Work Programme and also finalize the work programme for the year 2009-10.

# THE 30TH MEETING OF THE NIH WORKING GROUP

# ENVIRONMENTAL HYDROLOGY DIVISION

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## NATIONAL INSTITUTE OF HYDROLOGY
## ROORKEE-247667

## PROGRESS OF STUDIES AND RESEARCH OF ENVIRONMENTAL HYDROLOGY DIVISION FOR THE YEAR 2008-09

| S.No. | Project | Project Team | Duration | Funding Agency |
|---|---|---|---|---|
| 1. NIH/EHD/CPCB/08-10 | Assessment of ground water quality in class-1 cities in India | Dr. V.K. Choubey; Sc. F<br>Dr. M.K. Sharma, Sc.-B | 2 Years | CPCB New Delhi |
| 2 NIH/EHD/NIH/06-09 | Hydrological Studies for Restoration of the Renuka Lake, District Sirmaur (HP) | Shri Omkar Singh,<br>Dr. V.K. Choubey; Sc. F;<br>Dr. M.K. Sharma, Sc.-B;<br>HID | 3 Years (2006-09) | NIH |
| 3 NIH/EHD/NIH/07-10 | Modelling of Pesticide Transport in Ground Water – a case study of Metropolitan City – Vadodara | Dr. M.K. Sharma, Sc-**B**<br>Dr. V.K. Choubey; Sc. F | 3 years (Oct., 07 to Sept. 2010) | NIH |
| 4 NIH/EHD/NIH/08-09 | Evaluation of water quality of rivers joining Tehri reservoir and downstream of the reservoirs | Dr. M.K. Sharma, Sc.-B<br>Dr. V.K. Choubey; Sc. F | 1 Year | NIH |

## WORK PROGRAMME OF THE ENVIRONMENTAL HYDROLOGY DIVISION FOR THE YEAR 2009-2010

| S.No. | Project | Project Team | Duration | Funding Agency |
|---|---|---|---|---|
| 1. NIH/EHD/CPCB/08-10 | Assessment of ground water quality in class-1 cities in India | Dr. V.K. Choubey; Sc. F<br>Dr. M.K. Sharma, Sc.-B | 2 Years | CPCB New Delhi |
| 2. NIH/EHD/HP-II/09-13 | Impact of sewage effluent on drinking water sources of Shimla city and suggesting ameliorative measures | Dr. V.K. Choubey; Sc. F<br>Shri Omkar Singh, Sc. E1<br>Dr. M.K. Sharma, Sc.-B;<br>I&FC Dept., Shimla | 4 years | HP-II |
| 3 NIH/EHD/NIH/07-10 | Modelling of Pesticide Transport in Ground Water – a case study of Metropolitan City – Vadodara | Dr. M.K. Sharma, Sc.-B<br>Dr. V.K. Choubey; Sc. F | 3 years (Oct., 07 to Sept. 2010) | NIH |
| 4 NIH/EHD/NIH/08-09 | Evaluation of water quality of rivers joining Tehri reservoir and downstream of the reservoirs | Dr. M.K. Sharma, Sc.-B<br>Dr. V.K. Choubey; Sc. F | 1 Year | NIH |

## 1. PROJECT REFERENCE CODE: NIH/EHD/CPCB/08-10

**a) Title of the study:** **Assessment of Ground Water Quality in 25 Class I Cities of India** (Guwahati, Raipur, Shimla, Imphal, Shillong, Aizawal, Kohima, Bhubneshwar, Agartala, Dehradun, Itanagar & Gangtok)

**b) Study Group:** V K Choubey, Scientist 'F'
M K Sharma, Scientist' B'

**c) Date of start:** October, 2008

**d) Duration of the study:** Phase I: 2008-09 (Twelve cities)
Phase II: 2009-10 (Thirteen Cities)

**e) Weather externally funded or not:** Yes, CPCB, Delhi

**f) Point wise objectives:**

i) To examine the suitability of ground water for various designated uses
ii) To identify degraded water quality zones and possible sources of pollution and specific parameters not conforming to water quality standards

**g) Brief methodology:**

- Identification of industrial areas, residential areas, petrol pumps and bulk storage of petroleum production, municipal solid waste disposal (land fill) areas
- Identification of (about 30) locations covering shallow and deep aquifer regions.
- Sampling of ground water in pre- and post-monsoon seasons
- Physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, COD, BOD, Major Cations (Na, K, Ca, Mg), Major Anions ($HCO_3$, Cl, $SO_4$, $NO_3$), Minor Ions (F, $PO_4$, B).
- Bacteriological Parameters: Total and Faecal Coliform
- Toxic (Heavy) Metals: As, Cd, Cr, Pb, Hg, Cu, Ni, Fe, Zn, Mn
- Pesticides: DDT, Total BHC, Endosulphan, Lindane, Aldrin, Deildrin, Carbamat, 2,4 D, Malathion, Parathion, Pyriphos, Chloropyriphos
- Polynuclear Aromatic Hydrocarbon (P AH): location-specific

- Data for pre- and post-monsoon seasons will be processed as per BIS and WHO standards to examine the suitability of ground water for drinking purpose, ionic relationships will be developed and water types will be identified. Spatial distribution map will be prepared in the form of contour diagrams to identify degraded water quality zones. Suitability of ground water for irrigation purpose will be assessed on the basis of total soluble salts, SAR, RSC and boron content. Classification of water will be made using Piper trilinear diagram, Durov plots, Chadha's diagram, U S Salinity Laboratory Classification and Gupta Classification.

h) **Progress/Present Status:**

- Recruitment of Project Staff has been done.
- Procurement of Chemicals, Glasswares, Laboratorywares is under process.
- First round of sampling from the twelve class - I cities (Guwahati, Raipur, Shimla, Imphal, Shillong, Aizawal, Kohima, Bhubneshwar, Agartala, Dehradun, Itanagar & Gangtok) will be carried out in the month of February, 2009.

i) **Expected date of completion:** September 2010

## 2. PROJECT REFERENCE CODE: NIH/EHD/NIH/06-09

**a) Title of the study:** **Hydrological Studies for Restoration of the Renuka Lake, District Sirmaur (HP)**

**b) Study Group:** Shri Omkar Singh, Sc. E1
Dr. V.K. Choubey, Sc. F;
Dr. M.K. Sharma, Sc. B; HID

**c) Date of start:** April 1, 2006

**d) Duration of the study:** 3 years

**e) Funding Agency:** Internal

**f) Objectives:**

- To study water quality of the Renuka lake
- To study eutrophication status of the Renuka lake
- To monitor thermal behaviour of the Renuka lake
- To estimate water balance of the Renuka lake

**g) Brief Methodology:**

The lake water quality was assessed based on spatio-temporal and depth wise monitoring of lake for physical, chemical and bacteriological analysis. Eutrophication status was carried out on the basis of Trophic State Indices (Carlson, 1977) for observed phosphate concentration data. The isotopic composition of the lake was also studied. The depth wise thermal behaviour of the lake is monitored using thermometer. The following equation was used to study the water balance of the Renuka lake:

$$\Delta L = (RO+RF+GWI)-(DR+EV+GWO)$$

Where, $\Delta L$ is change in lake level, RO is surface runoff from the lake catchment, RF is rainfall over lake, GWI is groundwater inflow, DR is withdrawal from lake (i/c pumping and other outflow), EV is evaporation loss, GWI is groundwater outflow from the lake.

The water balance components (RF, EV, ΔL) of the Renuka lake were monitored on daily basis in the field. The daily evaporation of the lake water was estimated multiplying US Class-A pan data with a pan coefficient of 0.7. The net groundwater contribution (GWI-GWO) was estimated on rearranging the above water balance equation (in depth units) as given by (LaBaugh, 1986):

$$GWI - GWO = \Delta L + EV + DR - RF - RO$$

**h) Progress/Present status:**

The following components have been studied:

- Evaluation of drinking water quality of the Renuka lake based on the following parameters:
  - Physico-chemical
  - Bacteriological
  - Trace elements
- Eutrophication status of the Renuka lake
- Thermal behaviour of the Renuka lake
- Lake Sediment chemistry of the Renuka
- Isotopic characteristic of the lake water
- PCA analysis of the lake water quality for prioritization

**Monitoring of Hydro-meteorological data**: The following hydro-meteorological data has been monitored for determination of the lake water balance components:

- Daily rainfall data
- Daily water level/outflow
- Daily pan evaporation data

Contribution of groundwater is often considered to be unmeasured input or output in the water balance equation and, therefore, estimated from above mentioned measured components of the water balance. The data was analysed for estimation of the unmeasured component ie. net groundwater contribution (GWI-GWO) of the Renuka lake.

(i) **Expected date of completion:** March 2009

## 3. PROJECT REFERENCE CODE: NIH/EHD/NIH/07-10

**a) Title of the Study:** **Modelling of Pesticide Transport in Ground Water – a case study of Metropolitan City – Vadodara**

**b) Study Group:** **P.I:** M K Sharma, Scientist 'B'
**Co- P.I:** V K Choubey, Scientist 'F'

**c) Date of start:** October 2007

**d) Duration of the Study:** Thee Years

**e) Weather externally funded or not:** Internally funded

**f) Problem Definition and Study Area:**

Metropolitan city Vadodara witnessed a sudden spurt in industrial activity with the establishment of Gujarat Refinery, Indian Oil Corporation. Metropolitan city of Vadodara is the industrial nucleas of the Gujarat State. During the recent study carried out by NIH, very high concentration of pesticide lindane was observed in ground water of metropolitan city Vadodara. Therefore there is a need to study the lindane migration pattern in the ground water of metropolitan city Vadodara from future projections.

**g) Objectives of the Study:**

- To develop a contaminant source identification model from point source
- To study and characterize the contaminant (pesticide) migration pattern in the ground water in space and time for prediction purposes

**h) Brief Methodology:**

- Methodology will involve flow and transport of organo-chloro pesticide (Lindane) through column study (experimental) in unsaturated zone and modelling flow and transport using MODFLOW & MT3D in saturated zone. Initially, the model will be calibrated using data collected along space & time for a period of one year
- Calibrated model will be used to predict contaminant concentrations along the planning horizon.

**i) Results achieved with Progress/Present Status:**

a. Post-monsoon field visit of the metropolitan city Vadodara and surrounding area was made in the month of December, 2008 and collected soil sample, 45 water and waste water samples from open wells, tube wells and piezometeric wells maintained by GWRDC and identified main sources of pollution (drains) for analysis in the laboratory. The characteristics of the ground water and identified drains is given in Table 1:

Table 1: Characteristics of the ground water and identified drains

| | pH | EC, µS/Cm | TDS, mg/L | DO, mg/L | BOD, mg/L |
|---|---|---|---|---|---|
| **Groundwater Samples** | | | | | |
| Minimum | 6.2 | 730 | 467 | 1.0 | 0.05 |
| Maximum | 8.4 | 5352 | 3425 | 4.4 | 3.45 |
| **Drain/Rivers** | | | | | |
| Nandesari | 7.5 | 5496 | 3517 | 7.8 | 2.15 |
| GACL | 7.3 | 5510 | 3526 | 5.8 | 2.35 |
| Gujarat Refinery | 6.91 | 3456 | 2211 | 2.8 | 0.95 |
| IPCL | 7.31 | 12068 | 7724 | 8.6 | 1.05 |
| Kamati Bagh | 6.91 | 5854 | 3746 | 2.7 | 4.75 |
| GIDC | 7.61 | 3312 | 2119 | 0.7 | 2.65 |
| River Vishwamitri | 7.10 | 1624 | 1039 | 0.5 | 2.05 |
| River Jambua | 7.12 | 2175 | 1392 | 1.5 | 4.75 |

b. Collected the following ground water data from the State authority Ground Water Resources Development Corporation Ltd. (GWRDC), Gandhinagar, Gujarat for modeling purposes and being processed.

- Monthly ground water level data and water quality data of 9 piezometric wells under HP, 14 piezometric wells under NCCA (four times observation in a year) and 12 open wells (two times observation in a year) maintained by GWRDC.
- Pumping test data
- Location and Lithology of observation wells.
- Map showing location of observation wells

c. The collected samples from open wells, tube wells and piezometeric wells and drains analysed for pesticides and organochloro pesticides were detected in 3 ground water samples, 2 drains and river Jambua.

d. For transport of pesticides in unsaturated zone of the study area, the soil has been characterized and batch experiment for adsorption of lindane on soil for optimizing condition for the column study is in progress for different operating variables. Equilibrium contact time for adsorption of lindane was found to be 90 minutes, therefore all further adsorption experiment are being carried out for equilibrium time of 90 minutes.

**j) Expected Outcome/Output :**

- Identification of unknown source
- A predictive model will be developed
- Suggested measures for the control and management of contaminant in ground water system will be helpful for policy makers and stake holder.

**k) Expected date of completion :** September 2010

**Quarter-wise Work Programme for the Year 2007-2011**

| Year | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|
| 2007-08 | - | - | Field visit & Data collection | Field visit & Data collection |
| 2008-09 | Field visit, Sampling & Analysis | Field visit, Sampling & Analysis | Field visit, Sampling & Analysis | Field visit, Sampling & Analysis |
| 2009-10 | Processing and Analysis of Data, Modelling | Processing and Analysis of Data, Modelling | Processing and Analysis of Data, Modelling | Processing and Analysis of Data, Modelling |
| 2010-11 | Writing of the Report | Writing of the Report | - | - |

## 4. PROJECT REFERENCE CODE: NIH/EHD/NIH/08-09

**a) Title of the Study:** **Evaluation of water quality of rivers joining Tihri Reservoir and downstream of the reservoir**

**b) Study Group:** M K Sharma, Scientist' B'
V K Choubey, Scientist 'F'

**c) Date of start:** September, 2008

**d) Duration of the study:** One year

**e) Weather externally funded or not:** Internal (As suggested by MOWR)

**f) Point wise objectives:**

- To examine the suitability of water of the rivers joining Tihri reservoir and downstream for various designated uses
- To identify possible sources of pollution and assess the actual changes in river water quality after commissioning of Tihri Hydroelectric Project

**g) Brief methodology:**

- Identification of sampling sites in the rivers joining Tihri reservoir and downstream of Tihri Reservoir
- Sampling of water in different seasons
- Physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, COD, BOD, Major Cations (Na, K, Ca, Mg), Major Anions ($HCO_3$, Cl, $SO_4$, $NO_3$), Minor Ions (F, $PO_4$).
- Bacteriological Parameters: Total and Faecal Coliform
- Data for different seasons will be processed as per BIS and WHO standards to examine the suitability of river water for drinking purpose. Suitability of river water for irrigation purpose will be assessed on the basis of total soluble salts, SAR, RSC.

**h) Results achieved with Progress/Present Status:**

A reconnaissance field visit of Tihri reservoir and its joining rivers has been carried out and three water samples from reservoir, one sample each from river Bhilangana and Bhagirathi, two downstream samples from Zero point and Koteshwar have been collected in the month of December 2008 and analysed for physico-chemical parameters, bacteriological parameters (Total and Faecal coliform) and metals (Fe, Mn, Zn, Cu, Cr, Cd, Pb, Ni). The results of the analysis are below:

- All the physico-chemical parameters analysed, were found with in the desirable limit of drinking water.
- DO and BOD values vary from 7.4 to 9.3 mg/L and 0 to 2.0 mg/L respectively.
- Concentration of analysed metals were found well within the desirable limit except the concentration of iron in Bhilangana, Bhagirathi (upstream) and at Koteshwar.

| Parameters | Minimum | Maximum | Average |
|---|---|---|---|
| pH | 6.62 | 7.21 | 6.9 |
| EC, µS/Cm | 132 | 234 | 172 |
| TDS, mg/L | 84 | 150 | 110 |
| Hardness, mg/L | 33 | 81 | 51.7 |
| $HCO_3$, mg/L | 47.58 | 92.7 | 63.8 |
| Cl, mg/L | 2 | 6.0 | 2.9 |
| $SO_4$, mg/L | 5.7 | 18.0 | 11.9 |
| $NO_3$, mg/L | 0.62 | 1.0 | 0.7 |
| $PO_4$, mg/L | 0.11 | 0.7 | 0.4 |
| F, mg/L | 0.1 | 0.6 | 0.3 |
| Na, mg/L | 9 | 12.0 | 10.3 |
| K, mg/L | 0.1 | 0.3 | 0.2 |
| Ca, mg/L | 10 | 21.0 | 14.1 |
| Mg, mg/L | 2 | 7.0 | 4.0 |
| DO, mg/L | 7.4 | 9.3 | 8.1 |
| BOD, mg/L | 2 | 2.0 | 2.0 |

- Assessment of suitability of these river water for irrigation purpose on the basis of total soluble salts, SAR, RSC revealed that these waters are of excellent quality for irrigation purpose.

| Sampling point | SAR | Na% | RSC |
|---|---|---|---|
| Bhagirathi river (U/S) | 0.4825 | 21.3163 | -0.1038 |
| Bhilangana river | 0.5138 | 25.4726 | -0.1598 |
| Tihri reservoir R1 | 0.7277 | 37.9875 | 0.1261 |
| Tihri reservoir R2 | 0.7831 | 39.3220 | 0.1741 |
| Tihri reservoir R3 | 0.7546 | 39.7122 | 0.1161 |
| Bhagirathi at Zero Point | 0.6948 | 31.9446 | 0.0121 |
| Bhagirathi at Koteshwar | 0.5590 | 26.5509 | -0.0898 |

i) **Expected outcomes:**

- The changes in river water quality after commissioning of Tihri Hydroelectric Project

j) **Expected date of completion:** August 2009

# THE 30TH MEETING OF THE NIH WORKING GROUP

## GROUND WATER HYDROLOGY DIVISION

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**NATIONAL INSTITUTE OF HYDROLOGY**
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## Actions taken on the decisions of the last meeting:

| Decision on | Working Group's Decision | Action taken |
|---|---|---|
| Study entitled "Approximations of well functions for leaky aquifers and large diameter wells" | The chairman ruled that the technology should be disseminated to field engineers by suitably organizing workshop and training courses or in a form of a purpose-driven study (PDS) under HP-II | The concerned scientist has been advised to develop a purpose-driven study (PDS) under HP-II. |

## WORK PROGRAMME OF GROUND WATER HYDROLOGY DIVISION FOR THE YEAR 2008-09

| S.No. & Reference Code | Project | Project Team | Duration & Status | Funding Source |
|---|---|---|---|---|
| 1. NIH/GWD/NIH/07 -09 | Quantification of impact of rainwater harvesting on groundwater availability in the Aravalli Hills. | Anupama Sharma, Sc.-C (P.I)<br>C. P. Kumar, Sc.-E1<br>Suhas Khobragade, Sc.-C<br>Rajan Vatsa, Sc.-B | 3 years (04/07 – 03/10)<br>**Status:** In progress | NIH |
| 2. NIH/GWD/NIH/08 -4/09 | Mitigation and Remediation of Ground Water Arsenic Menace in India | NIH & CGWB | 08 months (09/08-04/09)<br>**Status:** In completing stage | NIH |
| 3. NIH/GWD/NIH/04 /07 – 03/09 | Approximations of well functions for leaky aquifers and large diameter wells | Dr. S. K. singh | 02 years<br>**Status:** Completed | NIH |
| 4. NIH/GWD/NIH/07 -6/08 | Hydrological and hdrogeological investigations to assess causes of seepage from the reservoir of Jaswant Sagar Dam in Jodhpur, Rajasthan | N C Ghosh (P.I.)<br>P K Majumdar<br>C P Kumar<br>Sudhir Kumar<br>Anupma Sharma<br>R Vasta | 1 year (06/07-0.6/08)<br>Status: Completed & Final report submitted to the sponsoring agency on 30th Oct, 2008. | NIH |

| **Technology Transfer Activities** | | | |
|---|---|---|---|
| 5-days training course under HP-II for CGWB officials | Data analysis and management for groundwater assessment and modeling. | Coordinator : Anupma Sharma, Sc.-C | January 2009<br>**Status:** Rescheduled to organize in March, '09 |
| 10-days training course for Groundwater officials of Rajasthan Govt. | Groundwater Modeling and Management | Coordinator : C. P. Kumar, Sci.-E1 | November, 2008<br>**Status:** No response from the State Govt.'s received. |

## PROPOSED WORK PROGRAMME OF GROUND WATER HYDROLOGY DIVISION FOR THE YEAR 2009-10

| S.No. & Reference Code | Project | Project Team | Duration & Status | Funding Source |
|---|---|---|---|---|
| 1. NIH/GWD/NIH/07-09/ | Quantification of impact of rainwater harvesting on groundwater availability in the Aravalli Hills. | Anupama Sharma, Sc.-C (P.I)<br>C. P. Kumar, Sc.-E1<br>Suhas Khobragade, Sc.-C<br>Rajan Vatsa, Sc.-B | 3 years (04/07 – 03/10)<br>**Status:** In progress | NIH |
| 2. NIH/GWD/NIH/08-4/09 | Mitigation and Remediation of Ground Water Arsenic Menace in India | NIH & CGWB | 08 months (09/08-04/09)<br>**Status:** In completing stage | NIH |
| 3. NIH/GWD/NIH/09-10 (New) | Water table evolution due to subsurface drainage with arbitrary recharge using a numerical model | Dr. S. K. singh | 01 year | NIH |
| 4. NIH/GWD/NIH/09-12/ | Impact of Climate Change on Dynamic Groundwater Recharge | Dr. Surjeet Singh (P.I.)<br>Mr. C. P. Kumar<br>Dr. Anupma Sharma<br>Mr. Rajan Vatsa | 3 years (04/09 – 03/12)<br>**New study** | NIH |

## 1. PROJECT REFERENCE CODE: NIH/GWD/NIH/07-09/

**a) Title of the study:** **Quantification of Impact of Rainwater Harvesting on Groundwater Availability in Aravalli Hills**

**b) Date of start:** April 1, 2007

**c) Duration of the study:** Three years (2007 – 2010)

**d) Whether externally funded or not:** Internal funding

**e) Objectives of the study:**

To quantify impact of rainwater harvesting schemes on groundwater availability at micro and macro watershed scale in Aravalli hills.

**f) Brief methodology:**

The technical program of the proposed study comprises the following:

Identification of observation network.
Data collection and monitoring of groundwater levels and stream flows.
Data processing and creation of database on GIS.
Mathematical modeling at micro and macro watershed scale to analyse the hydrological impact of rainwater harvesting schemes.

**g) Progress/Present status:**

Identification of study area – The Savana macro-watershed has been selected for detailed investigations in the Jaisamand Lake Catchment.
Literature review – Relevant literature review carried out.
Data collection – Several field visits to the study area have been undertaken by the scientists working on the project. During the visits, data pertaining to ground water level, water quality, geology and soil were collected in addition to rainfall and other necessary data related to water harvesting structures. Satellite data have been procured to study the landuse and presence of lineaments etc. Data monitoring in Savana watershed was initiated in May 2008. Wells identified for water level monitoring and water levels are being monitored regularly.

Database preparation - Preparation of database on GIS and data analysis is under progress.

Tracer studies – Tracer studies are underway in the watershed that would provide insight into the potential and actual volume of rainwater that can be harvested, along with determining the fate of the harvested rainwater that is recharged to groundwater.

Geophysical and topographic survey – would be completed by March 2009.

Impact of water harvesting schemes studied in Gangeshwar macro-watershed.

**h) Expected date of completion:** March 2010

## 2. PROJECT REFERENCE CODE: NIH/GWD/NIH/08-09/

**a) Title of the Study:** **Vision document on "Mitigation and Remediation of Ground Water Arsenic Menace in India".**

**b) Executing Organization:** NIH and CGWB under the aegis of MoWR.

**d) Date of Start:** September, 2008

**e) Duration:** 8 (eight months)

**f) Whether externally funded:** Funded by the MoWR Resources under the Institute's Plan Fund.

**g) Point wise Objectives:**

To prepare a vision document emphasizing; up to date status of the problem, state-of-art of scientific knowledgebase and technologies available both nationally & internationally, technologies in place, work to be undertaken, roadmap to achieve targets, framework of activities, and methods of operation of the envisages tasks.

**h) Brief Methodology:**

By identifying topic-wise resource persons to prepare different contents of the conceived vision document. After receiving write up on each assigned topic from different resource persons, those will be compiled and edited to put them in appropriate framework.

**i) Progress/Present status:**

Six out of eight chapters have been received from the resource persons. The other two chapters are yet to receive. The document is under compilation and editing stage.

**j) Expected date of completion:** April 31, 2009.

**k) Expected outcomes:**

A National perspective plan and programme document to remediate "Arsenic Menace in India".

## 3. PROJECT REFERENCE CODE: NIH/GWD/NIH/04/07 – 03/09

**a) Title of the study:** **Approximation of well functions for leaky aquifers and large diameter wells**

**b) Study group:** Dr. Sushil K. Singh

**c) Date of start:** 01 April 2007

**d) Duration of the study:** Two years

**e) Whether externally funded?** No

**f) Objectives:**

To develop the computationally simple algebraic approximations for the well functions for leaky aquifers and large diameter wells.
Such functional approximations can avoid tedious process of numerically evaluating these well functions and would be helpful to field engineers and practitioners as these can be worked out on a hand-held calculator for any arbitrary value of the argument.

(The report is completed and placed on the table)

**g) Brief methodology:**

The intended approximations were developed using the tabulated values of the well functions for large-diameter well and leaky aquifers.

**h) Results achieved:**

A computationally simple approximation of the well function for large diameter wells, which can be worked out on a hand-held calculator, has been developed. The developed approximation outperforms the prior such approximations (e.g., by Swamee, P. K., and Ojha, C.S.P; and Cimen, M.). To show the enhanced applicability of the developed function for approximating the well function, it has been applied for obtaining the drawdown due to unsteady pumping discharge. Based upon this part of the study, the following paper has been published in International Journal.

"Singh, S. K., "Approximation of well function for large diameter wells." *J. Irrig. Drain. Eng.*, ASCE, 133(4), Jul/Aug 2007, 414-416." Discussion by Zakai Sen, 134(4), Jul/Aug 2008, 543; Closure by Author, 134(4), Jul/Aug 2008, 543-544.

A computationally simple approximation for the well function for leaky aquifers, which can be worked out on a hand-held calculator, has also been developed. The developed approximation outperforms the prior such approximation (e.g., by Swamee, P. K., and Ojha, C.S.P). To show the enhanced applicability of the developed function for approximating the well function, it has been applied for estimating the leaky aquifer parameters. Based upon this part of the study, the following paper has been accepted for publication in International Journal.

"Singh, S. K., "Approximation of well function and identification of leaky aquifer parameters." *J. Irrig. Drain. Eng.*, ASCE, 134(6), 864-871.

**i) Expected date of completion:** 31 March 2009 The report is completed and placed on the table.

# NEW PROJECT PROPOSALS

## 4. PROJECT REFERENCE CODE: NIH/GWD/NIH/09-10

**a) Title of the study:** **Water table evolution due to subsurface drainage with arbitrary recharge using a numerical model**

**b) Study group:** Dr. Sushil K. Singh

**c) Date of start:** 01 April 2009

**e) Duration of the study:** One year

**f) Whether externally funded?:** No

**g) Point wise objectives:**

To obtain the evolution of water table due to subsurface parallel drains using a numerical model and compare the results with those obtained using the analytical solutions proposed by the writer, under different condition of recharge. The writer's solutions for evolution of water table due to subsurface drains is given in

Singh, S. K., "Generalized analytical solutions for groundwater head in a horizontal aquifer in the presence of subsurface drains." *Journal of Irrigation and Drainage Engineering*, ASCE, accepted.

**h) Brief methodology:**

It intended to use the writer's analytical solutions and a numerical model

**i) Results achieved:**

This is a new proposed study

**j) Expected date of completion:** 31 March 2010

## 5. PROJECT REFERENCE CODE: NIH/GWD/NIH/09-12/

**a) Title of the Study:** **Impact of Climate Change on Dynamic Groundwater Recharge**

**b) Date of Start:** April 1, 2009

**c) Duration of the Study:** Three years

**d) Whether externally funded:** No

**e) Objectives of the Study:**

To quantify the impacts of climate change on groundwater recharge in a part of Sonar basin, Madhya Pradesh.

To simulate the groundwater levels and investigate the temporal response of the aquifer system to historic and future climate periods.

**f) Brief Methodology:**

The technical program of the proposed study comprises the following:

**First Year:** Literature review
Field visits and data collection
Basic data preparation using GIS
Hydrogeological characterization of the study area

**Second Year:** Synthetic generation of daily values of precipitation, mean temperature, and solar radiation (using a weather generator)

Estimation of groundwater recharge based on available precipitation and temperature records and anticipated changes to these parameters (using Visual HELP)

Quantification of the spatially distributed recharge rates using the c limate data and spatial soil survey data

**Third Year:** Simulation of groundwater flow using each recharge data set and evaluation of the changes in groundwater flow and levels on time. Preparation of report.

**g) Milestones and Expected Output / Outcome**

The study will quantify the impact of climate change on groundwater recharge and therefore enable better planning and management of groundwater resources.

**h) Expected Date of Completion:** March 31, 2012

The division is developing one PDS under HP-II in collaboration with Gujarat Water Resources Department on "Coastal groundwater dynamics and management in the Shaurashtra region, Gujarat". The division is expecting one demand driven project on "Study of rising groundwater table in Jodhpur City, and to evolve a management plan to contain the rising trend" from the PHED, Govt. of Rajasthan.

THE 30TH MEETING OF THE NIH WORKING GROUP

# HYDROLOGICAL INVESTIGATIONS DIVISION

आपो हि ष्ठा मयोभुवः

NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

## PROGRESS OF STUDIES AND RESEARCH OF FOR HYDROLOGICAL INVESTIGATIONS DIVISION THE YEAR 2008-09

| S. No. & Reference Code | Project | Project Team | Duration | Funding source |
|---|---|---|---|---|
| 1. NIH/HID/UYRB/06-08 | SW and GW Interaction at Selected Locations Along River Yamuna in NCT, Delhi | Sudhir Kumar<br>M. S. Rao<br>P. K. Garg | 4/06 – 3/09<br>(3 yrs) | UYRB |
| 2. NIH/HID/DST/07-12 | National programme on isotope fingerprinting of waters of India (IWIN) | M.S. Rao<br>B. Kumar<br>Sudhir Kumar<br>S.P. Rai<br>S.K. Verma<br>Pankaj Garg | 7/07 –6/12<br>5 yrs | DST |
| 3. NIH/HID/FRI/08-13 | Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakahand | S.P. Rai<br>Bhishm Kumar<br>J.V. Tyagi | 4/08 – 3/13<br>5 years | FRI |
| 4. NIH/HID/THDC/08-09 | Identification of source and location of seepage in Tehri Dam using isotopic techniques | S.P. Rai<br>Bhishm Kumar<br>Sudhir Kumar<br>S. K. Verma<br>Pankaj Garg +<br>Officials of THDC | 5/08 -3/09 | THDC |
| 5. NIH/HID/CGWB/08-10 | Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes | M.S. Rao<br>Bhishm Kumar<br>Sudhir Kumar +<br>Officials of CGWB | $3^1/_2$ years from the date of approval | HP-II |
| 6. NIH/HID/HP-2/08-13 | Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka | Sudhir Kumar<br>B.K. Purandara<br>S.P. Rai<br>M.S. Rao | $3^1/_2$ years from the date of approval | HP-II |
| 7. NIH/HIDINCID/08-11 | Estimation of irrigation return flow and stream flow regeneration in parts of the selected canal command areas | M S Rao<br>Bhishm Kumar<br>S. K. Verma<br>Pankaj Garg | 2 years from the date of approval from INCID | INCID |

## WORK PROGRAMME OF THE HYDROLOGICAL INVESTIGATIONS DIVISION FOR THE YEAR 2009-2010

| S. No. & Reference Code | Project | Project Team | Duration | Funding source |
|---|---|---|---|---|
| 1. NIH/HID/DST/07-12 | National programme on isotope fingerprinting of waters of India (IWIN) | M.S. Rao<br>B. Kumar<br>Sudhir Kumar<br>S.P. Rai<br>S.K. Verma<br>Pankaj Garg | 7/07 –6/12 (5 yrs) | DST |
| 2. NIH/HID/FRI/08-13 | Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakahand | S.P. Rai<br>Bhishm Kumar<br>J.V. Tyagi | 4/08 – 3/13 (5 years) | FRI |
| 3. NIH/HID/CGWB/08-10 | Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes | M.S. Rao<br>Bhishm Kumar<br>Sudhir Kumar +<br>Officials of CGWB | 10/08-3/12 ($3^1/_2$ yrs) | HP-II |
| 4. NIH/HID/HP-2/08-13 | Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka | Sudhir Kumar<br>B.K. Purandara<br>S.P. Rai<br>M.S. Rao | 10/08-3/12 ($3^1/_2$ years) | HP-II |
| 5. NIH/HIDINCID/08-11 | Estimation of irrigation return flow and stream flow regeneration in parts of the selected canal command areas | M S Rao<br>Bhishm Kumar<br>S. K. Verma<br>Pankaj Garg | 2 years from the date of approval from INCID | INCID |
| 6. NIH/HID/NIH/2009-12 (NEW) | Hydrological Investigations of Pushkar Lake (Raj.) for Conservation and Management | S.D. Khobragade<br>Sudhir Kumar<br>S. P. Rai<br>M. S. Rio<br>Sh. S. K. Verma | 4/09-3/12 ( 3 yrs) | NIH |

## 1. PROJECT REFERENCE CODE: NIH/HID/UYRB/2006-08

**a) Title of the study:** **Surface Water and Groundwater Interaction at Selected Locations along River Yamuna in NCT, Delhi**

**b) Study Group:** Sudhir Kumar, M. S. Rao, P. K. Garg

**c) Date of Start:** April 2006

**d) Duration:** 2 years, Extended upto 31st March, 2009

**e) Funding:** UYRB through MOWR

**f) Objectives:**

i) To study the surface water and groundwater interaction along river Yamuna in National Capital Territory of Delhi.

ii) To identify the areas where the contribution of river water to groundwater is more than natural and the reasons thereof.

**g) Brief Methodology**

***Isotopic Approach***

Isotopic tracers provide a mean for identifying the actual mass transport of water in the hydrologic cycle. The approach is based on the fact that the rivers originating at higher altitudes have a different stable isotopic composition than that of the local precipitation in plains. The stable isotopic composition ($\delta^{18}O$) of the Yamuna River water is more depleted (-8 $^{0}/_{00}$ to –12 $^{0}/_{00}$) than that of groundwater derived from infiltration of local precipitation (– 5 $^{0}/_{00}$ to – 6 $^{0}/_{00}$). Therefore, stable isotopes of hydrogen and oxygen can be used to determine the contribution of groundwater to river or vice versa.

***Groundwater Modelling Approach***

Surface and groundwater interaction would be analysed using modelling approach. A 3-dimensional groundwater model, MODFLOW, would be calibrated to the field conditions to corroborate and compliment the isotopic approach used in the study. This approach will help in assessing the groundwater, flood recharge and river boundary components that contribute to the pumping.

**h) Progress / Present Status**

i) Groundwater samples have been collected from twenty one existing wells (19 shallow hand pumps, 1-shallow tube well, 1-renney well) located along 4 cross sections across the Yamuna River along with two samples from the river in the month of June, August and September 2006.

ii) Ten piezometers were installed (5 each on both sides of the river) in June 2007. Groundwater samples are being collected from these constructed piezometers since July 2007. GW samples along one more cross-section (from exiting hand pumps near village Jhangola) are also being collected.

iii) Eight new piezometers have been installed on the Delhi side in August/September 2008. Out of these 8 piezometers, 3 are installed between river and the line of pumping wells and remaining 5 to the west of pumping line, i.e., towards Delhi.

iv) Grain size analysis of the soil samples collected during the drilling of the piezometers has been completed. The subsurface sediments are mostly sand and loamy sand in texture. Sand percentage in most of the samples is >90%.

v) Water level at 15 days interval is being measured since July/August 2007 on both the sides of the River Yamuna.

vi) Isotopic analysis of the samples collected till 27$^{th}$ Dec 2008 has been completed.

vii) Raingauge has been installed in July 2007 for collecting the rain samples. The rain water samples have been collected during the monsoon 2007 and analysed. The isotopic ratios of $\delta^{18}O$ in rain varies from -0.41$^0/_{00}$ to -9.23$^0/_{00}$.

viii) Groundwater (developed due to rainfall recharge) has the isotopic composition varying between a narrow range of -6.6$^0/_{00}$ to -7.00$^0/_{00}$.

ix) Within the floodplain of river Yamuna in Palla area, $\delta^{18}O$ in groundwater varies between -5.6$^0/_{00}$ to -11.9$^0/_{00}$, between -6.6$^0/_{00}$ to -12.30$^0/_{00}$ in the river water and between -6.9$^0/_{00}$ to -8.1$^0/_{00}$ in pumped water.

x) Velocity of groundwater in the river bed is estimated to be 2m/d whereas in the flood plain (between PZW-1 and PZW-2) it is 1 m/day.

xi) PZW-4 seems to be lying in a paleochannel, as the isotopic composition in this well is not commensurate to the isotopic composition in PZW-3. It shows much depleted values of $\delta^{18}O$ (upto -11.9$^0/_{00}$) which has not been observed in any other piezometer.

xii) Component of river water in pumped water varies from month to month and vary in the range of 9 to 45 %.

**i) Expected Date of Completion:** March, 2009

## 2. PROJECT REFERENCE CODE: NIH/HID/DST/07-12

**a) Title of the study:** **National Programme on Isotope Fingerprinting of Waters of India (IWIN)**

**b) Study Group:** M.S. Rao, B. Kumar, Sudhir Kumar, S.P. Rai, S.K. Verma, Pankaj Garg

**c) Date of Start:** July 2007

**d) Duration:** 5 years

**e) Funding:** DST

**f) Participating Organizations:** PRL, **NIH**, BARC, NRL (IARI), NIO, NGRI, CPCB, CWC, CGWB, IMD, CRIDA, IIT-KGP, Anna Univ.

**g) Objectives**

i) Identifying Regional/local water vapour components in the local atmosphere.
ii) Quantifying the partitioning of vapours into rain and re-partitioning of rain into various components as evapotranspiration, soil moisture, stream flow* and groundwater* (*these samples will be collected by the participating organizations).
iii) Residence time of vapour/water in different inland hydrological units.
iv) Atmospheric/surface water/groundwater interaction on seasonal and spatial basis.
v) Developing a web resource for isotope hydrology data-base of the Indian sub-continent.

**h) Brief Methodology (Work component to be carried out by NIH)**

(i) Sample collection:
a) Daily sampling of atmospheric moisture from near ground level and from 17.6 m height at NIH, Roorkee and near ground level at R.C. Sagar.
b) Sampling of precipitation at Roorkee and Sagar.
c) Weekly sampling of River Ganga from Upp. Ganga Canal, Roorkee.

d) Fortnightly sampling of groundwater from depths approx. 10 m & 40 m at Roorkee and monthly sampling from shallow aquifer at Sagar.

(ii) Analysis: □D, □$^{18}$O analysis of river water, groundwater, precipitation and atmospheric moisture, and $^{3}$H analysis of river and groundwater samples.

(iii) Data collection: Meteorological and hydrogeological data from State/Central Organizations.

(iv) Interpretation of data: Final interpretation of the data will be carried out jointly with IWIN member organizations at PRL, Ahmedabad.

**i) Results Achieved With Progress / Present Status:**

- Samples collected: As per the existing criteria of sample collection, during the period 2008-09, 1637 samples were collected at NIH, Roorkee and Sagar. These include atmospheric moisture, rainwater, groundwater and river water. The summary of the samples analyzed is given in Table.

**Table:** Summary of the samples collected and analyzed

| Station | Sample type | Frequency | No. of samples collected & analyzed | |
|---|---|---|---|---|
| | | | Since March 2008 (up to Jan-09) | Since July, 2007 |
| Roorkee | Atmos. Moisture | 1/day | | |
| | * using Ice | | 444 | 587 |
| | * using $LN_2$ (all hts) | | 487 | 487 |
| | * Using $LN_2$ (nr. Grnd) | 8/day (once in a month) | 83 | 86 |
| | Rain samples | Event based | 36 | 36 |
| | Groundwater | Twice/month | 182 | 241 |
| | Upper Ganga Canal | Weekly | 60 | 101 |
| Sagar | Atmos. Moist. (Ice) | 1/day | 312 | 484 |
| | Rain water | Event Based | 22 | 33 |
| | Groundwater | Monthly | 11 | 18 |
| Total Samples Analyzed | | | 1637 | 2073 |

- During the project period 942 samples from IWIN member group (AU-265, PRL-305, BARC-324 and NRL-48) were received for isotopic analysis.
- Stable isotope analysis of all the samples collected as per the existing criteria, as per the new experiment and from the IWIN member group was analyzed.
- In order to examine isotopic variation over 24 hours in a day, an experiment was conducted. Atmospheric moisture was collected at 3hourly interval for 24 hrs period in the last week of each month. The experiment was commenced in October 08.

***Data Interpretation:***

The isotopic data for the water vapour, collected at NIH, Roorkee, have been plotted with time and absolute humidity in order to understand the temporal variation. Short term and long term data have been plotted separately (see figures below).

The short term data is plotted for 4 months for period from Oct-08 to Jan-09 (figure 1). The data indicates variation of isotopic composition of atmospheric moisture over day and night and for months October to January. The minor variation in isotopic composition of vapour in day and night is probably due to the vertical dynamics of water vapour. The 24hrs data shows most depleted isotopic composition of water vapour at 3 pm. Thereafter, the isotopic composition of vapor starts enriching and between 6pm to night 12 it saturates. The extent of depletion and enrichment varies over different months. Depletion is ~2‰ more in the winter months (December-January) than during post monsoon (Oct-Nov).
The seasonal aspects of isotopic changes are more clearly visible in the long term

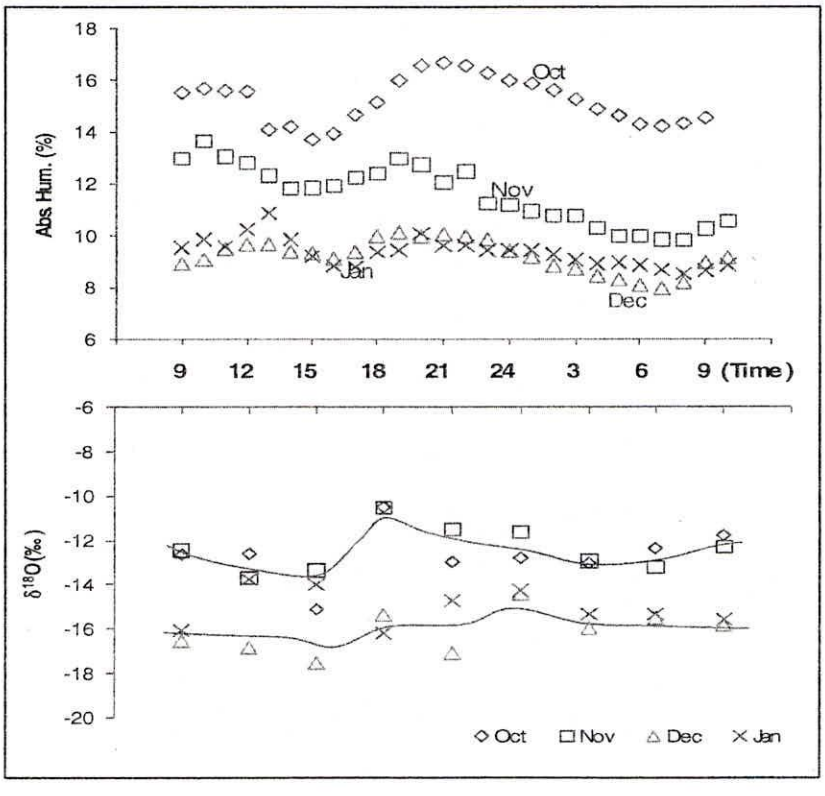



**Figure 1:** Variation of absolute humidity and $\delta^{18}O$ in atmospheric moisture in 24 hrs between Oct-08 to Jan-09 (Samples were collected in the last week of the month).

isotopic data (figure 2). The data presented in the figure is for the period Apr. 06-Jan. 09. From the isotopic plot it can be seen that atmospheric vapour is most depleted (depletion in $\delta^{18}O$ is ~20‰) in the monsoon season. It is clearly seen in the $D_{excess}$ data that with the arrival of monsoon vapours (on set of monsoon) Dexcess peaks up above the background. At peak monsoon $D_{excess}$ is 40‰ above the background. With the withdrawal of the monsoon vapours $D_{excess}$ decreases and ultimately reaches to its background. Thus the isotopic data of atmospheric moisture appears to be useful in deciphering weather and climate details.

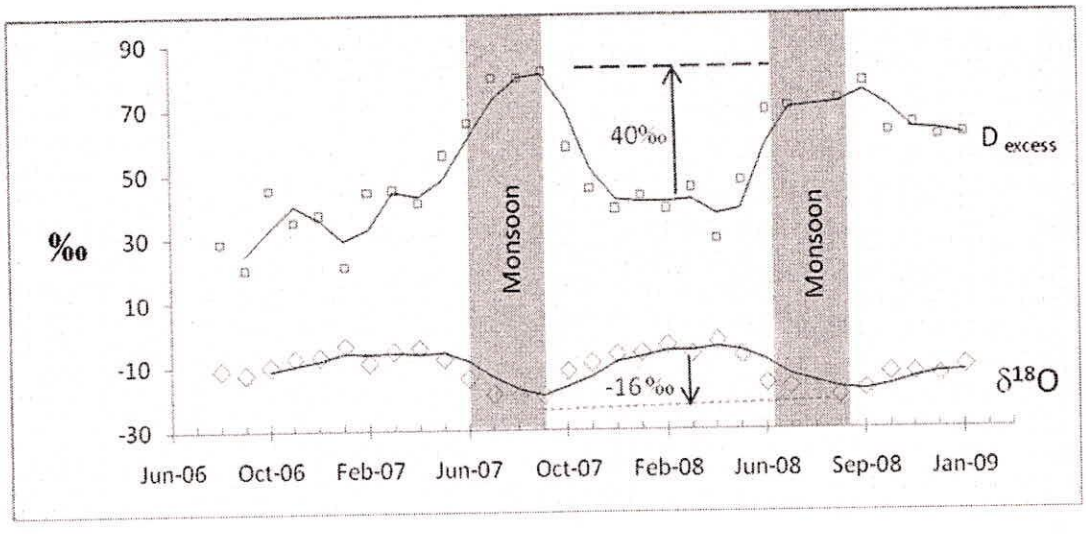



**Figure 2**: Seasonal variation of $D_{excess}$ and $\delta^{18}O$ for the period Aug. 06 to Jan.09

**j) Expected Date of Completion**: June, 2012

## 3. PROJECT REFERENCE CODE: NIH/HID/FRI/08-13

**a) Title of the study:** Impact Assessment of Landuse on the Hydrologic Regime in the Selected Micro-watersheds in Lesser Himalayas, Uttarakhand

**b) Study Group:** S.P. Rai, Bhishm Kumar, J. V. Tyagi (NIH) and Rajeev Tiwari (FRI)

**c) Date of Start:** March 2008

**d) Duration:** 5 Yrs

**e) Funding:** Rs. 3.5 lac, Forest Research Institute, Dehradun

**f) Objectives:**

i) Impact of forest cover on stream discharge pattern.
ii) To separate surface runoff & ground water components in the stream discharge using conventional and isotopic technique
iii) Soil erosion under different forest cover.
iv) Identification of recharge zone of stream & springs using isotopic techniques
v) To define the role of forest on hydrological regime

**g) Brief Methodology:**

- Two micro-watersheds with different forest covers having almost same geological and geographical features have been selected.
- Input parameters such as (precipitation, Infiltration, Temperature, Humidity, forest cover) and output parameters such as (discharge, sediment load, evaporation, evapotranspiration) of micro-watersheds are being monitored using auto and manual instruments.
- Stable isotopes of oxygen and hydrogen, environmental radioisotopes like Cs-137, Pb-210 and H-3 will be used for the study of recharge zones, hydrograph separation and soil erosion pattern along with conventional techniques.

## h) Progress / Present Status

The Arnigad watershed covers an area of 2.85 $km^2$ under Oak forest and Bansigad watershed covers an area of 1.3 $km^2$ under degraded oak and pine mixed forest have been selected to study the hydrological response under varied forest cover. The $120^0$ 'V' Notch and automatic water level stage recorder have been installed in these watersheds for monitoring the continuous stream discharge. Meteorological observatories have been installed near the outlet of each watershed for monitoring the rainfall, temperature, humidity and evaporation etc. The continuous data haave been recorded since June onwards. For isotopic characterization of rain and streams, 200 and 300 water samples, respectively, from each categories have been collected for measuring $^{18}O$ and D analysis and also for $^{3}H$ analysis.

The average air temperature varies between $15.5^0C$ (minimum) and $25^0C$ (maximum) in degraded watershed and $18^0C$ to $22^0C$ in forested watershed. The relative humidity is observed minimum in summer months and maximum in rainy months. The evaporation rate varied from minimum 2.5 mm/day in rainy months to maximum 6 mm/day in summer months. Discharge in degraded watershed varied between minimum $0.01 m^3$/sec in the month of June and maximum 1.02 $m^3$/sec in the month August while in forested watershed it is observed minimum between 0.05 $m^3$/sec in the month of June and maximum 0.88 $m^3$/sec in the month of August. In the both the watersheds response of the rain to discharge is very quick. Figures shows relationship between the rainfall and discharge during monsoon season 2008.

At Bansigad site, the $\delta^{18}O$ of rain varies between minimum –21.2 ‰ in the month of September to maximum 2.6 ‰ in the month of June. In stream water, $\delta^{18}O$ varies from -12.9 ‰ in the month of August to -7.5 ‰ in the month of June. At Arnigad site, the $\delta^{18}O$ of rain varies between minimum –16.7 ‰ in the month of August to maximum 5.7 ‰ in the month of May. In stream water, $\delta^{18}O$ varies from -9.9 ‰ in the month of August to -7.56 ‰ in the month of May. The depleted isotopic signature during rainy months and enriched values during pre-monsoon months reveals the seasonal variations due contribution from rain and subsurface flow.

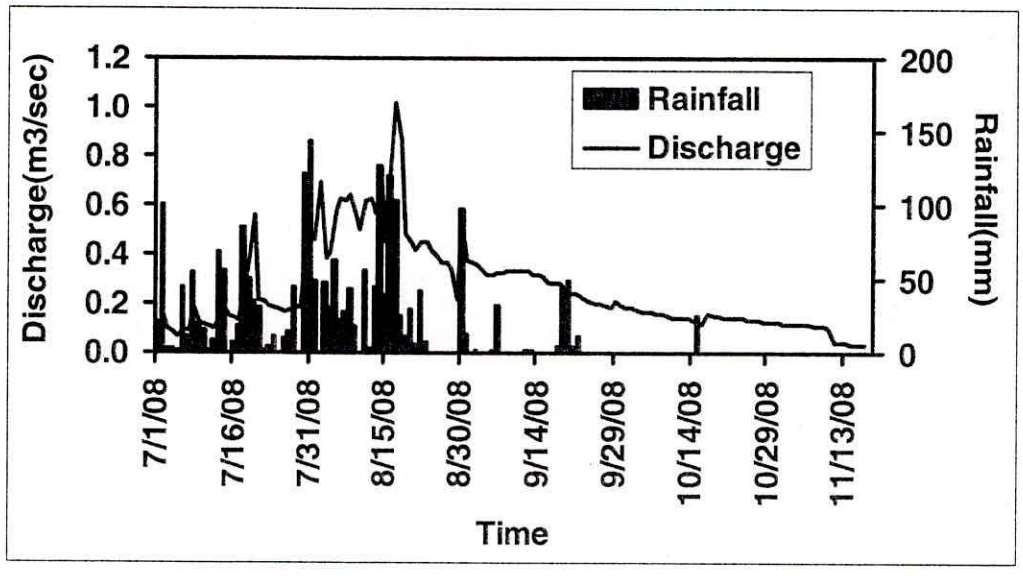



Figure 1: Variation of discharge with rainfall on daily basis at Bansigad site

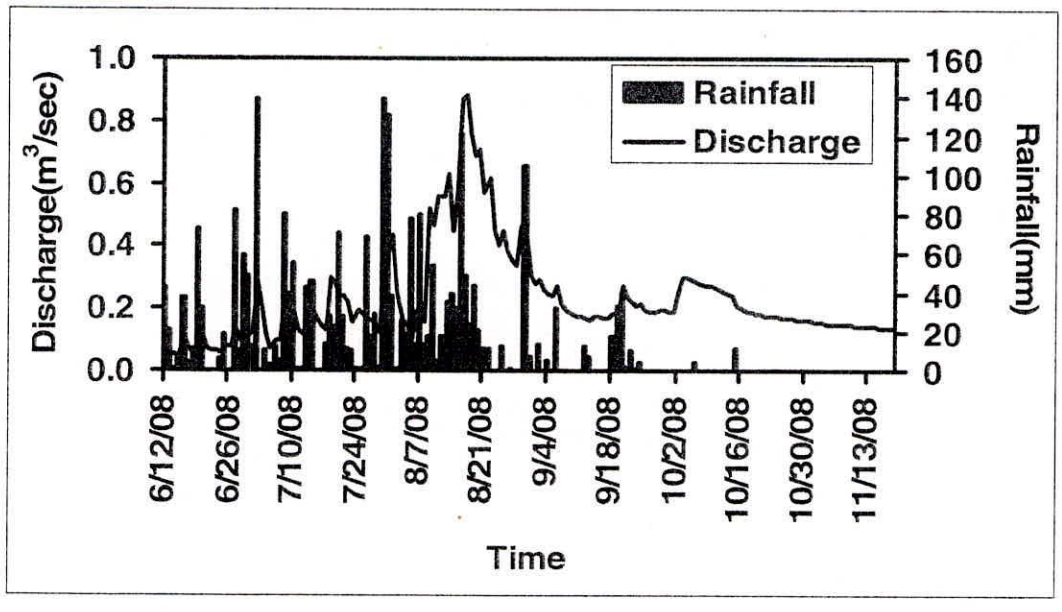



Figure 2: Variation of discharge with rainfall on daily basis at Arnigad site

The sediment discharged from both the watersheds has been measured on the basis of daily sampling during monsoon period. The suspended concentration in stream water discharged through V notch at forested watershed found minimum 2 mg/l during summer month to maximum 8170 mg/l during rainy period and 2 mg/l to maximum 5860 mg/l is recorded from degraded watershed of Bansigad.

i) **Expected date of completion:** March, 2013

## 4. PROJECT REFERENCE CODE: NIH/HID/THDC/08-09

| | |
|---|---|
| **a) Title of the study:** | **Identification of Source and Location of Seepage in Tehri Dam Using Isotopic Techniques** |
| **b) Study Group:** | S.P. Rai, Bhishm Kumar, Sudhir Kumar, S.K. Verma, Pankaj Garg + THDC Officials |
| **c) Date of Start:** | March 2008 (started in May 2008) |
| **d) Duration:** | 1 Yr |
| **e) Funding:** | Respective funding from both organizations (THDC and NIH) |

**f) Objectives :**

Identification of source and location of seepage in Tehri Dam

**g) Brief Methodology**

- Stable isotopes of oxygen and hydrogen, environmental radioisotopes like H-3 and artificial radioisotope like Au-108 will be used for the identification of seepage source/s and location.
- If required, hydrgeological and hydrochemical studies will be carried out to identify the location of seepage points in reservoirs in the second phase.

**h) Progress / Present Status**

Tehri dam is a 260.5 m high earth and rockfill dam and presently is in operation stage. For relieving the water pressure in the d/s abutments of dam, a network of drainage galleries has been provided. During the filling and depletion of reservoir, quantum of seepage through various drainage galleries is being regularly observed. High seepage discharge has been observed from few locations in the drainage galleries i.e., AGR3 and AGIR. In order to identify the source of seepage, water samples are being collected from high seepage discharge points, reservoir and other sources like drains, springs (groundwater) and precipitation. Water sampling has also been carried out from the different locations in the reservoir covering its complete width and depth. Samples have been analysed for stable isotopes of oxygen and hydrogen till Dec. 2008.

Leakages are mainly from two drainage galleries, namely, AGR-3 and AGIR. Leakage samples were collected at three sites (D5, D6 and D7) of CH. 246 of Gallery AGR-3. In case of AGIR Drainage Gallery, three samples from three different CH. named as CH.155, CH. 185 and CH. 241 were collected from sites D9, D10 and D11, respectively. Apart form these leakages, the daily reservoir samples were collected from the reservoir surface (D12) for isotopic analysis. The daily reservoir level and discharge from the leakages were also collected. Additionally, temperature of water samples at the time of collection is also being monitored.

The plot of reservoir level (RL) with discharge from leakages reveals that as RL reaches at the level of 780 m, the discharge from AGR-3 Drainage Gallery (combined discharge of D5, D6 and D7) gallery shows the increasing trend and this trend continues up to the level of 791 m. As the reservoir level rises above the 791 m, there is no marked increase in discharge of leakage from AGR-3 gallery. In case of AGIR Drainage gallery, the discharge shoots up when the RL touches the level of 794 m and this trend continues up to the level of 820 m. Fig 1 shows the variation of discharges from AGR-3 and AGIR Galleries with reservoir level.

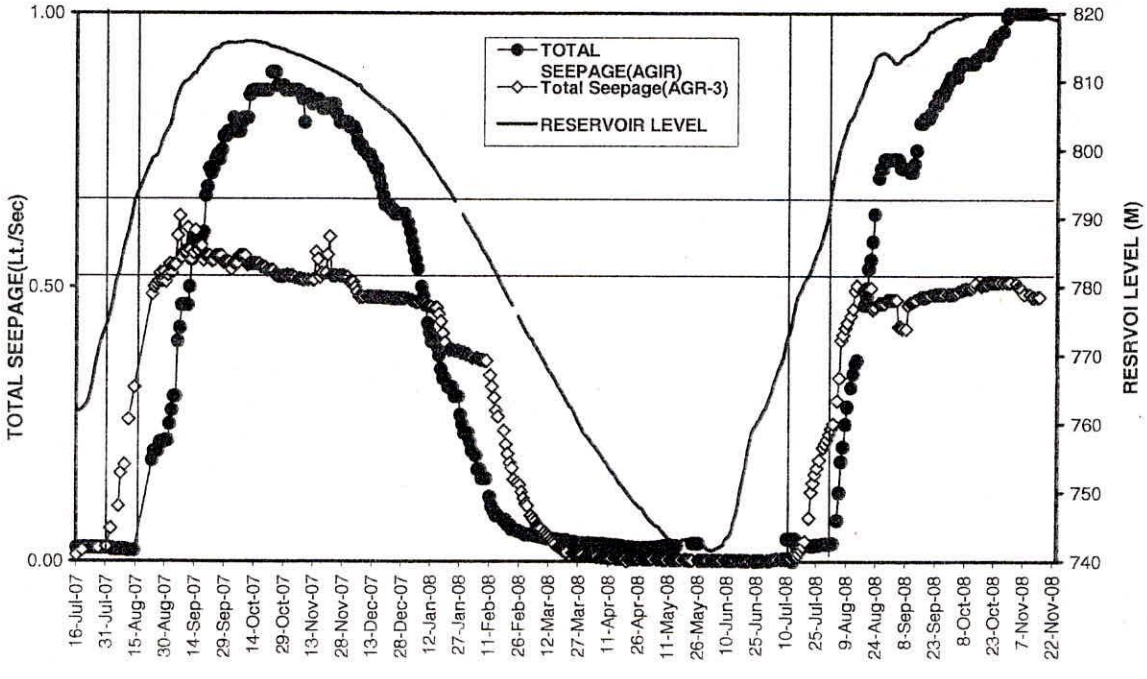



Fig. 1: Variation of reservoir level and discharge from leakage points.

As per the available $\delta^{18}O$ data of the leakage sites in AGR-3 Drainage Gallery (D5, D6 and D7) matches with the reservoir $\delta^{18}O$ during the month of August and September when reservoir level is between 800 m to 810 m. September onwards trend is similar but isotopic values differ. The $\delta^{18}O$ of sites D10 and D11 of AGIR gallery matches with the reservoir signatures when reservoir levels reaches to 805 m and continue up to 820 m level. However, the $\delta^{18}O$ values of the D9 differ from the reservoir values. This clearly indicates that the source of increased discharged during the Monsoon months through the D5, D6, D7, D10 and D11 is reservoir while D9 seems to be not connected with the reservoir. In case of D10 and D11 the isotopic results corroborate the trend of reservoir level Vs discharge of the gallery AGIR. Thus it looks that the fractures responsible for leakage in AGIR Gallery are located above the reservoir level of 800 m. The reservoir level Vs discharge from the AGR-3 gallery indicate that the fracture responsible for leakage lies between 780 m to 800m. The isotopic data of reservoir and gallery are missing when the reservoir level rises from the 750 m to 780 m. However, to confirm the location of seepages continuous samples are required from the leakage and reservoir sites.

i) **Outcome**

Source of leakages for the sites D5, D6, D7 of drainage gallery AGR-3 and D10 and 11 of AGIR is reservoir while D9 is not connected with the reservoir. In case of AGR-3, the fractures responsible for the leakage lie between 780 to 800m. In case of AGIR, fractures lie when the reservoir level is between 800m to 820 m. However, for further confirmation about the location, continuous data during the increasing and recession period of leakage is required.

j) **Expected Date of Completion:** March, 2009

## 5. PROJECT REFERENCE CODE: NIH/CGWB/08-10

**a) Title of the study:** **Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes**

**b) Study Group:** M.S. Rao, Bhishm Kumar, Sudhir Kumar + Officials of CGWB

**c) Date of Start:** October, 2008

**d) Duration:** $3^1/_2$ years

**e) Funding:** MoWR

**f) Participating Organizations:** CGWB, NWR, Chandigarh.

**g) Objectives**

i) Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope technique
ii) Groundwater modelling

**h) Brief Methodology (Work component to be carried out by NIH)**

i) Sample collection: surface and groundwater at regular intervals.
ii) Data Collection: Hydrogeological, hydrometeorological, topographical data
iii) Generating various thematic maps: Land use, soil map, aquifer geometry etc.
iv) Measurements: Chemical, stable and radioactive analysis of samples.
v) Interpretation: Integrated analysis of sample data with the hydregeological data to identify recharge zones, recharge sources and flow pattern
vi) Modeling of groundwater

**i) Results Achieved With Progress / Present Status:**

1) The first meeting of the team members of the participating organizations NIH-CGWB was held on 11th December, 2008 in the NIH Roorkee to prepare the work-plan for the year 2008-09.
2) In the last week of Jan-09, a field survey in the BIST Doab was carried out. Emphasis was given on sample collection along the river banks with

special emphasis on the region of upper reaches. 26 samples including river, canal and groundwater were collected. All the samples were analyzed for □$^{18}$O and □D.

The graphical representation of the analyzed data along with Meteoric Water Line (MWL) for north region is shown in the figure below provides the following information:

1. Groundwater in Bhabhar/Siwalik region falls on the MWL.
2. The most depleted isotopic values of groundwater in the Bhabhar/Siwalik region suggest isotopic index for rainfall (□$^{18}$O, □D) ~ (-6‰, -39‰) respectively.

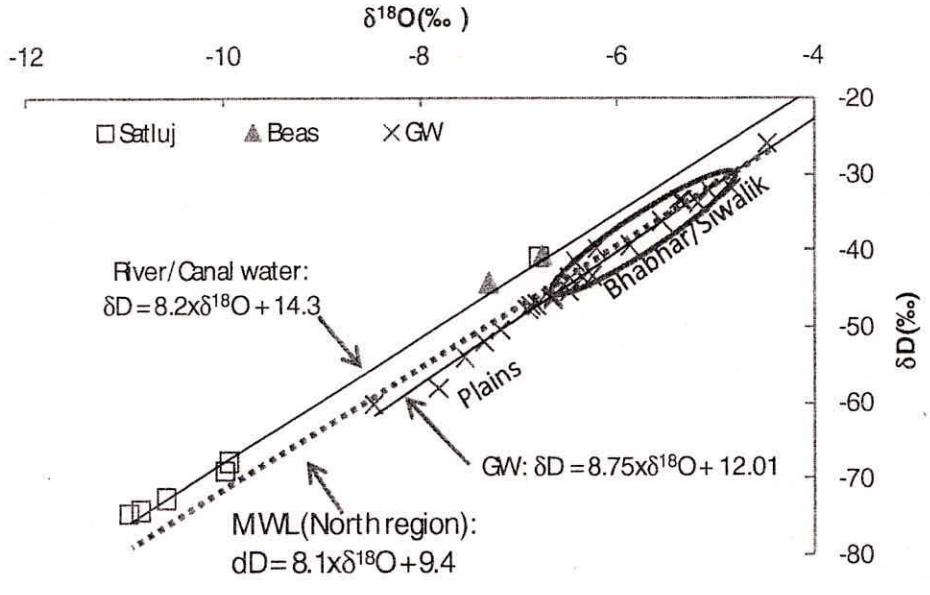



**Figure:** Isotopic characteristic of groundwater and surface water in BIST Doab. (samples were collected in the last week of Jan. 09)

3. The isotopic trend line for river/canal water with its slope value similar to MWL but with higher intercept ($D_{excess}$ = 14.3) suggest that this water is originated by recycling of evaporation and re-condensation of local surface water. Such a scenario is likely to exist in the present situation as these rivers originate from Bhakra and Pong reservoirs.
4. Isotopic composition of groundwater in plains (□$^{18}$O ~-8‰) is about 2‰ more negative with respect to groundwater in Bhabhar/Siwalik region (□$^{18}$O ~6‰). This depletion indicate a probable mixing of Satluj river water (□$^{18}$O ~ -10.5‰) addition to the direct rainfall recharge.

The results thus suggest (a) groundwater in Siwalik/Bhabhar region is formed from direct precipitation and (b) groundwater in plains from the combination of direct precipitation with a component from recharge through river/canal seepage.

The groundwater recharge zones for the recharge from the sources viz., river, canal and direct precipitation can be mapped on dating groundwater from multiple aquifers.

j) **Expected date of Completion:** March, 2012

## 6. PROJECT REFERENCE CODE: NIH/HID/HP-2/08-13

**a) Title of the study:** **Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka.**

**b) Date of Start:** October 2008 (Expected)

**c) Duration:** 3 ½ years.

**d) Funding:** MOWR (PDS under HP-II)

**e) Objectives**

i) To analyze groundwater productivity at specific study sites including artificial recharge structures and an assessment of potential increases and their contribution to rural livelihood improvement.

ii) To develop integrated understanding of hydrologic, social, economic, and institutional perspectives.

iii) To improve stakeholder engagement and community participation for developing a common vision, goal and partnership for managing Basin's groundwater resources.

iv) To identify anthropogenic interventions and evaluate their likely impact for effective groundwater management.

v) To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis.

**f) Brief Methodology**

The problem requires a comprehensive multi-institutional, multi-disciplinary and multi-locational study approach. The State Groundwater Departments would provide crucial inputs pertaining to hydro-geology, hydrology, land use etc. Inputs from NGO's and other stake holder's will also be considered. Conjunctive use of surface/ groundwater, artificial recharge/ draft regulation and institutional interventions would be crucial decision variables. After a detailed understanding of hydro-geology, hydrology and land use practices, conceptual and real-life models (specific and general) would be developed, within Simulation-Optimization framework (Rao et al 2004, 2006) to arrive at policy guidelines for managing and regulating the groundwater resources by state agencies. Insight

obtained from groundwater modeling and experience of groundwater hydrologists/ hydro-geologists will be used in arriving at policy guidelines which will be the basis for optimal groundwater management. The project will seek to build strong linkages between stake holders and regulating agencies through capacity building strategies for effective groundwater governance and harmonized groundwater use.

Steps of the proposed methodology are as follows:

i) Selection of Watersheds: Two watersheds have been be selected
ii) Assessment of data availability and data gap
iii) Technology development: This will involve following subheads.
a) Reconnaissance surveys
b) Data base development: Spatial, temporal, socio-economic
c) Digitization of data
d) Integration of data
e) Procurement of equipment/ software and field interventions
f) Consultancy support
g) Groundwater assessment, modeling and calibration
h) Groundwater management modeling and future scenarios
i) Optimal Policy evaluation for sustainable development and management
iv) Organizational of capacity building
v) Training of stakeholders
vi) Scope of extension/ replication to other study areas

**g) Progress / Present Status**

The detailed project proposal was submitted to HP-II cell in June 2008. The same has been approved by HISMG (TECH) on 11/07/2008. Two watersheds have been identified in the Tumkur and Chitradurga districts. The instruments are being procured and the staff is being engaged to start the work in these watersheds.

**h) Expected Date of Completion:** March, 2012

## 7. PROJECT REFERENCE CODE: NIH/HID/INCID/08-11

**a) Title of the study:** **Estimation of irrigation return flow and stream flow regeneration in parts of the selected canal command areas**

**b) Study Group:** M S Rao, Bhishm Kumar, S K Verma, Pankaj Garg, O. P. Dubey (WALMI, Lucknow)

**c) Date of start:** from the date of approval- awaited

**d) Duration:** 2 years

**e) Funding:** Rs. 39,77,200/-, for NIH (Total Funding Rs. 54,68,400/-) (INCID, MoWR (Approval Awaited)

**f) Objectives**

i) Estimation of irrigation return flow in different types of soils and crops in the selected canal command areas (two) using isotopes.
iii) Development of suitable mathematical formulation for estimation of irrigation returns flow with rainfall/irrigation and soil type/ type of crops.

The study will also answer the questions like,

i) Irrigation return flow to different crops in different seasons
ii) Irrigation return flow in different types of soils
iii) Relation among different influencing parameters like rainfall, type of soil, crop and irrigation return flow

**g) Brief methodology:**

- Procurement of data for sub-surface strata, water table, groundwater draft, hydrometerological data, remote sensing data, land use, cropping pattern, soil map water demand, and literature related to the work carried out in the study area by different institutions/organizations.
- Generating study area maps, drainage, field map, DEM etc.

- Field survey to identify suitable sites for sample collection for isotope analysis and groundwater inventory for water quality survey.
- Collection of groundwater/surface-water for tritium dating and stable isotopic analysis.
- Collection of soil samples and injection of tritium in the identified sites before sowing of crops.
- Collection of soil samples after the crop harvesting.
- Analysis of soil samples for the measurement of volumetric moisture content, bulk density, particle size analysis etc. for both the set of soil samples.
- Distillation of soil moisture from second set of soil samples and its analysis for injected tritium. Estimation of irrigation-return-flow for different crop/soil pattern.
- Measurement of $^{3}H$ (environmental and artificially injected, both), $^{2}H$ and $^{18}O$.
- Correlation maps between measured isotopic data, salinity and water table. Interpretation of results.
- Modelling of groundwater flow and regeneration flow component using field & laboratory data
- Preparation of reports and research contribution.

**h) Progress/ Present Status**

The INCID Sub-committee-III approved the project technically in the meeting held on 22$^{nd}$ Jan 2008 with a suggestion to revise the project to include the regeneration flow component and to add ground water quality aspects. Accordingly, the project was revised and submitted to the committee in March, 2008. The project will start as soon as the approval will be received.

**i) Expected date of completion**: 2 years from the date of approval

# NEW PROJECT PROPOSALS

## 8. PROJECT REFERENCE CODE: NIH/HID/PUSHKAR/2009-12

**a) Title of the study:** **Hydrological Investigations of Pushkar Lake (Rajasthan) for Conservation and Management**

**b) Study Group:** S. D. Khobragade, Sudhir Kumar, S. P. Rai M. S. Rio, Sh. S. K. Verma

**c) Date of Start:** April, 2009

**d) Duration:** 3 Yrs (2009-2012)

**e) Whether externally funded or not:** No

**f) Objectives:**

(i) Water availability status of the lake
(ii) Energy balance and hydrodynamics of the lake
(iii) Sedimentation rate and expected life of the lake
(iv) Water quality and other pollution aspects of the lake
(v) Measures for systematic management and conservation of the lake

**g) Brief Methodology:**

All available data/literature/maps related to Pushkar Lake would be collected. Daily data of hydro-meteorological parameters of last 10 years would be purchased form IMD. Bathymetric survey of the lake would be conducted using the echo sounder/plane table survey and depth area depth area capacity curve would be prepared. Land use map of the lake would be prepared using remote sensing technique. Water samples from the lake would be collected and analyzed in the laboratory for both water quality and isotope analysis. Lake evaporation would be estimated using the energy balance of the lake. Various components of the energy balance would be estimated using the hydro-meteorological data. Net radiometer and evaporation pan would be installed in the vicinity of the lake.

Regular measurement of depth wise temperatures would be carried out. Water availability in lake would be studied using the water balance. Inflow and out flows from the lake would be monitored. Automatic water level recorder would be installed. The detailed analysis of the sedimentation as well as groundwater lake interaction would be carried out using the isotope techniques. Functional open wells in the lake catchment would be identified and water levels in them would be monitored on monthly basis. Health of the lake as well as extent of eutrophication would be assessed from the collection and analysis of the water quality data of the lake.

h) **Milestones and Expected Output:**

The final output of the study will be in the form of a comprehensive report where in the various finding/data/maps etc would be incorporated. Attempt would be made to assess the impact of easterly movement of the Thar desert on the sedimentation of the lake. Attempt would also be made to study the impact of the annual cultural event on the water quality of the lake. Specific recommendations for conservation and proper management the lake would be made based on the findings of the study.

i) **Expected date of completion:** March, 2012.

The work programme of the Division for the year 2008-09 is given in Annexure-I while the work programme proposed for the year 2008-09 is given in Annexure-II

# THE 30TH MEETING OF THE NIH WORKING GROUP

## SURFACE WATER HYDROLOGY DIVISION

आपो हि ष्ठा मयोभुवः

**NATIONAL INSTITUTE OF HYDROLOGY**
**ROORKEE-247667**

## WORK PROGRAMME OF SURFACE WATER HYDROLOGY DIVISION FOR THE YEAR 2008-09

| S. No. & Reference Code | Project | Project Team | Duration | Funding Source |
|---|---|---|---|---|
| 1. NIH/SWD/NIH/07-09 | Development of Drought vulnerability indices for preparedness and mitigation | RP Pandey<br>A Aggrawal<br>Sanjay K Jain<br>Omkar Singh | 2 years (July 2006 to July 2008) plus extended period | INCOH |
| 2. NIH/SWD/NIH/08-09 | Impact of climate change on the flow characteristics of beas river at pandoh dam site | A.K. Lohani<br>Sanjay K. Jain<br>Manohar Arora<br>R. D. Singh | 1 year | NIH |
| 3. NIH/SWD/NIH/08-09/ | Impact of climatic change on the flow characteristics of a sub-basin of Ganga Basin (Bhagirathi Basin up to Tehri Dam) | Sanjay Kumar<br>Sanjay Kumar Jain<br>R. D. Singh<br>Rakesh Kumar | Feb. 2008 to March 2009 | NIH |
| 4. NIH/SWD/NIH/08-09 | Assessment of environmental flow requirements in river Ganga at Loharinag Pala project site | R. D. Singh<br>Manohar Arora<br>Rakesh Kumar | 1 year | NTPC |
| 5. NIH/SWD/NIH/08- | Monitoring and modelling of streamflow for the Gangotri Glacier | Manohar Arora<br>Rakesh Kumar | To be continued | NIH |
| 6. NIH/SWD/NIH/07-09 | Modelling of suspended sediment concentration using Artificial Neural Networks | A. R. Senthil Kumar<br>A. Aggarwal<br>R. D. Singh | 2 years | NIH |
| 7. NIH/SWD/NIH/05-10 | Integrated Hydrological Study for Sustainable Development of two Hilly Watersheds in Uttaranchal | Avinash Agarwal<br>R P Pandy<br>S P Rai<br>S K Singh | 5 years | DST |
| 8. NIH/SWD/NIH/07-10 | Hydrological studies in a forested watershed in Uttarakhand | J.V. Tyagi<br>Rakesh Kumar<br>Digamber Singh | 3 years | NIH & FTA |
| 9. NIH/SWD/NIH/07-10 | Runoff and Sediment Modelling in a part of Brahmaputra River Basin using ANN | Archana Sarkar<br>R D Singh<br>Nayan Sarma | 3 years | NIH |
| 10. NIH/SWD/NIH/08-12 | Study on integrated water resources management of sub-basin to cope with droughts | R.P. Pandey<br>Ravi V. Galkate<br>Surjeet Singh<br>L.N. Thakaral | 4 years | NIH |

# PROPOSED WORK PROGRAMME OF SURFACE WATER HYDROLOGY DIVISION FOR THE YEAR 2009-10

| S. No. & Reference Code | Project | Project Team | Duration | Funding Source |
|---|---|---|---|---|
| 1. NIH/SWD/NIH/08- | Monitoring and modelling of streamflow for the Gangotri Glacier | Manohar Arora<br>Rakesh Kumar | To be continued | NIH |
| 2. NIH/SWD/NIH/05-10 | Integrated Hydrological Study for Sustainable Development of two Hilly Watersheds in Uttaranchal | Avinash Agarwal<br>R P Pandy<br>S P Rai<br>S K Singh | 5 years | DST |
| 3. NIH/SWD/NIH/07-10 | Hydrological studies in a forested watershed in Uttarakhand | J.V. Tyagi<br>Rakesh Kumar<br>Digamber Singh | 3 years | NIH & FTA |
| 4. NIH/SWD/NIH/07-10 | Runoff and Sediment Modelling in a part of Brahmaputra River Basin using ANN | Archana Sarkar<br>R D Singh<br>Nayan Sarma | 3 years | NIH |
| 5. NIH/SWD/NIH/08-12 | Study on integrated water resources management of sub-basin to cope with droughts | R.P. Pandey<br>Ravi V. Galkate<br>Surjeet Singh<br>L.N. Thakaral | 4 years | NIH |
| 6. NIH/SWD/NIH/09-12 | Snow melt runoff modelling in Sultej basin | A. R. Senthil kumar<br>Manohar Arora<br>Avinash Agarwal<br>D. S. Rathore<br>Digambar Singh | 3 years | NIH |
| 7. NIH/SWD/NIH/09-11 | Data book - hydro-meteorological observatory 2001-2008 | Digambar Singh<br>A. R. Senthil kumar<br>Manohar Arora | 2 years | NIH |

## 1. PROJECT REFERENCE CODE: NIH/SWD/NIH/07-09

**a) Title of study:** **Development of Drought Vulnerability Indices for Preparedness and Mitigation**

**b) Study group:** RP Pandey, Sc E1, & P.I.
A Aggrawal, Sc E1
Sanjay K Jain, Sc E1
Omkar Singh, ScE1

**c) Date of start:** July 2006

**d) Duration of the study:** 2 years (July 2006 to July 2008) plus extended period

**e) Funding:** INCOH

**f) Objectives of the project:**

This research project was taken up with following objectives:

- Identify and characterize the drought indicative parameters – meteorology, hydrology, agriculture and social in realizing drought and preparedness.
- Prepare drought vulnerability scenario under different conditions for macro and micro level physio-graphical units – watershed or district / villages.
- Capacity building in understanding / realizing the preparedness and vulnerability indices.
- Generate guidelines for timely recognition, preparedness planning, vulnerability reduction, and mitigation of drought.

**g) Description of the Project Activities**

The study was taken up in five sites representing different climatic zones, physio-graphical heterogeneity, cropping systems and socio-economic conditions, etc. were identified in five different districts in the country. The Details of study sub-basins selected for this study are shown in Table 1. The study teams of NIH have visited project sites from time to time during *kharif* and *ravi* cropping seasons and conducted investigations and field surveys, etc. The relevant data/information/maps etc. were gathered from various sources. Long term rainfall records (monthly and yearly) for the past 50-100 years were collected from various sources/agencies/State Revenue departments/ Institutions etc. Stream flow data has also been obtained for some of the study sites from state

Water Resources Departments wherever stream gauges exists. Stream flow data for other sites will also be collected from CWC if available. Ground water level observations were collected from various sources for Sonar, Lanth, Don, Manar and Sarlasagar sub-basin. Observers/field men were placed at project study sites for regular monitoring, observation and survey etc. the sites and liaisoning/links was established with other departments located at study sites for comprehensive data gathering/data monitoring and for keepng precise watch on the development of water stress and drought conditions in the study areas. Data base preparation and information compilation work for different study sites was completed for hydro-meteorological data and preparation of GIS data base like digitization of maps, preparation of DEM, maps of crop coverage, land use and soil cover etc. Remote Sensing for 27-scenes of (LISS-3 data) were procured from NRSA. Above data was processed and analyzed. The results of hydro-meteorological data analysis and various GIS layers on morphological components have been integrated to device drought vulnerability scenarios in space and time.

Table 1: Particulars of sub-basins selected for study.

| Sl. No. | Name of sub-basin selected for study | Name of major river system | Geographical location (Districts/States) | Catchment area (Sq km.) | Mean Annual Rainfall (mm) |
|---|---|---|---|---|---|
| 1 | Sonar sub-basin | Ken River (A tributary of River Yamuna) | Damoh/Sagar districts in M.P. | 6550.0 | 1186.0 (Dry sub-humid) |
| 2 | Don sub-basin | Krishna River | Bijapur in Karnataka and Sangli district in Maharashtra | 2486.0 | 643.0 (Semi arid) |
| 3 | Lanth sub-basin | Tel River (a tributary of River Mahanadi) | Bolangir in Orissa | 1562.0 | 1443.0 (Sub-humid) |
| 4 | Manar sub-basin | Krishna River | Nanded and Latur districts in Maharashtra | 2423.0 | 928.0 (Dry Sub-humid) |
| 5 | Pedda Vagu up to Sarala Sagar Dam site | Krishna River | Mahaboobnagar in A.P. | 1225.0 | 674.0 (Semi arid) |

**h) Brief report of progress and analysis (July 2006- Jan 2009):**

Inventories of drought events and physiographic conditions for different study sites were prepared. For example, the topographic conditions and poor groundwater availability in the Sonar-sub basin, inherently cause water shortages during the summer months. During drought years, condition of water shortages aggravates and the region faces severe water stress even in domestic water supply. In spite of the above problems, the pace of water resources development in this region had been inadequate. Severe and prolonged water stress due to deficit of rainfall over the prolonged periods with reference to normal rainfall expectation is considered to describe meteorological droughts in general term.

During previous year (2006-07) the Sonar basin observed delayed onset of monsoon and it has affected the cropping pattern to large extent. To study the effect of delayed monsoon the survey was conducted in Patharia, Batiagarh and Damoh blocks of Damoh district falling in lower catchment area and Kesli block of Sagar district falling in upper catchment of Sonar river basin. Farmers were interviewed to assess their views on planning and strategies to face such circumstances in the study area. The major kharif crops in the region are soyabean, sorghum, black gram and arhar. The majority of farmers have adopted soyabean since decade due to its suitability and high yield in the region. Generally region experiences onset of monsoon in second week of June but this year monsoon was delayed by 3-4 weeks. In Sagar district monsoon started in last week of June and in Damoh district monsoon started in 2$^{nd}$ week of July. In Damoh district monsoon effectively started from 14$^{th}$ July in almost all blocks and the cultivation could be started in 3$^{rd}$ week of July. Similarly, investigations were conducted for other sites too. Drought conditions also prevailing in Mahaboobnagar, district of A.P. during the year 2006 and 2007 and the crops were significantly affected both in kharif and Rabi season. However, in other sites namely, Balangir, Nanded, and Bijapur normal rainfall occurred and no drought conditions were observed in above three sites during past two years. Hydro-meteorological data were analysed Standard Precipitation Index(SPI), Effective Drought Indes (EDI), Decile Index and percent deviation from normal were applied for identification of droughts. Also relationship of evapotranspiration/precipation (EP/Pa) with SPI, EDI, % normal Pa, Decile Index were developed to examine the applicability of above indices at different sites. Also the classification of above indices were revised for their suitability at our sites. Annual rainfall deviations w.r.t. normal and estimated time series for Standard Precipitation Index are shown below for Mahboobnagar site.

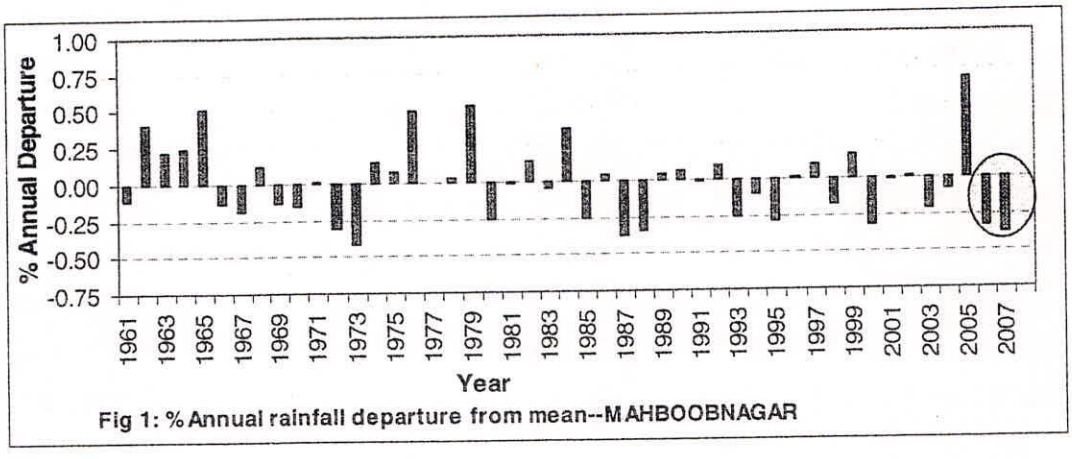



Fig 1: % Annual rainfall departure from mean--MAHBOOBNAGAR

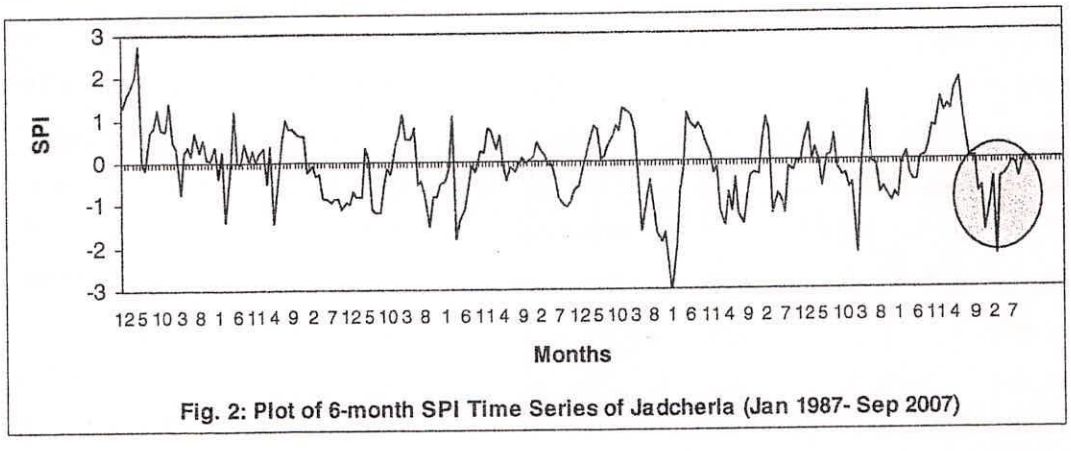
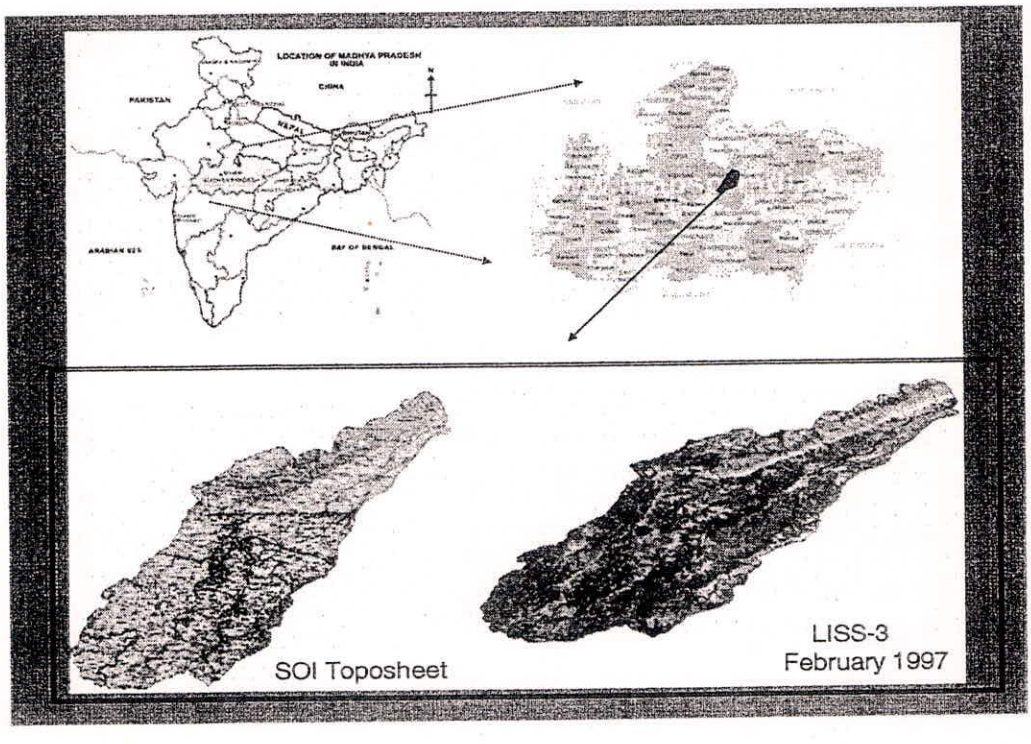



Fig. 2: Plot of 6-month SPI Time Series of Jadcherla (Jan 1987- Sep 2007)

Second year's work started in time. The teams have conducted surveys in June-September 2007. Liss-3 data were analyzed for estimation of NDVI, a scene for above analysis is shown below.



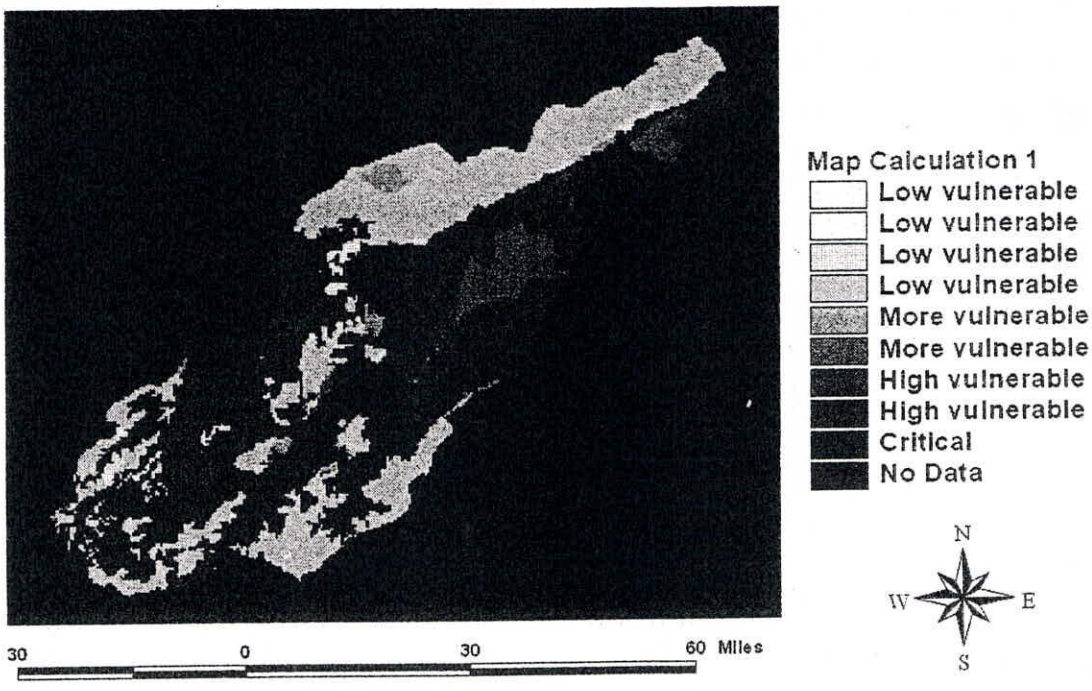



Fig.: Integrated drought vulnerability map for Sonar Basin

The weighted-value vulnerability maps have been prepared for other study sites and an integrated drought vulnerability index has been proposed.

**Proposed Integrated drought vulnerability Index (DVI)**

$$DVI = \frac{\sum W_i}{kN}$$

Where,

DVI = Drought Vulnerability Index

N = Number of indicators under consideration

wi = Weights of drought vulnerability indicators , *(where, i= 1,2,.....N)*

k = Upper limit of vulnerability weights *(Say, range = 0-k, where, k is highest value of Wi )*

**Proposed Classification of DVI**

| Sl. No | Values of DVI | Vulnerability Class |
|---|---|---|
| 1 | 0 - 0.2 | Least vulnerable |
| 2 | 0.2 – 0.4 | Moderately vulnerable |
| 3 | 0.4 – 0.6 | vulnerable |
| 4 | 0.6 – 0.8 | severely vulnerable |
| 5 | >0.8 | Critically vulnerable |

The proposed index is validated using physical ground truthing and NDVI estimates. Guidelines for timely recognition of onset of drought, assessment of vulnerability to drought and mitigation options are being incorporated in report. Further, fine tuning of the proposed methodology and report writing are in progress. Complete project work and results have been presented in the previous working group meeting in October 2008.

i) **Expected date of completion:** Final project report is under advance stage of completion and it expected to be submitted by March 2009.

## 2. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-09

a) **Title of the study:** **Impact of Climate Change on the Flow Characteristics of Beas River at Pandoh Dam Site**

b) **Study group:** A.K. Lohani, Sc E1 & PI
Sanjay K. Jain, Sc.E1 & PI
Manohar Arora, Sc. B, Co-PI
R. D. Singh, Director

c) **Date of start:** April 1, 2008

d) **Duration of the study:** One year

e) **Funding:** NIH

f) **Background:**

According to the action plan for studies related to climate change, Ministry of Water Resources, Government of India has assigned a number of studies to National Institute of Hydrology on development of appropriate model for three major basins i.e. Ganga, Brahmaputra and Indus and one for peninsular rivers for predicting the flow series under varying conditions. In this context, Beas river of the Indus system has been considered and the Beas basin up to Pandoh dam is proposed as the focus area of the present study. The Beas River is an important river of the Indus River system. It originates at an elevation of 3900 m and the length of the river up to the Pandoh dam is 116 km. The catchment of the Beas basin up to Pandoh dam is 5278 $km^2$ out of which only 780 $km^2$ is under permanent snow. The altitude varies from 832 m near Pandoh to more than 5000 m near Beo-Toibba. Some of the major tributaries which join the Beas River upstream of Pandoh dam are: Parvati River near Bhuntar, Tirthan and Sainj rivers near Larji, Sabari nala near Kulu and Bakhli khad near Pandoh dam. All these rivers are perennial and the flow varies considerably during different months of the year. Steep slopes are very common but are terraced at several places in the lower ranges up to an elevation of 1982 m for agricultural purposes. In certain reaches, thick forests exist mostly between elevations of 1830 m to 2744 m. The reservoir extends to about 9.25 km upstream of Pandoh dam; it has a gross storage capacity of 4100 hectare-meter and its maximum water level is at 896.42 m.

**g) Objectives:**

- To calibrate and validate SNOWMOD for selected basin.
- To simulate streamflow for the study basin in present climatic conditions using long term records
- To simulate stream flow for the basin considering various scenarios of atmospheric temperature
- To evaluate the impact of changes in climatic variables on stream flow and compare it with base line flow characteristics

**h) Brief methodology:**

- Data Collection & Processing
- Calibration and validation of hydrological model
- Evaluation of the impact of changes in climate variables on simulated flows

**i) Results achieved with progress/present status**

The base maps (drainage/contour/DEM) of the study area have been prepared in GIS data base. The DEM has been divided into number of elevation bands. Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data (weekly) for the study area have been obtained from National Snow and Ice Data Center (NSDIC). The snow cover area for the years 2000-2005 have been computed and depletion curved have been prepared. This snow cover area for different elevation bands has been computed with SCA and DEM (Fig 1). Processed the discharge, rainfall and temperature data of the study area collected from BBMB Sunder Nagar. After data processing SNOWMOD model has been calibrated. Further, the stream flow at Pandoh Dam site has been simulated using the calibrated snow melt runoff model. Impact of temperature on snow melt and stream flow has been carried out by considering various scenarios related to atmospheric temperature rise. Figure 2 shows the simulated daily snowmelt runoff under T+1° C scenario considering rainfall unchanged. Similarly, Figure 3 shows the simulated daily snowmelt runoff under T+2° C scenario considering rainfall unchanged. It is observed that increase in temperature increases early snowmelt from May month onwards. But after August month the melt contributed by snowcover decreases below the present scenario. Hence, a shift is observed in snowmelt runoff contribution early in the summer. But later in the summer it reduces significantly producing lesser melt. During winter even higher temperature could not produce melt runoff because of very low temperature.

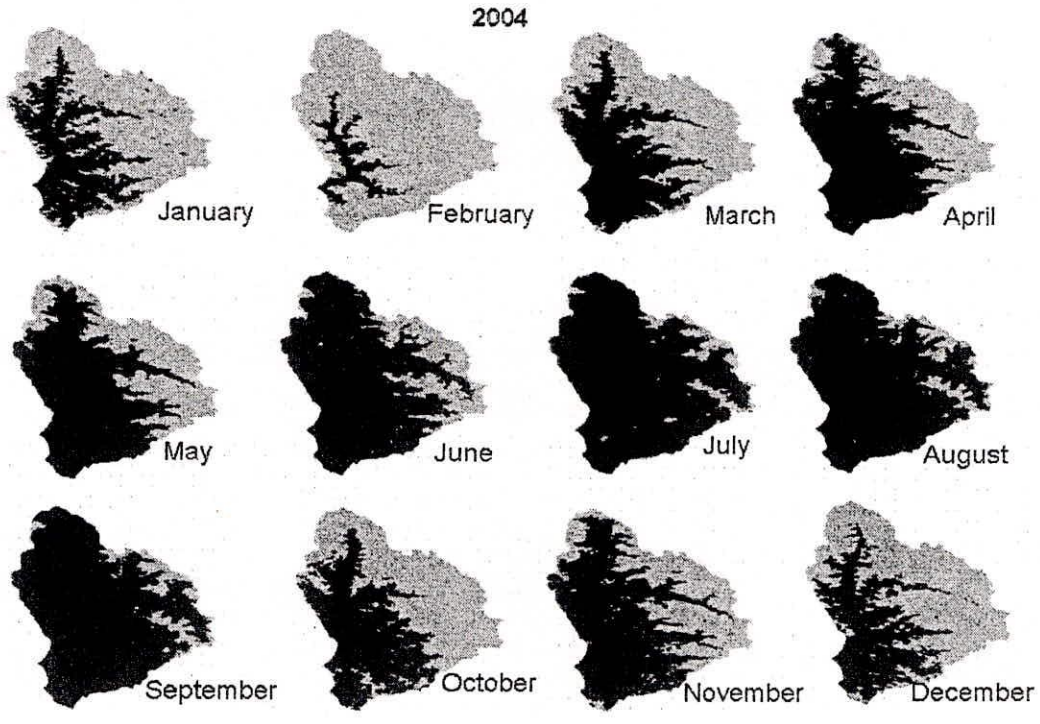



Figure 1: Snow Cover Area MODIS

Figure 2: Simulation of stream flow with temperature increase by 1°C

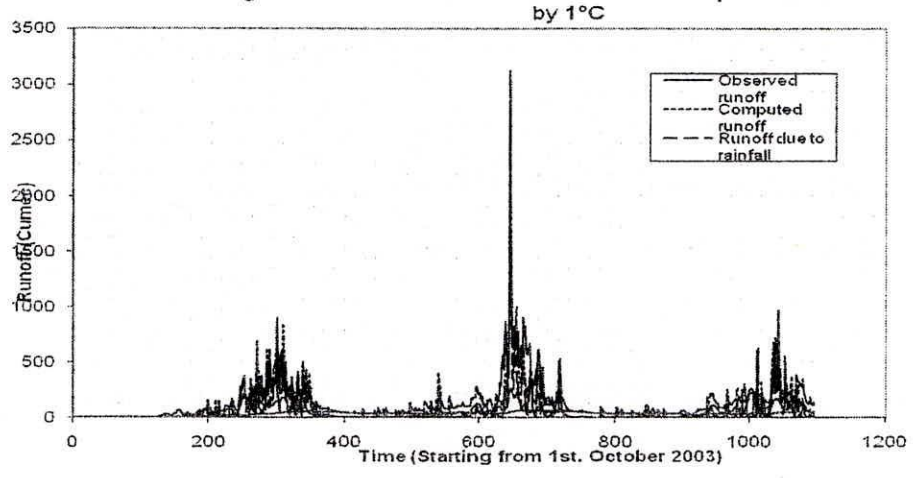
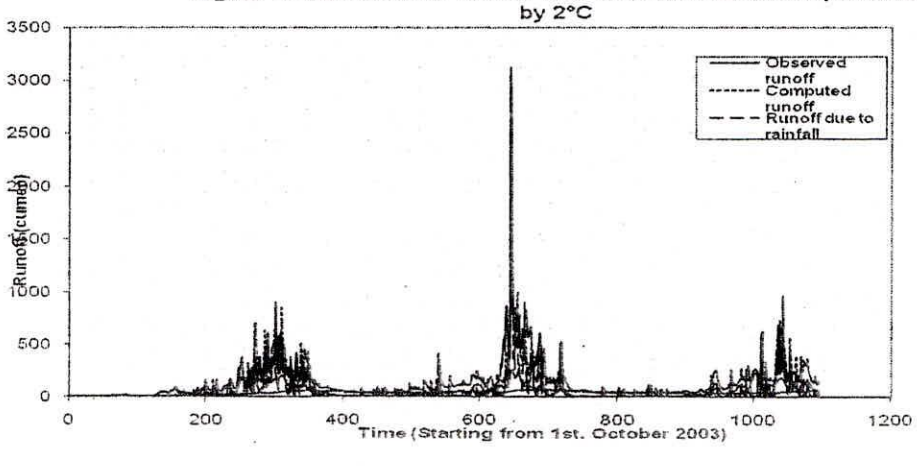



Figure 3: Simulation of stream flow with increase in temperature by 2°C



**j) Output/outcome**

In this study an effort has been made to predict the impact of atmospheric temperature rise on the flow characteristics of Beas river at Pandoh dam site. Stream flow including snowmelt runoff from the catchment at Pandoh site has been modeled using SNOWMOD model. During April to June when the major component of stream flow is from snowmelt, prediction of stream flow is very beneficial for reservoir operation. In this regard various scenarios of the temperature has been considered as an input to the calibrated and validated hydrological model. Further, flow series has been simulated for each scenario. The basic flow characteristics have been computed and compared with the base line flow characteristics in order to predict the possible impact on the river flow. The study is useful in understanding of changes in flows under changing climate scenario. A draft technical report has been prepared for the study.

## 3. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-09

a) **Title of study:** **Impact of Climatic Change on the Flow Characteristics of a Sub-Basin of Ganga Basin (Bhagirathi Basin up to Tehri Dam)**

b) **Study Team:** Sanjay Kumar, Sc C
Sanjay Kumar Jain, Sc E1
R. D. Singh, Director
Rakesh Kumar, Sc F

c) **Date of Start:** February 2008

d) **Duration of the study:** February 2008-March 2009

e) **Funding:** NIH.

f) **Objectives of the study:**

- To develop a suitable hydrological model for the selected sub-basin.
- To simulate the river flow for the present climatic conditions in the selected sub-basin.
- To simulate the river flow considering various scenarios of climatic variables in the selected sub-basin.
- To evaluate the impact of changes in climatic variables on the stream flow and compare it with the base line flow characteristic.

g) **Methodology**

A suitable data based hydrological model for the long term hydro-meteorological time series will be developed for the selected sub-basin (Bhagirathi basin up to Tehri). The developed model will be used to simulate the effect of climatological variables such as rainfall, evaporation, temperature on the flow characteristics of the sub-basin. Various scenarios of the climatological variables would be considered as input to the hydrological model and the flow series would be generated for each scenario. The simulated flow characteristics for various possible scenarios of climatological variables would be compared with the base line flow characteristics in order to predict the possible impact on river flow regime.

h) **Present status/progress in physical terms:**

a) The base maps (drainage/contour/DEM) of the study area have been prepared from Survey of India toposheets. The Digital Elevation Model (DEM) has been divided into number of elevation bands. MODerate-resolution Imaging Spectoradiometer (MODIS) satellite data (weekly) for the study has been obtained from National Snow and Ice Data Center (NSDIC). The Snow Cover Area (SCA) for the years 2000-2004 have been computed and depletion curve have been prepared as shown in Fig:1 The elevation zone-wise computation of SCA for different years is completed.

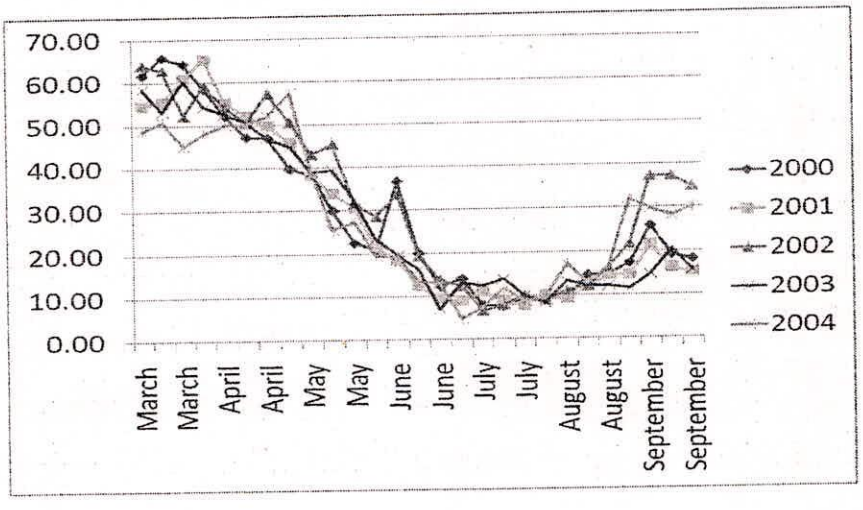



Fig 1: Snow Cover Depletion Curves

b) A request to release hydro-meteorological data of Bhagirathi basin was made by NIH to River Data Directrate, CWC, New Delhi during August 2008. The hydro-meteorological data of the following sites in the Bhagirathi basin was released by the CWC office **vide letter no. HDG/DB-33/2008/50 dated 16th January, 2009.**

**Table 1: Hydro-Meteorological Data of Bhagirathi River Basin**

| S.N. | CWC Site/River Name | Data | Frequency | Duration |
|---|---|---|---|---|
| 1 | Uttarkashi/ Bhagirathi | Discharge, Gauge, Rainfall and Temperature | Daily | 1978 to 2006 |
| 2 | Devprayag/ Ganga | Discharge, Gauge, Rainfall and Temperature | Daily | 1978 to 2006 |
| 3 | Tehri Dabrani/ Bhagirathi | Discharge, Gauge, Rainfall and Temperature | Daily | Bhagirathi Tehri 1978-2003; Bhagirathi Dabrani 2003 to 2006) |

c) Processing of the data has been completed.

d) Database preparation for the runoff analysis and development of the snow melt runoff model is in progress.

i) **Expected date of completion:** 31st March, 2009.

## 4. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-09

**a) Title of study:** **Assessment of Environmental Flow Requirements in River Ganga at Loharinag Pala Project Site**

**b) Study group:** R. D. Singh, Director
Manohar Arora Sc 'B'
Rakesh Kumar Sc 'F'

**c) Date of start:** 01.04.2008

**d) Duration of study:** One Year.

**e) If externally funded:** Yes (NTPC Sponsored)

**f) Objectives of the study:**

The objectives of the study are:

- To assess environmental flow requirements (EFR) in River Ganga at Loharinag Pala project site

**g) Methodology:**

For the assessment of EFR two methods will be used. The first one is Flow Duration Curve method. In this methodology seventeen fixed percentage points are taken for the computation of dependable flows. The flow duration curve plotted using these fixed points is termed as reference flow duration curve. The Six EMCs (Environmental Management Classes) are used in this study and six corresponding default levels of EWR may be defined. It starts with the unmodified and largely natural conditions (rivers in classes A and B), where no or limited modification is present or should be allowed from the management perspective. In moderately modified river ecosystems (Class C rivers), the modifications are such that they generally have not (or will not – form the management perspective) affected the ecosystem integrity. Largely modified ecosystems (Class D rivers) corresponds to considerable modification from the natural state where the sensitive biota is reduced in numbers and extent. Seriously and critically modified ecosystems (Classes E and F) are normally in poor conditions where most of the ecosystem's functions and services are lost. The other method is Tenant's method. This method is based on the computation of MAR.

h) **Results achieved with progress/present status:**

(i) The EFR values computed as % of total volume of water for the period from May 2005 to September 2007 considering 17 fixed points of probability of exceedences are 75.7%, 56%, 41% and 29% for the EMC Class A, Class B, Class C and Class D respectively.

(ii) The EFR values computed as % of total volume of water for the period from May 2005 to September 2007 considering 10 fixed points of probability of exceedences are 58.1%, 30.7%, 16.2% and 8.5% for the EMC Class A, Class B, Class C and Class D respectively.

(iii) The EFR values computed as % of total volume of water for the period from 1989/90 to 2005/06 (transposed data at Loharinag Pala) considering 17 fixed points of probability of exceedences are 72.9%, 51.9%, 36.6% and 26.5% for the EMC Class A, Class B, Class C and Class D respectively.

(iv) The EFR values computed as % of total volume of water for the period from 1989/90 to 2005/06 (transposed data at Loharinag Pala) considering 10 fixed points of probability of exceedences are 57%, 29.1%, 14.5% and 7.5% for the EMC Class A, Class B, Class C and Class D respectively.

(v) The FDC method is recommended if the underlying relation of hydrology to biology (habitat) is substantiated within the target region.

(vi) The volume of water diverted to the power house (considering the minimum release at Loharinag Pala as 1 Cumec per day and maximum diverted flow to the power house as 158 Cumec per day) is 273340 Cumec days. The total volume of water available in the river system between Loharinag Pala and Maneri sites during 2005/06 is 64% of the total volume of water available at Loharinag Pala during this period. Whereas the % EFR for EMC Class A is 72.7 as obtained from the long term transposed data at Loharinag Pala site.

(vii) The volume of water diverted to the power house (considering the minimum release at Loharinag Pala as 4 Cumec per day and maximum diverted flow to the power house as 158 Cumec per day) is 26499.6 Cumec days. The total volume of water available in the river system between Loharinag Pala and Maneri sites during 2005/06 is 70% of the total volume of water available at Loharinag Pala during this period. Whereas the % EFR for EMC Class A is 72.7 as obtained from the long term transposed data at Loharinag Pala site.

(viii) The EFR value computed by the Tenants method, considering it as 10% of the MAR, is 3848 Cumec Days for a calendar year.

i) **Expected outcome:** The draft report has been submitted to NTPC.

## 5. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-

**a) Title of study:** **Monitoring and Modelling of Streamflow for the Gangotri Glacier**

**b) Study group:** Manohar Arora Sc 'B'
Rakesh Kumar Sc 'F'

**c) Date of start:** 01.04. 2008

**d) Duration of the study:** To be continued

**e) If externally funded:** No

**f) Objectives of the project**

The objective of this study includes:

i. Continuous monitoring of meteorological and hydrological data for monthly and seasonal specific water yield and its variability from the year to year
ii. To study the melt water storage and drainage characteristics of the glacier
iii. To improve the hydrological model for simulating daily streamflow

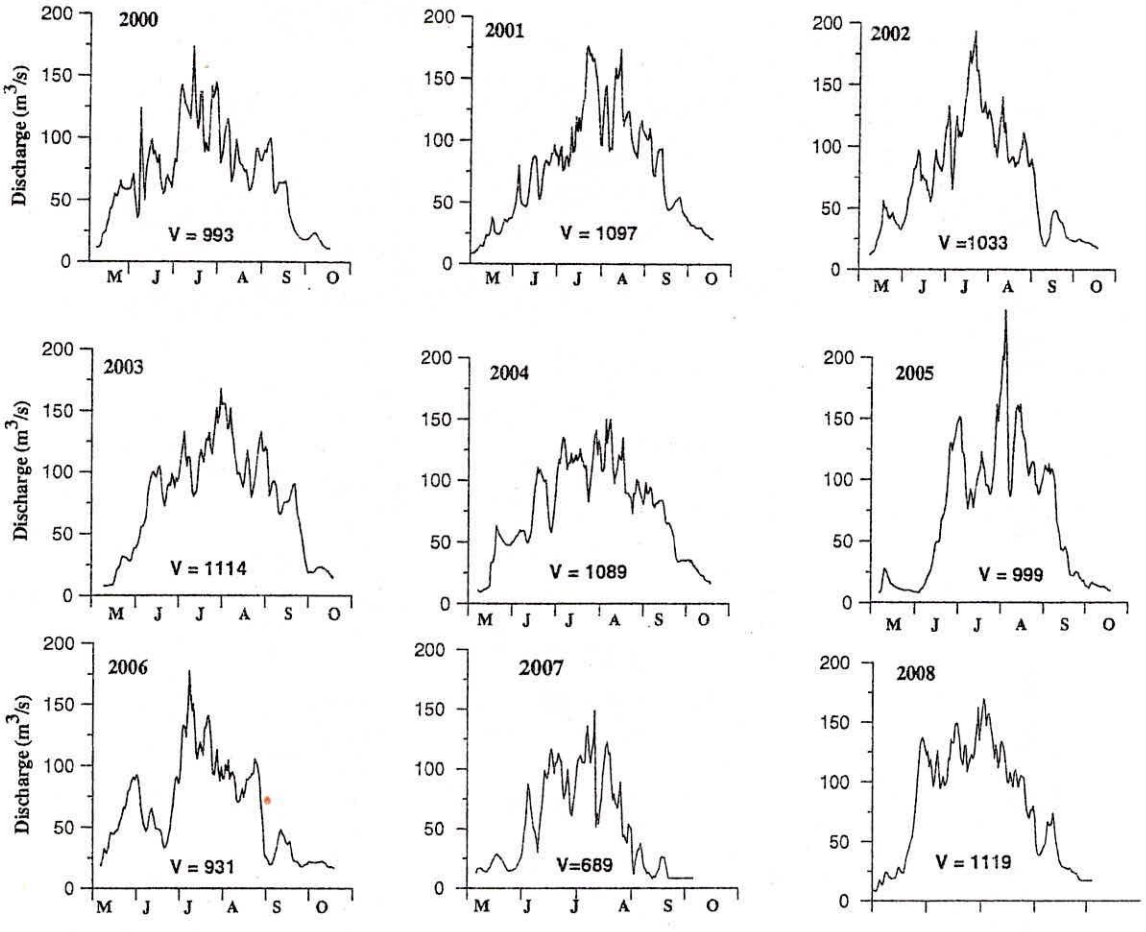
**g) Methodology**

The methodology involves collection and analysis of hydro-meteorological and discharge data of the glacier site. The second step is to develop and apply a snow melt model for streamflow generation and identification of different runoff components.

**h) Status**

This study was started in April 2008 after completion of three years DST project. The DST sponsored study has been completed and final report was submitted to DST. The results obtained are presented in the following paragraph in brief.
The field investigations were started in the first week of May 2008. The cross-section of river channel was determined at the site and observations were made continuously till the end of the ablation season i.e. October first week. In the field investigations six scientific staff participated with the undersigned. The data collected is being analysed in the proper format. The samples collected for the estimation of suspended sediment are being analysed in the laboratory. The maximum temperature observed was 19.5°C and the minimum temperature was -

2.8°C. The total volume of water for the ablation season 2008 was computed to be 1119 MCM. The hourly data is being digitised for further analysis.




i) **Expected date of completion:** This study will be continued for a longer duration and the data collected will be utilized for the climate change studies.

## 6. PROJECT REFERENCE CODE: NIH/SWD/NIH/07-09

**a) Title of the study:** **Modelling of Suspended Sediment Concentration Using Artificial Neural Networks**

**b) Study Group:** A. R. Senthil Kumar, Sc C
A. Aggarwal, Sc E1
R. D. Singh, Director

**c) Date of start:** 1 April 2007

**d) Duration of the study:** 2 YEARS

**e) Funding:** NIH

**f) Objectives of the study:**

(i) To develop an ANN model to predict the suspended sediment concentration and to determine the life of the reservoir

(ii) To determine the revised elevation-area-capacity curve

**g) Brief methodology:**

**ANN Model**

Three layered feed forward structure has been selected for the development of ANN model to predict the suspended sediment concentration. The training of the model is done by back propagation algorithm. The optimal number of hidden nodes is fixed by trial and error procedure. The transfer function used in the model is logistic sigmoid function. The performance of the model during calibration and validation is evaluated by coefficient of correlation (CORR), root mean squared error (RMSE) and Nash-Sutcliffe model efficiency (EFF). The generated sediment concentration will be used in determining the life of the reservoir.

**h) Present status**

ANN model for predicting the suspended sediment concentration at Kasol, upstream of Bhakra reservoir has been developed. The daily data from 1987 to 2000 is considered for the training and validation of the model. The model performed fairly well during the calibration and validation. But the high range

values of sediment concentration are slightly deviated from the observed values during the validation of the model.

The Gobind Sagar reservoir of Bhakra dam has 6 tributaries such as Seer Khad, Sukhar Khad, Sarhali Khad, Gambher Khad, Ali Khad, Lunkhar Khad. These tributaries carry sediment from its catchment and the sediment deposits in the reservoir. However, the sediment load in these tributaries is less compared to the main river Sutlej.

In view of the above, ANN models have been developed for predicting the suspended sediment concentration at Bangana situated along Lunkhar Khad tributary and at Berthin along Seer Khad. The required data for Lunkhar Khad and Seer Khad are available from 1987 to 2004 on daily basis and only from July to September for all the years. Three ANN models have been developed for Bangana by considering three domains of data in the series. It is observed from the performance indices that all models performed poor during the calibration and validation process. The same performance is observed for ANN model developed for Berthin.

It has been decided to develop ANN models for both the tributaries on monthly and annual data to improve the performance of the models. It is observed from the results that the performance of the models has not been improved. The scatter plots of the sediment load versus rainfall for monthly and annual values clearly indicate less possibility over the improvement of model performance.

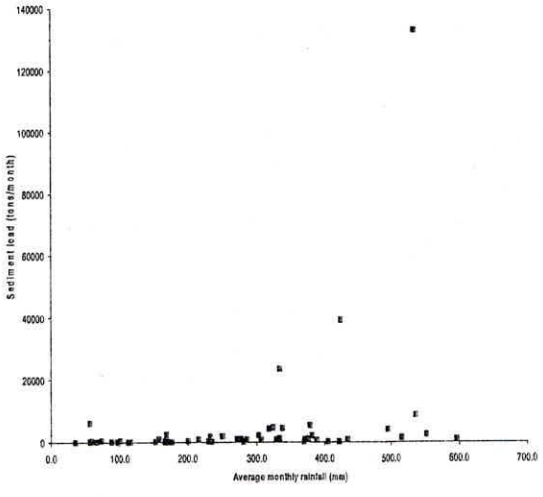



Fig. 1 Scatter plot of Sediment load Vs rainfall for monthly data at Bangana

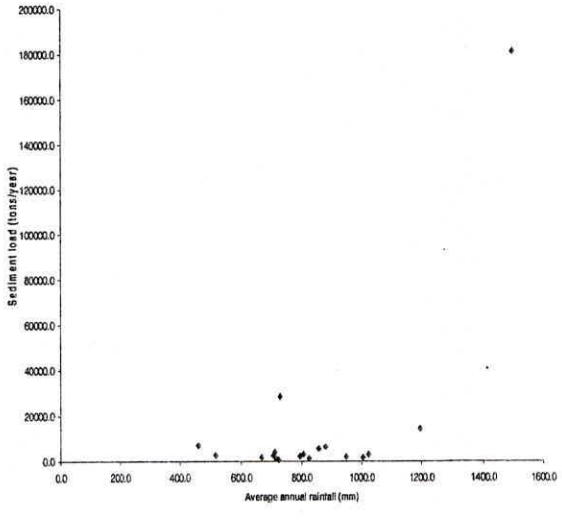



Fig. 2 Scatter plot of Sediment load Vs rainfall for annual data at Bangana

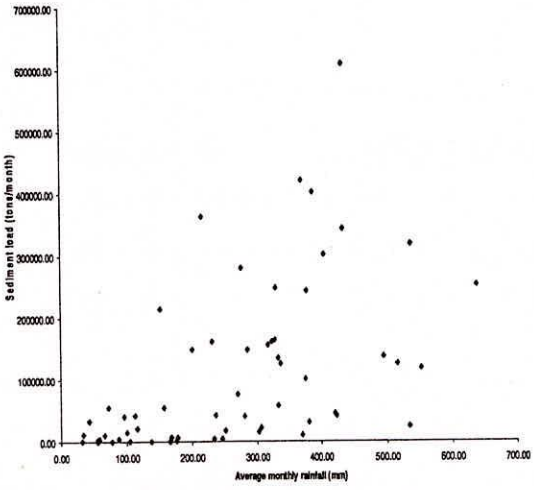



Fig. 3 Scatter plot of Sediment load Vs rainfall for monthly data at Berthin

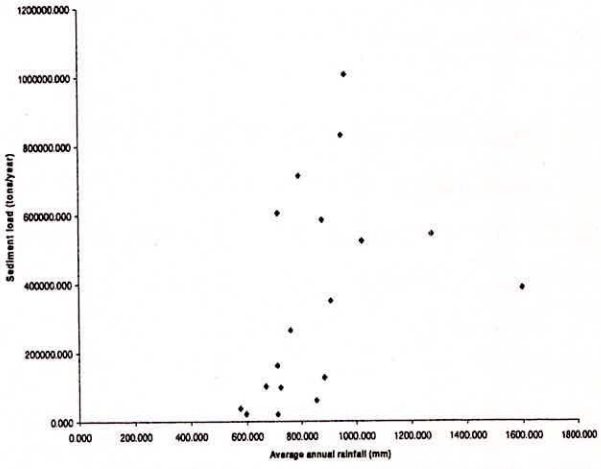



Fig. 4 Scatter plot of Sediment load Vs rainfall for annual data at Berthin

**i) Date of completion:** 31 march 2009

## 7. PROJECT REFERENCE CODE: NIH/SWD/NIH/05-10

**a) Title of study:** **Integrated Hydrological Study for Sustainable Development of two Hilly Watersheds in Uttaranchal.**

**b) Study group:** Avinash Agarwal, Sc E1
R P Pandy, Sc E1
S P Rai, Sc C
S K Singh, Sc E1

**c) Date of start:** July 2005

**d) Duration of study:** 5 Years

**e) Whether externally funded:** DST

**f) Objectives of the project:**

Department of Science & Technology, Govt. of India, initiated a network of projects on hydrological study of small watersheds, in different agro-ecological regions of the country with following as broad objectives.

- Detailed hydrological monitoring, collection of data at sub-watershed scale and creation of a centralized database for watershed for the benefit of the users
- Rainfall-runoff-sediment yield studies to develop strategies for conservation of soil and water resources
- Delineation of recharge and discharge zones of springs using nuclear techniques
- Water management planning for domestic use and crop production purposes
- Develop linkages with state line departments, local technical NGO's etc.
- To act as a hub for transfer of NRDMS technologies related to watershed management

**g) Study Area**

The study area of this project lies in 'Western Himalaya' agro-ecological region of the Sub-humid Ecosystem at elevation of 720 m to 2350 m. Climate in this region is warm with air temperature 3°C to 35°C sub-humid to humid and per-humid with average annual rainfall 900 mm to 1200 mm.

### I. Chandrabhaga watershed

The Chandrabhaga watershed is located geographically between $30^0$ 18' N to $30^0$ 19' N and $78^0$ 35' E to and $78^0$ 36' E, Jakhnidhar block of Tehri-Garhwal district (Uttarakhand). The total area of watershed is 4.34 $Km^2$. It is Subhumid with moderate rainfall with annual average of 1200 mm. The springs of Anjanisain flow through deep gorges posing added physical strain for those who draw water.

### II. Danda watershed

The Danda watershed is 4.42 $Km^2$ is located geographically between 30° 14' N to 30° 16' N and 78° 37' E to 78° 39' E Jakhnidhar block of Tehri-Garhwal district (Uttarakhand). The altitude in this watershed ranges from 780 m to 1700 m above MSL. It is Subhumid with moderate rainfall with annual average of 900 mm.

## h) Brief methodology followed

Watershed management is a continuous process of measurement and implementation of policies. The collection of data is the first step to begin planning for managing natural resources of a watershed. Using an integrated approach of hydrological instrumentation, investigation, remote sensing and GIS, a database of spatial and non-spatial data in two watersheds will be prepared. Appropriate modeling will be done to simulate hydrological behaviors of two watersheds (Chandrabhaga and Danda) and parameters will be established utilizing observed hydrological data.

## i) Results achieved with progress/ past status

### (a) Monthly analysis of hydro-metrological data

Regular hydro-metrological data since Jan 99 to Dec 2007 have been compiled specially for weighted rainfall, runoff from v-notch, springs in the watershed and for pan evaporation. The daily data has been converted to monthly, annul and water year basis for plotting, presentation and for different analysis for further requirements. (Presented in 29$^{th}$ working Group)

**(b) Spring flow analysis**

The spring flow in the watershed are the major source of available water during the periods of unavailability of rain. Total around forty one numbers of springs are under observation for both the watersheds and daily spring flow discharge is being recorded. As for as possible all the available springs in the watersheds is being considered. The construction of ten daily flow duration curves was done as per the procedure of Institute of Hydrology. The spring behavior was identified considering cumulative mean monthly rainfall values starting from June and cumulative stream flow for the same period. (The spring response to rainfall for few selected cases was presented in 29$^{th}$ working Group).

**(c) Delineation of recharge Zone**

The recharge zone of the spring for both the watersheds is identified using nuclear techniques. Under nuclear techniques two type of analysis viz. $O_{18}$ and $H_2$ are carried out for the water samples collected in both the watersheds for rainfall, V-notch and all the springs under observation in both the watersheds. Similarity of trend for the plots of $O_{18}$ versus $H_2$ highlights the source of water being same (Presented in 29$^{th}$ working Group).

**(d) Rainfall-runoff-sediment yield studies**

In absence of continuous record of sediment concentration, the sediment-runoff relationship is developed for both the watershed from the data collected during year 99 to 03. Based on the collected data, the relationship of the form of second order polynomial and exponential are developed. The correlation coefficient of the relationships indicates that the polynomial equation is better than exponential equation in present case. Using the developed polynomial relationships, the sediment yield from the watersheds for water years have been estimated and presented in 29$^{th}$ working group.

**(e) Water Balance (Present progress)**

The daily rainfall, runoff and the pan evaporation data collected from the watershed has been converted to monthly scale. The measured evaporation (ET) has been converted to potential evapotranspiration (PET), the potential evaporation is converted to actual evapotranspiration (AET) and the surplus/deficit by using equation based on method ER,SCS and ER,FAO.

Table 1: The major findings for the Chandrabhaga and Danda watersheds.

| Variables | Chandrabhaga | Danda |
|---|---|---|
| Total numbers of effective springs | 22 Nos. | 21 Nos. |
| Average spring flow | 0.17 l/s | 0.22 l/s |
| Average 10 day flow | Lower | higher |
| Total volume of water from all springs | 24.86 mm | 37.93 mm |
| Average runoff at V notch | 189.39 mm | 274.40 mm |
| Average annual rainfall( eight years) | 1067 mm | 742.8 mm |
| Average annual rainfall( long term) | 1200 mm | 900 mm |
| Water balance | +155 mm | -350 mm |

The total amount of availability of water through springs in Danda watershed is greater than Chandrabhaga. The runoff from Danda watershed is higher than Chandrabhaga watershed. The average annual rainfall in Danda watershed is lower than Chandrabhaga (Table 1). The water deficit for Danda watershed indicated through water balance.

**(f) Use of ERDAS and ARC VIEW for modelling.**

(a) Chandrabhaga delineated on 1:25,000 scale and Danda on 1:50,000.
(b) Land use cover taken form global land cover facility for year 2000.
(c) Contour and other layers are drawn.
(d) Collection of regular data is continued with existing instruments and manual.
(e) Sediment data is manually being collected three to four times depending on the storm.
(f) Instrument purchase is in progress and possibly be planted in March.
(g) Land use information is being collected from NBSS&LUP, new Delhi for land use layer.
(h) A detail survey for both the watersheds in respect of population, land holding, springs, tanks and all users point of water with location using GPS is in progress and will be utilized for making layer of water source and uses.

## 8. PROJECT REFERENCE CODE: NIH/SWD/NIH/07-10

**a) Title of study:** **Hydrological Studies in a Forested Watershed in Uttarakhand**

**b) Study group:** J.V. Tyagi, Sc E1
Rakesh Kumar, Sc F
Digamber Singh, Sc B

**c) Date of start:** April, 2007 (Phase II)

**d) Duration of study:** 3 years

**e) Whether externally funded or not:** NIH and FTA (Haldwani)

**f) Objectives of the project**

A Sal forested watershed of about 17 ha was selected in Nainital District in consultation with the FTA, Haldwani with the following objectives.

(i) To study the variation of soil moisture storage vis-à-vis the natural regeneration of Sal forest under different canopy densities.
(ii) To study the variation of light intensity and its effect on natural regeneration under various canopy densities.
(iii) To simulate the spatial erosion on the watershed using ANSWERS model and to study the effect of the erosion rates on the natural regeneration.
(iv) To help FTA in carrying out hydrological monitoring of forested watersheds.

**g) Brief methodology**

The soil moisture storage and the light intensity will be monitored on long term basis in experimental plots laid out under different canopy density classes. The natural regeneration in the experimental plots would be monitored through annual surveys and the relationship would be developed between the soil moisture storage, light intensity and the natural regeneration using the long term data. Since the high runoff velocity on steep slopes causes high soil erosion and results into uprooting and washing away of tender seedlings, the spatial distribution of soil erosion would be estimated using ANSWERS model to identify the areas of high erosion and thereby to study the effect of erosion on regeneration. Also, a field estimate of spatial erosion would be made through pegs in the experimental plots.

## h) Progress / Present Status

Experimental plots of 40mX40m size were demarcated under different canopy density classes of C1, C2 and C3, representing respectively the areas where canopy density had reduced to (0-0.30), (0.30-0.50), and (0.50-0.70). The soil moisture in these plots is being measured at weekly intervals at 0.25, 0.50 and 1 m depths using soil moisture sensors. The observations on light intensity under different canopy densities are being taken on fortnightly interval starting from May 2008. The regeneration survey of Sal species in these experimental plots was conducted in 2004 and was repeated in 2005, 2006, 2007 and 2008. The daily and short interval rainfall is being measured using an ordinary rain gauge (ORG) and a tipping bucket rain gauge respectively. The runoff from the watershed is being monitored with the help of a 'V' notch and stage level recorder. The runoff samples from the storm runoff are collected for analysis of sediment yield from the watershed. Besides above, a number of hydrological investigations (viz., determination of infiltration rate, saturated hydraulic conductivity, soil texture, soil physico-chemical properties, soil moisture characteristic curves) and field surveys viz., topographic survey and plain table survey were carried out. Based on these investigations and surveys, the DEM, slope map, aspect map, drainage map, soil texture map and land use map were prepared. The data collected so far have been analyzed and plotted.

## i) Key Results: Analysis of soil moisture and regeneration data

The soil moisture observations at different depths were analyzed for weighted soil moisture storage in experimental plots. The temporal variation of average soil moisture under different canopies was plotted on water year basis. The plots for the water years 2007-08 and 2008-09 are shown in Fig. 1 (a & b).

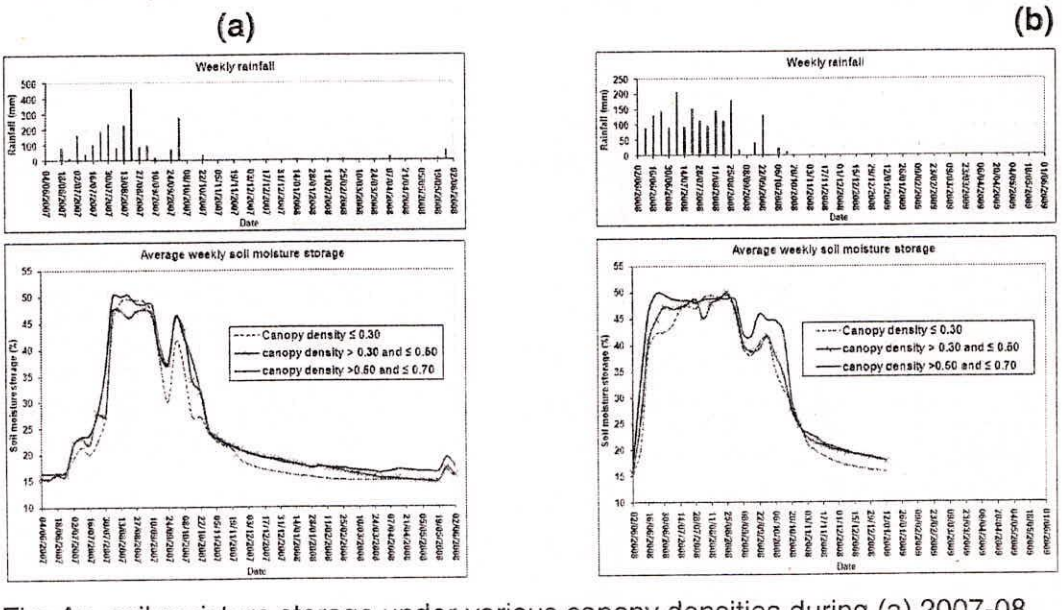



Fig: Av. soil moisture storage under various canopy densities during (a) 2007-08 & (b) 2008-09

**Table 1: Year-wise average score and annual incremental score of plot regeneration**

| Canopy class | Average Score of Plot regeneration (Plot Area = 40X40 $m^2$) | | | | | Annual Average Incremental Score of Plot | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2003-04 | 04-05 | 05-06 | 06-07 | 07-08 | 2004-05 | 05-06 | 06-07 | 07-08 |
| C1 | 7206 | 7255 | 7647 | 7982 | 8356 | 49 | 392 | 335 | 374 |
| C2 | 5727 | 5758 | 6319 | 6450 | 6880 | 31 | 561 | 131 | 430 |
| C3 | 3671 | 3697 | 4696 | 4849 | 4330 | 26 | 999 | 153 | -519 |

**Table 2: Average annual soil moisture storage and incremental plot score of regeneration under different canopy densities**

| Parameter | 2004-05 (4.10.04 - 31.05.05) | | | 2005-06 | | | 2006-07 | | | 2007-08 | | | 2008-09 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C1 | C2 | C3 | C1 | C2 | C3 | C1 | C2 | C3 | C1 | C2 | C3 |
| Av. ann. soil moist. storage (%) | 14.57 | 13.87 | 14.54 | 26.03 | 24.88 | 26.69 | 23.04 | 23.48 | 25.63 | 22.57 | 23.98 | 24.94 | 32.18 | 33.48 | 35.47 |
| Av. ann. Incremental score of regeneration | 49 | 31 | 26 | 392 | 561 | 999 | 335 | 131 | 153 | 374 | 430 | -519 | | | |

(j) **Expected date of completion:** March, 2010.

## 9. PROJECT REFERENCE CODE: NIH/SWD/NIH/07-09

**a) Title of study:** **Runoff and Sediment Modelling in a Part of Brahmaputra River Basin Using Ann**

**b) Study group:** Archana Sarkar, Sc B
R D Singh, Director
Nayan Sarma

**c) Date of Start:** April 1, 2007

**c) Duration of the Study:** 3 years

**d) If externally funded, please indicate:** In house R&D project

**e) Objectives of the study**

- Rainfall runoff and sediment yield modelling in a sub basin of Brahmaputra river basin in India using ANN
- Development of gauge discharge curves at important gauging sites of Brahmaputra River (Indian sites) using ANN
- Development of sediment rating curves at selected gauging sites (Indian sites) of the Brahmaputra river using ANN

**f) Brief methodology**

1. Collection of meteorological data (rainfall, temperature, evaporation), hydrological data (discharge, suspended sediment concentration), topographic maps from Survey of India, for the study area.
2. Rainfall runoff modelling for the selected sub basin using back propagation ANN.
3. Development of back propagation ANN models for sediment yield simulation for the sub basin. The input to ANN models will include geomorphological parameters besides meteorological & hydrological data.
4. Development of rating curves and ANN models for stage-discharge and sediment-discharge processes at three selected gauging sites of the Brahmaputra river. Comparison of the two techniques.

**g) Results achieved with progress/present status**

- For Runoff simulation in a sub basin of Brahmaputra River in India, Subansiri river basin has been identified. Subansiri is a north bank tributary of Brahmaputra River and it is highly flood prone as well as carries high sediment load for which rainfall-runoff-sediment studies are very important. The drainage map and digital elevation model of this sub basin has been prepared. All other relevant information regarding this sub basin has been collected from literature. Daily and hourly discharge data for the tributary has being procured from CWC office in Guwahati during a field trip during May 2008. Daily rainfall, maximum and minimum temperature data is being procured from RMC, Guwahati. The raingauge stations falling in the sub-basin were identified during the field trip, the relevant daily data has been noted down in hard copy and procured from RMC. This hydrometeorological data is being transferred on the computer and after it is available in the required soft format, ANN models will be trained and validated.
- For sediment yield simulation in a sub basin of Brahmaputra river, back propagation ANN models will be developed for the Subansiri river basin. The input to ANN models will include geomorphological parameters besides meteorological & hydrological data. The structure of ANN models has been identified and the models will be trained when all the input data is available.
- Three important gauging sites of Brahmaputra River, viz, Pandu, Pancharatna, and Bhomoraguri (Indian sites) have been identified for development of Gauge discharge and sediment discharge rating curves using Back propagation ANN models. Daily discharge, stage and suspended sediment concentration data for the three gauging sites has been procured. ANN models for stage-discharge as well as sediment discharge rating curves have been developed for the sites Pandu and Choulduaghat (outlet of Subasiri sub-basin). Similar ANN models are under development for the sites Pancratna and Bhomraguri.

**h) Expected date of completion** : March 31, 2010.

## 10. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-12

**a) Title of study:** **Study on Integrated Water Resources Management of Sub-Basin To Cope With Droughts**

**b) Study group:** R.P. Pandey, Sc. E1
Ravi V. Galkate, Sc. C
Surjeet Singh, Sc. C
L.N. Thakaral, SRA

**c) Date of start:** Dec. 2008

**d) Duration of the study:** 4 years

**e) Funding:** Internal

**f) Objectives:**

The specific objectives of this project are to:

i. Developing inventory of drought events and water resources in the study sub-basin.
ii. Identification of strategic surface and groundwater resources to be used in drought situations.
iii. Study of alternative means for minimizing adverse impacts of droughts.
iv. Characterization of drought based on hydro-meteorological, environmental, and socio-economic aspects in the selected basin(s).
v. Identification of zones vulnerable to drought in the study sub-basin(s).
vi. Devising integrated water management plan for minimizing water stress on crops, human and animal life during drought situation.

**g) Proposed study area:**

Tons sub basins in Madhya Pradesh

**h) Work Plan**

Proposed work plan for the project consists of the following steps.

1. Reconnaissance survey, subsequent field visits and liasoning with the concerned departments/offices etc. in the proposed study areas.

2. Collection of maps and topo-sheets plus other documented relevant information for study site/region
3. Establishment field observation points for real-time data monitoring.
4. Collection of long term hydro-meteorological and other relevant data/records.
5. Random sampling and collection/investigation of socio-economic and environmental information.
6. Procurement/collection of meteorological records from IMD and stream flow records from various sources.
7. Procurement of hydro-meteorological equipments and computing appliances for the project.
8. Developing inventory of drought events, their impact and identification of indigenous knowledge (ITKs) on drought mitigation in the study areas.
9. Digitization of maps, toposheets, preparation of maps of drainage, landuse, cropping system, DEM, water availability maps (SW & GW), irrigation maps etc. using GIS.
10. Analysis of meteorological, hydrological data and agricultural records for establishing regional drought indicators/indices.
11. Impact assessment of drought on economy, environmental and social aspects.
12. Preparation of state of art report on drought management along with traditional practices
13. Evaluation of proposed indicators/indices with the past as well as the current information/records and verification of indices and vulnerability criteria.
14. Classification of zones vulnerable to drought and water scarcity (preparation of vulnerability maps and their physical verification with ground truth).
15. Assessment/quantification of existing surface and ground water resources in the study areas.
16. Dry spell analysis and studies of low flow regime.
17. Quantification of prevailing water demands and supplies.
18. Formulation first hand water resources management plan for field execution and its persuasion with local administration/developmental functionaries to minimizing adverse impacts of drought.
19. Near real time field monitoring of drought and application of proposed drought management plan/alternate strategies through state Government/field organizations.
20. Field training for execution officials/stack holders.
21. Monitoring and mid-term evaluations of first hand plan under item 18.
22. Identification of the effective water management practices for drought mitigation.
23. Finalization of comprehensive water resources management plan under drought situation on the regional basis.

**i) Progress of Project Work:**

The visit for the study area was taken for preliminary investigations and data collection during December 2009. Concerned agencies like CWC and IMD have been contacted discharge and meteorological data. Toposheets and other information is being obtained from various sources.

**j) Expected date of completion**: Dec 2012

**k) Work Schedule**

a. Date of Commencement – Dec- 2008
b. Duration of Study - 4 years ;
c. Table: Phase-wise activities for completion of targets *(Milestones)*

| Activity (months | 1 to 6 | 7 to 12 | 13 to 18 | 19 to 24 | 25 to 30 | 31 to 36 | 37 to 42 | 42 to 48 |
|---|---|---|---|---|---|---|---|---|
| Procurement & installation of instruments & establishment of field data collection center | | | | | | | | |
| Inventory of Water resources, drought events etc. in the study sites. | | | | | | | | |
| Monitoring of Rainfall, Temperature, Water level, Crop condition, Soil type, Water stress | | | | | | | | |
| Collection of data on:<br>1.Rainfall, temperature, evaporation, from agencies<br>2. Water flow information from CWC / state agencies<br>3.Ground water level from CGWB / state departments.<br>4.Crop type and area | | | | | | | | |

| | |
|---|---|
| 5.Socio-economic Profile<br>6.Drought event related information | |
| Studying events and prevailed conditions | |
| Data analyses and identification of critical parameters that influences drought situations | |
| Procurement of satellite data corresponding to drought events – IRS, MetSat, NOAA | |
| Creation of geo-information base | |
| Experiments &development of Drought Index | |
| Development of Warning / Alert System for water management actions | |
| Reporting / Assessment of progress | |
| Presentation of –status, achievement | |
| Final Report Submission | |

# NEW PROJECT PROPOSALS

## 11. PROJECT REFERENCE CODE: NIH/SWD/NIH/09-12

**a) Title of the study:** Snow Melt Runoff Modelling in Sultej Basin

**b) Study group:** A. R. Senthil kumar Sc C
Manohar Arora, Sc B
Avinash Agarwal, Sc, E1
D. S. Rathore, Sc E1
Digambar Singh, Sc B

**c) Date of start:** 1 April 2009

**d) Duration:** 3 YEARS

**e) Sources of funding:** NIH funded

**f) Objectives of the study:**

(i) To simulate snow melt runoff using conceptual models SRM and SNOWMOD
(ii) To develop an ANN model to simulate the snow melt runoff
(iii)To compare the results of conceptual models with ANN model

**g) Brief methodology:**

**Status/gaps**

Snowmelt runoff estimates are of high interest for flood warning and management of reservoirs for hydropower generation in drainage basins with significant snowmelt contribution. The rivers originate from Himalayas receive a significant flow from snow melt. Conceptual models such as Snowmelt Runoff Model (SRM) (Martinec et al, 2007) and SNOWMOD have been developed to simulate the snow melt runoff using elevation, rainfall, aspect, temperature and snow cover area as input. Development and application of conceptual models for the simulation of snow melt runoff require physical understanding of the process and generation of large quantity of data. Recently, neural networks approach has been applied in many areas of water resources due to its capability in representing any nonlinear processes by given sufficient complexity of the trained

networks (Maier and Dandy, 2000). ANNs are proven to produce improved performance over other traditional models such as conceptual models and black box models, in numerous hydrological studies (Hsu et al., 1995). The main advantage of the ANN models over traditional models is that it does not require information about the complex nature of the underlying process under consideration to be explicitly described in mathematical form. Tokar and Johnson (1999) developed ANN model for simulating the snowmelt runoff with observed temperature, precipitation (rain plus snow), snowmelt runoff as inputs. They compared the results of ANN with conceptual and regression model and found the ANN performed better than both the traditional models. Parent et al (2008) simulated the snow melt runoff using ANN model with the inputs as considered by Tokar and Johnson (1999) in addition to the snow covered area and they also found that ANN model performed better than other models considered in the study.

**SNOWMOD**

SNOWMOD is a conceptual model developed by NIH Roorkee to simulate the daily streamflow contributed from snow melt and rain. The following steps are adopted for the simulation of streamflow.

(i) Extrapolation of available meteorological data to the different elevation zones
(ii) Calculation of rates of melt and/or rainfall at different points
(iii) Integration of melt runoff from snow and glacier covered area (SCA) and rainfall runoff from snow free area (SFA), and routing of these components separately with proper accounting of baseflow to the outlet of the basin

The degree-day approach is adopted in the computation of snow melt runoff. The runoff contribution from snow covered area and snow free area are computed by standard formulae.

**SRM**

SRM is also a conceptual model developed by USDA. The model has been applied in over 100 basins spread over 29 countries. The snow melt runoff is computed by degree-day approach. The runoff contribution from snow covered area and snow free area are computed by Standard formulae.

**ANN Model**

In many of the ANN applications in water resources only three-layered feed forward structure has been used. Maier and Dandy (2000) report that not more than one hidden layer is required in feed forward networks because a three-layer network can generate arbitrarily complex decision regions. So three layered feed forward structure is selected for the ANN model in this study also. The training of the model will be done by back propagation algorithm. The performance of the model will be evaluated by coefficient of correlation, root mean squared error and model efficiency.

**Data required for the modeling**

The following are the data requirement for the simulation of snow melt runoff using SNOWMOD, SRM and ANN model.

(a) Total area of the basin, altitudinal distribution through elevation zones and their areas, altitude of precipitation and temperature stations

(b) Daily precipitation, mean air temperature, snow covered area/glaciated area and streamflow data

The catchment of Sutlej will be considered for analysis.

**h) Output of the study**

A model for predicting the snow melt runoff from glaciers will be developed.

**i) Outcome of the study**

The findings and the recommendations would be brought in the form of reports. An interim report would be prepared in the year 2009-10 and 2010-11. Final report would be prepared in the year 2011-2012.

**References**

Arora, M. 2008. Seasonal characterization of ablation, storage and drainage of melt runoff and simulation of streamflow for the Gangotri glacier, Project report, D.S.T., GOI.

Hsu, K-L., H.V. Gupta. and S. Sorooshian. 1995. Artificial neural network modeling of the rainfall-runoff process, Water Resources Research, 31(10), pp. 2517-2530.

Jain, S.K., A. Das. and D. K. Srivastava. 1999. Application of ANN for reservoir inflow prediction and operation,

Maier, H.R. and G.C. Dandy. 2000. Neural networks for the prediction and forecasting of water resources variables: A review of modelling Issues and applications, Environmental Modelling & Software, 15, pp. 101-124.

Martinec, J., A. Rango. and R. Roberts. 2007. Snowmelt Runoff Model (SRM) – User's Manual, USDA, 1400 Independence Ave., S.W. Washington, DC 20250.

Parent, A. C., F. Anctil, V. Cantin. and M. A. Boucher. 2008. Neural network input selection for hydrological forecasting affected by snowmelt, Journal of American Water Resources Association, 44(4), pp. 679-688.

Tokar, A.S. and A. Johnson. 1999. Rainfall-runoff modeling using artificial neural networks, Journal of Hydrologic Engineering, ASCE, 4(3), pp. 232-239.

## 12. PROJECT REFERENCE CODE: NIH/SWD/NIH/09-11

**a) Title of the study:** **Data Book - Hydro-Meteorological Observatory 2001-2008**

**b) Study group:** Digambar Singh, Sc B
A. R. Senthil kumar Sc C
Manohar Arora, Sc B

**c) Date of start:** 1 April 2009

**d) Duration:** 2 YEARS

**e) Sources of funding:** NIH

**f) Objectives of the study:**

(i) To bring out the data book for NIH hydro meteorological observatory for the years 2001-2008

**g) Brief methodology:**

Hydro-meteorological data is an initial and foremost requirement for the planning and execution of any water resources projects. National Institute of Hydrology commissioned a hydro-meteorological observatory in its campus in the year 1985. Observations of maximum temperature, minimum temperature, relative humidity, pan evaporation, rainfall, wind speed, wind direction are made on daily basis. The request for the data from other organizations is considerably more. So it is appropriate to bring out the data book in regular intervals. It is planned to enter the data in SWDES software and the related statistics of the data will be brought out in tabular forms.

**h) Technical programme**

The quarterwise programme for the year 2009-10 is given as follows:

| Sl. no | Activities | I-Qtr (Apr-Jun) | II-Qtr (Jul-Sep) | III-Qtr (Oct-Dec) | IV-Qtr (Jan-Mar) |
|---|---|---|---|---|---|
| 1 | Data entry and processing | | | | |
| 2 | Preparation of interim report | | | | |

i) **Output of the study**

Data book for NIH Hydrological Observatory for the years 2001-2008

j) **Outcome of the study**

An interim report would be prepared in the year 2009-10. Final report would be prepared in the year 2010-2011.

THE 30TH MEETING OF THE NIH WORKING GROUP

# WATER RESOURCE SYSTEMS
# HYDROLOGY DIVISION

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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

## WORK PROGRAMME OF WATER RESOURCES SYSTEMS DIVISION FOR THE YEAR 2008-09

| S.No. & Ref. Code | Project | Project Team | Duration | Funding Source |
|---|---|---|---|---|
| 1. NIH/WRSD/NIH/07-12 | Decision Support System (Planning) for Integrated Water Resources Development and Management | S K Jain<br>A K Lohani<br>D Chalisgaonkar<br>C P Kumar<br>M K Goel<br>Vijay Kumar<br>R P Pandey<br>P K Bhunya<br>Sanjay Kumar<br>A Sharma | 5 Years (04/07-03/12) | Hydrology Project |
| 2. NIH/WRSD /NWDA/07-08 | Hydrologic Studies for Ken-Betwa Link Project (Phase-II) | Sharad K Jain<br>Vijay Kumar<br>P K Bhunya<br>N Panigrahy,<br>Sanjay K Jain<br>Rama Mehta | Nine months after key data are provided by NWDA<br>(The proposal to extend the duration up to Dec 2008 has been submitted to NWDA) | NWDA (Phase-II: Rs. 16.15 lacs plus equipment)<br>(The revised estimate been submitted to NWDA) |
| 3. NIH/WRSD/NIH/06-09 | Impact of dams and diversions on hydrology | S K Jain<br>D.S. Rathore<br>Rama Mehta<br>Sanjay Jain<br>P.K. Bhunya | 3 Years | NIH |
| 4. NIH/WRSD /THDC/09 | Preparation of contour map and hypsometric curve of catchment area of Sankosh MPP and Bunakha HEP, Bhutan | S K Jain<br>D.S. Rathore | 1 Month | THDC |
| 5. NIH/WRSD/NIH/07-09 | Development of Empirical Methods for Reservoir Sedimentation Assessment for Indian Conditions | Sharad K. Jain<br>Sanjay K. Jain | 2 Years | Taken up on the advice of TAC |

| | | | | |
|---|---|---|---|---|
| 6. NIH/WRSD/NIH/06-09 | Use of Remote Sensing in soil moisture and water balance – case study of Solani catchment | Sanjay K. Jain<br>Sharad Jain<br>J.V. Tyagi<br>IIRS Dehradun | 3 Years | No |
| 7. NIH/WRSD/ HP-II/08-10 | Integrated approach for modeling snowmelt runoff and effect of climate change in Beas basin | Sanjay K. Jain<br>Sharad K. Jain<br>Vijay Kumar<br>Manmohan K. Goel | 2 years | Approved as PDS under HP-2, budget Rs. 77.50 Lakhs |
| 8. NIH/WRSD/ HP-II/08-12 | Hydrological Assessment of Ungauged Catchments (Small Catchment) | Pradeep Kumar Bhunya<br>Rakesh Kumar<br>Sharad. K. Jain<br>D S Rathore<br>P C Nayak<br>Niranjan Panigrahy<br>Sanjay Kumar Suhas Khobragade Director (Hydrology and W.R. Planning-I), Govt. of Orissa | 4 Years (2008-2012) | PDS under HP-II |
| 9. NIH/WRSD/NIH/08-10 | Web-based River Basin Information System for India | S K Jain<br>Deepa Chalisgaonkar<br>D S Rathore<br>N Panigrahy | 2 years | Internal |

## PROPOSED WORK PROGRAMME OF WATER RESOURCES SYSTEMS DIVISION FOR THE YEAR 2009-10

| S.No. & Reference Code | Project | Project Team | Duration | Funding Source |
|---|---|---|---|---|
| 1. NIH/WRSD/NIH/07-12 | Decision Support System (Planning) for Integrated Water Resources Development and Management | S K Jain, A K Lohani<br>D Chalisgaonkar<br>C P Kumar, M K Goel<br>Vijay Kumar, R P Pandey<br>P K Bhunya<br>Sanjay Kumar, A Sharma | 5 Years (04/07-03/12) | Hydrology Project |
| 2. NIH/WRSD/NIH/06-09 | Use of Remote Sensing in soil moisture and water balance – case study of Solani catchment | Sanjay K. Jain<br>Sharad Jain, J.V. Tyagi<br>IIRS Dehradun | 3 Years | NIH |
| 3. NIH/WRSD/ HP-II/08-10 | Integrated approach for modeling snowmelt runoff and effect of climate change in Beas basin | Sanjay K. Jain<br>Sharad K. Jain<br>Vijay Kumar<br>Manmohan K. Goel | 2 years | Approved as PDS under HP-2, budget Rs. 77.50 Lakhs |
| 4. NIH/WRSD/ HP-II/08-12 | Hydrological Assessment of Ungauged Catchments (Small Catchment) | Pradeep Kumar Bhunya<br>Rakesh Kumar<br>Sharad. K. Jain<br>D S Rathore , P C Nayak<br>Niranjan Panigrahy Sanjay Kumar Suhas Khobragade<br>Director (Hydrology and W.R. Planning-I), Govt. of Orissa | 4 Years (2008-2012) | PDS under HP-II |
| 5. NIH/WRSD/NIH/08-10 | Web-based River Basin Information System for India | S K Jain<br>Deepa Chalisgaonkar<br>D S Rathore<br>N Panigrahy | 2 years | INIH |
| 6. NIH/WRSD/NIH/09-12 | Impact of Climatic Change on Hydrological response of Ramganga basin, Uttarakhand. | Dr. Rama Mehta,<br>Dr. Sanjay K. Jain,<br>Dr. Vijay Kumar, Dr. Sharad K. Jain | 3 years | NIH |

## 1. PROJECT REFERENCE CODE: NIH/WRSD/NIH/04-07/1

**a) Title of the study:** **Decision Support System (Planning) for Integrated Water Resources Development and Management**

**b) Funding:** Hydrology Project

**c) Project Team:** S K Jain, A K Lohani, D Chalisgaonkar, C P Kumar, M K Goel, Vijay Kumar, R P Pandey, P K Bhunya, Sanjay Kumar, A Sharma, N Pannigrahy, Surjeet Singh

**d) Objective:**

To develop a Decision Support System to support the process of decision making covering (i) Surface water resources planning, (ii) Integrated operation of reservoirs, (iii) Conjunctive use of surface water and ground water resources, (iv) Drought management, and (v) Water quality management in a river basin.

This study will culminate with the development of a comprehensive DSS (Planning) under the Hydrology Project – II.

**e) Progress:**

The project commenced on December 1, 2008. NIH has held a series of preparatory workshops to introduce participating states and central agencies to the concept, practicalities and data needs of DSS in preparation for HP-II. The stating point in the DSS development is to undertake a 'need analysis' to define the nature of the water resources issues to be addressed by the DSS. NIH has already taken a preliminary need analysis at one of the workshops, which identified the nature and priority of water resources issues and outputs of each of the five components, i.e. the desired DSS capabilities.

**f)** The development of the DSS will begin with development of mathematical models, compilation and integration of existing data sources and development of generic DSS. This generic DSS will be applied to a pilot basin. This will provide opportunities and developing systems and processes for data compilation, model development and DSS application to other case study basins. Finally DSS will be tested and refined.

g) DHI, Denmark have been identified as the consultants for the development of DSS. An agreement has been signed with the consultants who have initiated the work on Dec. 10, 2008. The Inception workshop for DSS was conducted during Feb 9-10, 2009.

**h) Expected Date of Completion:**

This study is linked with the progress of the Hydrology Project – II.

## 2. PROJECT REFERENCE CODE: NIH/WRSD/NWDA/07/08

**a) Title of the study:** **Hydrologic Studies for Ken-Betwa Link Project (Phase-II)**

**b) Start Date:** September, 2007

**c) Duration:** Up to Dec 2008

**d) Funding:** NWDA (Phase-II: Rs.24.85 lakhs plus equipment)

**e) Project Team:** Sharad K Jain, Vijay Kumar, P K Bhunya, N Panigrahy, Sanjay K Jain, Rama Mehta

**f) Objectives:**

1. To estimate the water yield and conduct water balance studies for the three proposed sites (Makodia, Kesari and Barari) in Betwa basin.
2. To estimate the design flood for the above three proposed sites in Betwa basin.
3. To estimate the transport capacity of the Ken-Betwa link canal from Barwa Sagar up to Parichha weir and study the regulation capacity of Barwa Sagar.
4. To compute the height of the embankments up to Madla (downstream of the Daudhan dam), and to evaluate impacts of the Daudhan project on downstream flood conditions (up to Madla).
5. To conduct the river morphology analysis for Ken River from Daudhan to Madla.
6. To conduct dam break analysis for the Daudhan dam.
7. To simulate the multi-reservoir system of Ken-Betwa and derive reservoir operation policy for Daudhan and one dam and two barrages in upstream of Betwa Basin.
8. To estimate evaporation losses for the three proposed dams in Betwa basin.
9. To compute reservoir back water curve for the Daudhan Dam.

**g) Status**

The mean areal rainfall has been calculated considering data of 8 rain-gauges using Thiessen Polygon method, and the consistency of rainfall data has been carried out using double mass curve analysis. It was observed that for three

stations namely, Basoda, Berasia and Vidisha, significant change of slope is observed in the double mass curve. For remaining five stations, no significant change in slope of the double mass curve was observed. Hence, corrections for annual rainfall data for above listed three stations were made. These data have been used for computing mean rainfall over four sub-basins: (i) Up to Makodia; (ii) Up to Barari, (iii) Up to Kesari, and (iv) Up to Basoda.

The water needs in the different sub-basins for various purposes have been estimated for the year 2050 using projected population, livestock, cropped area and power generation. Water availability analysis has been carried out for the annual and monthly virgin yields at Basoda incorporating the upstream water utilization of various projects. The monthly and annual virgin yields at project sites have been estimated from Basoda yield using area and rainfall ratios and regression analysis. The 50, 75 and 90% dependable annual yields at different sites have been estimated.

The total sediment deposition in the Makodia reservoir during 50 and 100 years are estimated to be 37.5 and 75.0 MCM respectively. The new zero elevations after 50 years and 100 years have been found to be as 428.24 m and 430.0 m respectively.

The design flood for three project sites have been estimated using two approaches: (i) unit hydrograph and (ii) frequency analysis. In unit hydrograph approach, synthetic unit hydrographs were derived using CWC flood estimation report of zone 1(c). The derived SUH was convoluted with a critical design (critical sequencing of PMP) to produce the corresponding PMF hydrograph of the sub-catchments.

Reservoir simulation study has been carried out to fix the reservoir level and storage capacity of different reservoirs. Simulation of the operation of all the major regulation structures in the Ken-Betwa system up to Parichha weir was also carried out.

Dam break study of Daudhan dam was also carried out. The NWS-DAMBRK model was used for investigation of the flood wave propagation characteristics in the considered river reach, i.e. 11.4 km upstream of the Daudhan dam and 157 km downstream of the dam.

Backwater profile for Daudhan and Makodia dam, morphology analysis for Ken River from Daudhan dam to Banda, computation of maximum water level from Daudhan to Madla and Impact of Daudhan dam on downstream flood conditions were also carried out.

Design of canal from Barwa Sagar to Parichha weir to safely carry the flow in the link canal was carried out by Lacey's theory. It was found that a channel with the dimension of width (B) as 32.87 m, depth (D) as 1.20 m and side slope of 0.5:1 will safely pass the link flow. The regulation capacity of Barwa Sagar was also estimated and comes out to be of the order of 4 days.

**The final report has been submitted.**

## 3. PROJECT REFERENCE CODE: NIH/WRSD/NIH/06-09

**a) Title of the study:** **Impact of dams and diversions on Hydrology**

**b) Study Group:** S K Jain. Sanjay Jain, D.S. Rathore, P.K. Bhunya, Rama Mehta

**c) Start Date:** April 2006

**d) Duration:** Three years

**e) Whether externally funded or not:** Internal funded

**f) Objectives**

To create GIS based database of selected salient features for major and medium dams in India.
To study impacts of dams on various components of hydrologic cycle.

**g) Brief Methodology**

Creation of a database of the dams and diversions requires collection of salient features and location maps for dams and diversions and input of the information in to a database and GIS software. Salient features of various major and medium projects were obtained from various sources namely reports, papers, books, internet sites etc. Database and GIS software namely MS Access and Arc View are identified. Salient features were entered in the software. Location of dams and diversions were digitized. Apart from locations, thematic maps namely basins, rivers, states, physiographic units etc. were digitized.

*Impacts*

Dams and diversions affect hydrological cycle upstream, within, and downstream of the reservoir and in the command areas. Due to changes in the water and sediment discharge regimes, morphological changes in channels and tributaries also take place. The hydrological impacts of dams and diversions are listed below:

- Rise in groundwater table upstream of a dam,
- Change in volume and temporal pattern of flow downstream of dams/diversions,
- Changes in sediment concentration, particle size downstream of a dam,
- Increased infiltration in command area and its impact on groundwater regime,
- Changes in evaporation and ET from reservoir and canal command areas,
- Changes in hydrological cycle for the catchment as well as the region,
- General scour of the main channel below the dams,
- Changes at the confluences downstream of dams,

**h) Results achieved / Present Status**

Geographic coordinates of 1812 medium and major dams have been entered in the database. Salient feature data base contains details of 614 dams and diversions. Out of these, locations of 414 dams and diversions were available.
Report writing is in progress.
Computation of monthly evaporation from selected Indian reservoir is in progress.

**i) Expected date of completion:** March 2009

## 4. PROJECT REFERENCE CODE: NIH/WRSD /THDC/09

**a) Title of the study:** **Preparation of contour map and hypsometric curve of catchment area of Sankosh MPP and Bunakha HEP, Bhutan**

**b) Study Group:** D.S. Rathore, Sharad K Jain

**c) Start Date:** January 2009

**d) Duration:** One month

**e) Whether externally funded or not:** Sponsored by THDC, Budget Rs 2,42,697.00

**f) Objectives**

1. To create DEM using SRTM and topographic maps in raster and TIN format.
2. To create contour map at 100 m interval in softcopy and print form.
3. To delineate basin and river network up to the project site.

**g) Brief Methodology:**

The methodology consists of the following steps:

- Georeferencing of the topographic maps (internet source) to UTM map projection.
- Digitization of the contours (150- 800 m interval). The topographic maps (internet source) have contours at 150- 800 m contour interval. In steep sloping terrain, even this interval results in very closely spaced (horizontally) contours and the interval will suffice in correctly representing the topography.
- Creating DEM: A DEM will be created from contours in GIS in raster or TIN formats.
- Developing hypsometric curve: Hypsometric curve will be prepared from DEM in GIS, through density- slicing of the raster DEM 1t 100 m interval.
- Georeferencing SRTM data.
- Comparing the data with the topographic maps.
- Digitizing stream network
- Digitizing basin boundary
- Generating stream network and basin boundary automatically from DEM

**h) Results achieved / Present Status**

- Digitization of topographic maps for Sankosh project is in progress.
- Hypsometric curve (Fig. 1) and contour maps have been prepared for Sankosh project using SRTM data.

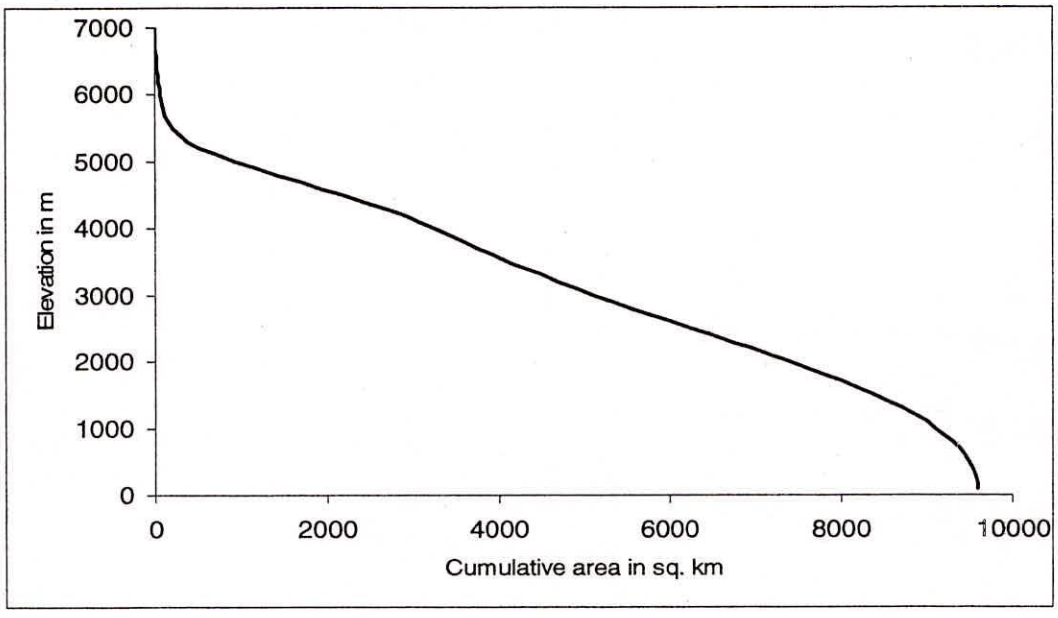


Fig. 1 Hypsometric curve for Sankosh MPP using SRTM data

**i) Expected date of completion:** March 2009

## 5. PROJECT REFERENCE CODE: NIH/WRSD/NIH/07-09

**a) Title of the Study:** **Development of Empirical Methods for Reservoir sedimentation Assessment for Indian Conditions**

**b) Date of Start:** 1st April 2007

**c) Duration of the Study:** 2 Years

**d) If Externally Funded:** Taken up on the advice of TAC

**e) Study Group:** Dr. Sharad K. Jain, Dr. Sanjay K. Jain

**f) Objective:**

To develop the design curves for Indian conditions using the data of Indian reservoirs.

**g) Brief Methodology:**

- The elevation-storage data for all the reservoirs will be plotted and value of m will be found.
- Original as well as revised storage data will be plotted to determine change in the value of m with time. For all the reservoirs, plot of percentage depth versus percentage sediment deposition will be plotted.
- For each reservoir, sediment deposition in various zones will be tabulated.
- The plot of data of Indian reservoirs will be compared with those of the USBR curves to ascertain whether the Indian data also follows the same or a different trend. If a different trend is noticed, then curves for the Indian reservoirs will be developed. If enough data are available and analysis reflects so, attempts will be made to develop regional curves.
- Other data analysis techniques will be developed to investigate if an alternate method of predicting sedimentation can be developed.

**h) Results Achieved with Progress/Present Status**

The elevation-area-capacity data of 110 reservoirs (30 in Gujarat, 19 in Maharashtra, 46 in Andhra Pradesh and 15 in other states) have been collected.

A preliminary analysis of these reservoirs has been carried out. The values of m and type of curve for the reservoirs have been determined. Also area design curves have been prepared using the available data.

Based on the slope of elevation-capacity curve, the reservoirs were classified in four classes. Out of these 110 reservoirs, 40 reservoirs have been classified as type 3 followed by 34 reservoirs of type II. However 9 reservoirs are under type I and 27 reservoirs are under type IV. Now, for forty reservoirs falling in a particular type, relative depth vs. relative sediment area was plotted on a graph. The coefficients C, m, and n were systematically changed so as to obtain a curve that best represents the aggregate behaviour of all the reservoirs. This process was repeated for all the four types. Characteristics curves derived for four types of reservoirs have been drawn for 40 reservoirs and the values of C, m, and n for reservoirs have been obtained. For rest of the reservoirs preparation of characteristics curves are in progress. Report writing is in progress.

i) **Expected Date of Completion:** 31st March 2009

## 6. PROJECT REFERENCE CODE: NIH/WRSD/NIH/06-09

**a) Title of the Study:** **Use of Remote Sensing in soil moisture and water balance – case study of Solani catchment**

**b) Date of Start:** 1st April 2006

**c) Duration of the Study:** 3 Years

**d) If Externally Funded:** No

**e) Objectives:**

a. To assess soil moisture in the field using Zypsum blocks
b. To assess soil moisture using remote sensing data and compare it with field observations
c. To measure rainfall, discharge and selected meteorological variables in the field
d. To carry out water balance study of the catchment using SWAT model

**f) Brief Methodology:**

a. Measurement of soil moisture in the field using Zypsum blocks at eight locations according to soil strata.
b. Measurement of meteorological data (RH, wind speed etc.) with the help of Automatic Weather Station at two locations (Mohand and Roorkee)
c. Measurement of gauge data at Roorkee during monsoon period.
d. Soil moisture assessment using remote sensing data. For this purpose NOAA AVHRR/ MODIS data involving thermal bands will be used.
e. Rainfall runoff study of the catchment will be carried out.

**g) Results Achieved With Progress/Present Status**

The progress made so far is as follows:

- Daily rainfall, evaporation, humidity etc. data of AWS installed near Mohand by IIRS, Dehradun and at NIH, Roorkee are being collected from 2006 onwards.

- The gauge observations (using AWLR) at an interval of one hour have been started since mid July 2007. Velocity measurements using current meter whenever there is high flow in the river has been/are being collected. For the year 2006, G&D measurements have been taken at old Solani aqueduct.
- The soil moisture index was developed using SWIR bands as significant correlation has been obtained between reflectance in the 1.93 to 2.18μm electromagnetic spectrum. SWIR bands of ASTER were used to develop soil moisture index which varied from -0.49 to 0.437. It was observed that higher the index, higher is the moisture content. Based on NDVI and $T_s$-$T_a$ space relationship, surface soil moisture status (qualitatively) in the watershed has been studied. The VIT trapezoid has good potential to study the soil moisture condition qualitatively. This approach integrates both remotely sensed land surface reflectance and thermal properties and gives the emphasis on difference between LST and ambient air temperature and NDVI based on NDVI-($T_s$-$T_a$) space relation. Hence TIR data can also be used efficiently for understanding soil moisture conditions qualitatively.
- The data base for SWAT (AVSWAT- Arc View interface) model has been prepared. The land use and soil maps have been prepared in Arc View and also reclassified using AVSWAT.
- Simulation was carried out using AVSWAT model for daily, weekly and monthly time steps from July 2006 to October 2006 (monsoon period) and results were compared with measured flow data. AVSWAT model simulates daily flows accurately showing 81% agreement with observed flow. First month simulations were found to highly deviate from the observed flows but from the next month onwards, simulation improved considerably. Daily simulated flows had high correlation with observed flows (r=0.94) and follow the observed pattern well. Low flows are well simulated except in the first month.
- Weekly flow simulation from AVSWAT model is in acceptable range and the simulated flows follow the pattern of observed flows. Simulated and observed flows are highly correlated (r=0.93). Monthly simulation results shows that for the first month, AVSWAT model over estimated the flow while the flow of the second month was under-estimated. For the next two months simulated and observed flows are almost equal. The results obtained from AVSWAT were in good agreement with rainfall during all four months period.
- The report writing is in progress.

h) **Expected Date of Completion:** 31st March 2009. It is proposed to continue this study for another term of three years so that we have good data base and detailed modeling can be carried out.

## 7. PROJECT REFERENCE CODE: NIH/WRSD/HP-II/08-10

**a) Title of the Study:** **Integrated approach for modeling snowmelt runoff and effect of climate change in Beas basin**

**b) Date of Start:** 1st April 2008

**c) Duration of the study:** Two years

**d) If externally funded:** Approved as PDS under HP-II, budget Rs. 77.50 Lakhs

**e) Study Team:** Dr. Sanjay K. Jain, Dr. Sharad K. Jain, Dr. Vijay Kumar, Dr. Renoj Theyyan.

**f) Objectives:**

Considering the importance of snowmelt runoff in Himalayan basin and also effect on stream flow because of climate change, the objectives of the study are:

a. To create data base such as DEM, meteorological/hydrological data base for the study area
b. To estimate snow cover area using remote sensing data
c. To estimate snow melt runoff in Beas River at Pandoh dam.
d. To study trend of precipitation, temperature and stream flow using parametric and non parametric approaches, and
e. To investigate the impact of likely future changes in climate on stream flow using GCM generated scenarios in the study area.

**g) Brief Methodology**

The methodology consists of four stages as described below:

**Stage1:** In this stage, data related to the study area including maps, flow and meteorological data, development works taken place so far and the relevant data in terms of land features, vegetation, land-use etc. will be collected and a database will be created.

**Stage-2:** For this, snow cover area curves will be prepared from satellite data and then snow cover depletion maps will be prepared.

**Stage-3:** Stream flow from the basin will be estimated by using the available snowmelt runoff model. The whole basin will be divided into elevation zones. The model will compute daily runoff from the snow covered area and snow free area separately. The model will be calibrated using the dataset and then the results will be validated.

**Stage-4:** Evaluation of the trend of temperature, rainfall and stream flow in a Himalayan basin. The major objective of the study is to analyse the trend of the above mentioned meteorological variables in the last three decades. Trend analysis will be carried out using linear regression method and non parametric method.

**Stage-5:** The effect of climate change on runoff will be studied by applying changes in temperature and precipitation to the data from the meteorological stations used in the model. To study the effect of climate change on snowmelt runoff under changed conditions, GCM generated scenarios will be applied.

## h) Results achieved with progress/present status

The base maps (drainage/contour/DEM) of the study area have been prepared in GIS data base. The DEM has been divided into number of elevation bands. MODIS satellite data (weekly) for the study area have been obtained from NSDIC. Processing of this satellite data is in progress. The snow cover area for the years 2000-2005 have been computed and depletion curved have been prepared. This snow cover area for different elevation bands has been computed with SCA and DEM. A visit to BBMB Chandigarh has been made for getting necessary permission to obtain data of the study area. A visit to Sundernagar was undertaken in the month of September for data collection. The rainfall, temperature and discharge data have been collected.

Simulation of stream flow has been carried out for the years 2000-2005. Satellite data procurement from NRSC, Hyderabad is in progress.

## i) Expected Output/outcome

Stream flow including snowmelt runoff from the catchment at Pandoh site will be modeled using a snowmelt model. During April to June when the major component of stream flow is from snowmelt, prediction of stream flow is very beneficial for reservoir operation. Also this estimate is very much required for

hydropower projects which are coming up in the Himalayan region. Besides an analysis of the trend of the historical data will help in understanding and quantifying the impacts of the expected changes in climatic variables and precipitation in future. Also the scenarios generated in the study will give important information regarding future climate change aspects.

## 8. PROJECT REFERENCE CODE: NIH/WRSD/HP-II/08-12

**a) Title of the study:** **Hydrological Assessment of Ungauged Catchments (Small Catchment)**

**b) Date of Start:** July, 2008

**c) Duration of the Project:** Four Years (2008-2012)

**d) If Externally Funded:** PDS under HP-II

**e) Study Group:** Pradeep Kumar Bhunya, Rakesh Kumar, Sharad. K. Jain, D S Rathore, P C Nayak, Niranjan Panigrahy, Sanjay Kumar, Suhas Khobragade, Director (Hydrology and W.R. Planning-I), Govt. of Orissa.

**f) Objectives:**

(i) To calibrate and validate an event based model employing unit hydrograph approach to the available data of flood events for the gauged catchments in the region.

(ii) To identify few robust flood frequency distributions that may be used for the computation of return period flood for the gauged catchments in the region.

(iii) To develop regional flood formulae using statistical correlation of the observed peak characteristics with important catchment and storm characteristics, for the estimation of the peak, and time to peak for the ungauged catchments in the region.

(iv) To develop regional unit hydrograph, and regional flood frequency analysis procedures utilizing the available data and methodologies.

(v) To develop methodology for the regionalization of the hydrological parameters for the computation of the water availability for the ungauged catchments in the region.

**g) Status**

For many small catchments in the study area, the stream flow data are limited; both in regard to length of recorded period and time steps. This was observed during the continued field visits. And for ungauged basins it is not available, e.g.,

in a recent *Rushukulya* basin map prepared by Water res. Deptt, Orissa, at least 11 small catchments that have high flow response, five catchments have some data for 10 yrs. Under such circumstances, regional unit hydrograph and regional food frequency methods along with regional empirical formula developed using the data of gauged catchments in the region are used to arrive at design flood for the ungauged catchments. Regional unit hydrographs for such regions are derived using their physical, hydrological and storm characteristics. Research Designs and Standard Organization (RDSO) and Central Water Commission (CWC) documented a report in 1980 recommending regional hydrograph parameters and SUH relationships. This covers a part of the study area (proposed for this project) i.e. Mahanadi sub-zone (3d). In addition to this, the CWC has recommended criteria to be adopted for estimation of design flood for waterways of rail and road bridges in North Bengal, which doesn't cover the present study area. An interim draft report has been submitted and with revised objectives an interim draft report is being prepared under hydrology project. During this period a review/status chapters has been prepared, and a few data base/ detail specifications of recent date remote sensing imageries covering these sites (small scale) is being prepared. In last visit to CWC, some information was collected regarding published reports on Mahanadi basin (including some small catchments).

**Future**

In future, it is envisaged to add a few more physiographic parameters using remote sensing imageries and GIS, which are sometime difficult to interpret from the Survey of India toposheets or might have changed due to natural and human activities in the region. CWC has already stipulated design return periods for different schemes depending on their size (small, medium, and large) along with the specification for using either PMF or SMF for design flood computation. Therefore, it is envisaged to analyses various distributions and recommends a standard statistical distribution for flood frequency analysis in the region. The theoretical analysis shall include all the recent developments in the topic and the latest available data of the region.

**h) Issues and Recommendations**

1. Mahanadai, Rushukulya, and Brahmani catchments in state of Orissa that are included in the study area are fast developing industrial belts. Therefore, there is always a need for engineers to plan water availability, design flood for

planning of culverts, bridges, road embankments etc. Such works require estimation of design return period flood, peak floods for different storm, and unit hydrographs of different durations. Most of these parameters are to be computed for flow contribution from small catchments that are ungauged, a standardized procedure of flood estimation, and regional formulae would be very much useful to the field engineers.

2. Government of Orissa is initiating small to medium water harvesting structures and tanks for artificial recharge purpose mainly in southern part (Rushukulya catchment) prone to drought. For design of such structures, water availability studies are pre-requisite. A regional flow duration curve along with empirical regional formulae to estimate mean flow shall assist the field engineers in computing the design parameters for small-ungauged areas. In addition to these design and sanction of small projects in the state, which require design return period flood, unit hydrograph and water availability analysis gets delayed because of lack in data or due to lack of any standard procedures. Further the existing regional formulae for such design parameter estimation, if exists need to be updated and standardized with latest available data and methods.
3. Studies so far recommend regional formulae for return period flood, regional parameters of flow duration curves for a selected region.

**i) Planned training courses:**

A training course is planned on 'Flood forecasting' at Water Resources Department, Govt. of Orissa, and Bhubaneswar during July, 2009.

## 9. PROJECT REFERENCE CODE: NIH/WRSD/NIH/08-10

**a) Title of the study:** **Web-based River Basin Information System for India**

**b) Date of Start:** April 1, 2008

**c) Duration:** 2 years

**d) Funding:** Internal

**e) Project Team:** S K Jain, Deepa Chalisgaonkar, D S Rathore, and N Panigrahy

**f) Background:**

River basin management deals with technical, as well as socio-economic and ecological aspects and calls for an integrated approach. It involves planning and execution of measures to reduce environmental degradation and to ensure sustainable use of water, including water allocation, water user conflicts, monitoring, protection and rehabilitation of ecosystems. Basin wise information on rainfall, water availability, water resources projects, irrigation potential are useful inputs for planning and management.

**g) Brief Methodology:**

The main design objective of the package is to provide a common, integrated, and quantitative geo-spatial framework for providing the hydrological information of India over a variety of domains, from national to sub basin level. Its major design objective is to explore the contemporary status of large river basins that will be affected by the individual and conjunctive impacts of climate variability and change, land cover change, industrialization, pollution, consumptive use of water, and hydraulic modification of river systems. The themes of the package have been given in Table 1 and are discussed below:

**A) Topography:** This theme contains the general topographic features of the country. In addition to the regions, division of the Indian geographical region to different states and river basins has also been included in this section.

**B) Water Facts:** This theme contains information about past, present and future water availability in the country, water distribution, surplus and deficit regions, water budget, pricing and financial aspects in simplified nonprofessional's language.

**C) River Basins:** The major river basins of India are presented in this theme. Selecting a basin from this section, one can access the required information of the basin using other sections.

**D) Water Resources Utilization:** It contains links to the information about different surface and ground water resources utilizing projects, their potential and current status of utilization. It also includes the information related to drinking water, irrigation, hydropower, industrial use, environmental use etc.

**E) Climate:** This theme contains the quantitative information about the climate of the selected region. It includes the information about rainfall, temperature, evaporation, humidity etc.

**F) Thematic Maps:** It contains links to various maps, which can be interpreted visually. These maps are essential for planning and designing of any developmental activity or water resources projects.

The package also includes information about water policy and constitutional provisions for water use. Several treaties (international and inter-state) have been signed in the past and water related disputes have been arisen. The details of these treaties and resolution disputes are also. Ancient literature such as *The Vedas* and *The Upanisads* also provide some meaningful information about weather prediction, drainage, water use etc. To make the user aware of the ancient methods and practices of hydrology the system includes a section for it. The option of e-learning has also been incorporated in this. The e-learning feature is very helpful as a reference hydrological book. It has a large number of figures and more than 600 definitions of various terminologies related to hydrology. Another important feature of the package is the option of online ET-computation. This option includes six commonly used methods (Penman-Montheith, Hargreaves, Blaney Criddle, Doorenbos Pruitt, Priestley Tailor, temperature based) of ET-computation.

The options for getting sub-basin wise information will be developed during next year.

**h) Expected Outcome**

A comprehensive, reliable, user-friendly and web-based information system with emphasis on:

a) Graphical visualisation on maps by users for identifying/selecting required information,
b) Offline and web-based options,
c) Comprehensive hydrological information system.

## 10. PROJECT REFERENCE CODE: NIH/WRSD/NIH/09-12

**a) Title of the study:** **Impact of Climatic Change on Hydrological response of Ramganga basin, Uttarakhand.**

**b) Study Group:** Dr. Rama Mehta, Dr. Sanjay K. Jain, Dr. Vijay Kumar, Dr. Sharad K. Jain

**c) Date of Start:** April, 09

**d) Duration:** 3 years

**e) Funding:** Internal

**f) Objectives:**

- To carry out the trend analysis of rainfall, temperature and flow at the basin outlet,
- To carry out rainfall-runoff modeling of the study basin using SWAT model.
- To study the impact of climate change on hydrological response of the basin using SWAT model.

**g) Brief Methodology:**

Literature survey and collection of hydro-meteorological data for the study area will be done first. Statistical and trend analysis of the hydro-meteorological data will be carried out to establish the temporal trend, present if any. Long term persistence of hydro-meteorological time series will also be developed. The methodology employed for land cover classification of satellite imagery, change detection and classification accuracy will be presented and the observed land cover changes will be obtained.

An extensively used physically distributed hydrological model, Soil and Water Assessment Tool (SWAT) will be set up for the selected basin. The setup model will be calibrated and validated with the observed data set.

The impact of changing climate (temperature, rainfall and snowfall) and landuse will be simulated using the calibrated model.

**h) Year-wise Work Plan:**

| | |
|---|---|
| I[st] year | Literature survey, Hydro-meteorological data collection, Trend analysis of hydro-meteorological data, Long term persistence of hydro-meteorological time series, land cover classification of satellite imagery, SWAT model set up, Detailed accounts of model estimations, |
| II[nd] year | Construction of SWAT model input files, sensitivity of model parameters, calibration and validation of model |
| III[rd] year | Evaluation criteria for model efficiency, Model prediction uncertainty, Assess the impacts of land cover and climate changes with model output, Conclusions and recommendations, Report writing, paper publication |

**i) Expected outcomes:**

(i) This study will tell us about trends in hydrological variables of the study basin.
(ii) Rainfall – Runoff modeling will give parameters of the basin for SWAT model, which can be used for water resources management and the study of climate change.
(iii) Quantification of climate change with increasing and decreasing hydrological variables and vice versa.

**j) Date of completion:** March, 2012

| Table 1: Different Themes of HWRIS | | | | | |
|---|---|---|---|---|---|
| **Topography** | **Water Facts** | **River Basins** | **Climate** | **Water Resources Utilization** | **Thematic Maps** |
| • Overview<br>• States & River | • Water Availability<br>➢ *Surface water Availability*<br>➢ *Ground Water Availability*<br>➢ *Glaciers*<br>➢ *Lakes*<br>• Total Water Requirements<br>➢ *Annual Water Requirements*<br>➢ *Basinwise Water Requirements*<br>➢ *Statewise Water Requirements*<br>➢ *Water Use Changing Trends*<br>• Water Budget of India<br>• Water Pricing in India<br>• Financial Aspects of Irrigation Projects in India | • Area of Inland Drainage in Rajasthan Desert<br>• Brahmaputra & Barak<br>• Brahmani & Baitarni<br>• Cauvery<br>• Ganga<br>• East Flowing Rivers Between Mahanadi and Pennar<br>• East Flowing Rivers Between Pennar and Kanyakumari<br>• Godavari<br>• Indus<br>• Krishna<br>• Mahanadi<br>• Mahi<br>• Minor River Basins Draining in to Bangladesh and Myanmar<br>• Narmada<br>• Pennar<br>• Sabarmati<br>• Subernarekha<br>• West Flowing Rivers of Kuch, Saurashtra including Luni<br>• West Flowing Rivers from Tapi to Tadri<br>• West Flowing Rivers from Tadri to Kanyakumari<br>• Tapi | • Climatic Regions<br>• Rainfall<br>➢ *Annual Precipitations*<br>➢ *Summer Monsoon*<br>➢ *Winter Monsoon*<br>➢ *Monsoon Onset*<br>➢ *Western Disturbances*<br>➢ *Cyclones*<br>• Temperature<br>• Evaporation<br>• Humidity<br>• Radiation<br>• Wind Direction<br>• Dew Point | • Water Resources Projects<br>• Drinking<br>• Irrigation<br>• Hydropower<br>• Industrial Use<br>• Environment Use & Ecology<br>• Interlinking of Rivers<br>• Water Quality<br>➢ *Water Quality Standards*<br>➢ *River Water Quality*<br>➢ *Ground Water Pollution* | • Agroecological Regions<br>• Dams<br>• Landuse Map<br>• Population Density<br>• Rivers<br>• Soil Map<br>• Vegetation<br>• Water Related Problems<br>➢ *Natural Hazards Areas*<br>➢ *Flood Affected Areas*<br>➢ *Drought Affected States*<br>➢ *Arsenic Affected Areas*<br>➢ *Fluoride Affected Areas* |