Performa of Application for Research Grants

1. **Research Station / Institution**

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2. **Principal Investigator**

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3. **Co- Investigators**

Name:

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4. **Brief Bio-data of the Investigators**

(not to exceed one page per person)

(enclose at the end of the proposal) **Please see pages 32-26.**

5. **Project Title** (keep it as short as possible): Luni River Basin Climate and Hydrology Modeling
6. **Track Record and Workload Assessment of the PI**

List all the research and consultancy schemes, whether funded by MoWR or any other agency, in which the present PI is /was Principal Investigator, in following groups.

1 Schemes completed : None

2 Schemes foreclosed with reasons for foreclosure : None

3 Schemes ongoing : None

7. **If the scheme is sanctioned, in whose name the cheque is to be issued. (write precise title of the account)**

   Director, Institute of Technology Rajasthan, Jodhpur

8. **Category of R&D Activity (Tick those which are applicable)**

Basic Research

Applied Research: √

Action Research

Education & Training √

Mass Awareness Programme:√

Infrastructure Development

Creation of Centers of Excellence √

9. **Description of the Proposal**

(Describe the research proposal, the background, how the idea originated etc.)

The most important objective of this project is to provide the people of Luni with state-of-art prediction of the variables such as unpredictable climate, soil condition, water availability and water quality, which comprise the complete hydrologic cycle. An algorithm incorporating certain local assumptions will be used to define theRegional Climate Model for Luni River Basin (RCMLRB).

The proposed RCMLRB based on local assumptions will be performed by deriving a stochastic multi-variate multi-parameter function for the variables described in the assumptions using experimental data for year 2013. The ideas and assumptions local to Luni River Basin are as follows:

1. Anthropogenic activities such as agriculture cover, land degradation, wetlands *etc.* can affect climate and cannot be parameterized easily into RCM . Inclusion of dust effects due to change in land use need to be included.

2. In most of the simulation regarding Luni River Basin or Thar desert sensible latent heat flux is be assumed since latent heat flux is low (10 W m^{-2} , equivalent to an evaporation;0.3 mm^{-d}) in summers. In some aspects, the anomalies are induced locally by the expansion of the Thar Desert in contrast with the findings over other regions (e.g., the Sahel) where a warming is simulated [Bollasina and Nigam, 2011].

3. Topography and the geo-morphological features of the region are also expected to play an important role [Reichler and Kim 2007].

4. The changes in evaporation as well as evapo-transpiration rate due to viscosity changes in the Luni river and its tributaries due to inherent metallic as well as alkaline dissolutions in soil as well as effluent from industrial areas such as dyes from more than 600 factories lining the Bandi river shoreline [Rathore 2010].

5. Palaeo-hydrological studies are significant in deciphering climatic changes at Luni [Sridhar 2008].

6. More than 700 water harvesting structures recently (after 2008) have come up in the Luni River basin [Salina 2008]. The microclimatic conditions near to each of these water harvesting structures will be influenced by the water body.

The assumption stated above will help in designing the RCMLRB. Further, one of the major aspects of the project objectives is data collection. This data will be used to develop an indigenous empirical stochastic multi-parameter multi-variate model for predicting climate change utilizing daily and monthly data on various variables influencing Luni Climate. RCMLRB model will be compared with the downscaled climate models ECHAM5 and HADCM3 and Weather Research and Forecasting model (WRF). For the purpose of prediction of chemical changes in the atmosphere due to industrial pollution and dust effects at Luni, the WRF-Chem model will be appended.

10. ***Objectives. (Classify the objectives of proposed research under one or more of following and explain the objectives briefly***.

Finding answers to as yet un-answered questions. (List the questions)

a. To study the effects of variation in monsoon and other sea related climatic characteristics on the climatic health of Luni River Basin.

b. To measure the change in local climatic and ecological parameters due to construction of wetlands such as water harvesting structures.

c. To formulate an online interface of getting the latest predictions of climate and water availability in Luni river basin.

d. To study the effect of variations in land usage on climate.

e. How albedo and maximum irradiance affects climate in Luni river basin. This question is relevant since the Luni river basin is found to have a irradiance towards the extreme right of the normal distribution of irradiance on India.

Development of a new computational procedure. (State the purpose of the procedure)

1. Run RCMLRB for Luni including parameters stated in the assumptions. This will be performed by deriving a function for the variables described in the assumptions using experimental data for year 2013.

2. To investigate climate change scenario in the different climatological zones of Luni (categorised according to the homogenous climatologically characteristics) using a downscaled ECHAM5 regional climate models as well as RCMLRB.

Development of an new field technique. (State the purpose of software/ application)

Development of a new software/ application. (State the purpose of the purposed technique)

To develop an indigenous empirical stochastic multi-parameter multi-variate model for predicting climate change using real daily and monthly data on various variables influencing Luni climate. This RCM model will be named RCMLRB.

Design and/ or develop a new device. (State the purpose of the device)

Investigation of the behavior of a natural process. (State what new aspects are to be investigated and why)

Any other (Specify any explain) :

1. This project will also help in designing policies for water management.
2. To study the effect of ground and surface water availability, precipitation, and quality on changes of livelihood of the local people residing at Luni river basin.
3. IITJ and other collaborating institutions will construct a strong platform for the revival of historic traditional cultural aspects of water management such as building water harvesting structures *(such as kuia, kundi, agor, khadin, paal, johad etc.)* can change the ecological niche of the Luni river basin. This will positively affect the local preservation practices and advocate a paradigm shift in water usage, reuse and production by revisiting the technologies, prior social education and management tactics followed in the Luni culture.

Contribution to Water Resources Development

(*Describe very briefly the contribution envisaged to be made by the proposed R&D activity to the Water Resources Sector)*

1. Luni basin climate and hydrology models will help in water management and planning by assisting with data analysis of water use practices, spatial targeting of critical source areas for potential action, and temporal assessment of pollutant delivery. The information provided using the modeling approach can be simplified and made accessible to public using a digital web interface.
2. Climate parameters from the climate data collected, global model ECHAM5, MIKE-SHE (river hydrology model), QUASAR (Quality Simulation Along Rivers -has been developed to assess the environmental impact of pollutants on river water quality), SWAT (Soil and water assessment tool) and ARCGIS can be integrated to formulate novel prediction models for water and pollutant transport. The developed model showcased online will help the farmers to access the day to day climate prediction. Therefore, the farmer will have ample time to manage water and other agricultural practices on field.
3. The chemical transport will be used to assess loadings of effluents from Industries. This will provide information for local industries along the Luni River basin to manage their effluent by improvement in waste treatment.
4. Collaborating organizations such as AFRI, CAZRI, Jal Bhagirathi Foundation will help use the new prediction results to advocate farmers on land use strategies to reduce water consumption.

12 Putting the research to Use

Identify the possible end-users for the result of purposed research.

- Agricultural Community
- Industries

- General public
- NGOs and government organizations advising Luni basin communities.

List the action will be necessary to put the result to use.

- To interact with the communities living in Luni Basin (use of surveys) and provide them with a feedback.
- Use of web/audio interface to access climatic and hydrologic data.
- Use of sensors for collecting present climatic data.

List the difficulties/ problems that may be encountered in putting the results to use.

- To cross-link the rural cultural aspects of people at Luni River basin and the state-of-art technologies used in this proposal. This will require a combination of education, awareness and public participation. This can be eased by a collaborative effort between Jal Bhagirathi Foundation and other institutions in this project.

Are the possible end users being involved in the research? If yes then describe how, if not then explain why not.

- Yes, the end users namely users of water harvesting structures, NGOs such as Jal Bhagirathi Foundation, government institutions such as AFRI and CAZRI, academic technological institutes such as IIT Rajasthan and other technological institutes.

  Jal Bhagirathi Foundation will work with the water harvesting communities and collect their feedback and personal experiences to perform analysis. AFRI and CAZRI will supervise land use and water allocation in agricultural areas of Luni river basin. IIT Rajasthan will be using the data obtained to characterize and analyze the statistical distributions of climatic, hydrologic, pollutant transport variables as well as survey parameters.

  Finally, general public will be able to freely access and get feedback on the latest developments in climate and water resource management using the web and communication interface.

Present State of Art

Describe the work that has already been done at International level

Luni and majority of the other river systems have shown unexpected increase in water yield recently after monsoon [Gosain 2011]. This is clearly illustrated in Fig. 1 and Fig. 2. Further El-Nino is also thought to be a reason [IT, 2012]. The concept of El-Nino will be discussed below in the document. Surface runoff was found to generally decrease, and the severity of both floods and droughts increased, in response to the climate change projection (Gosain et al. 2006).

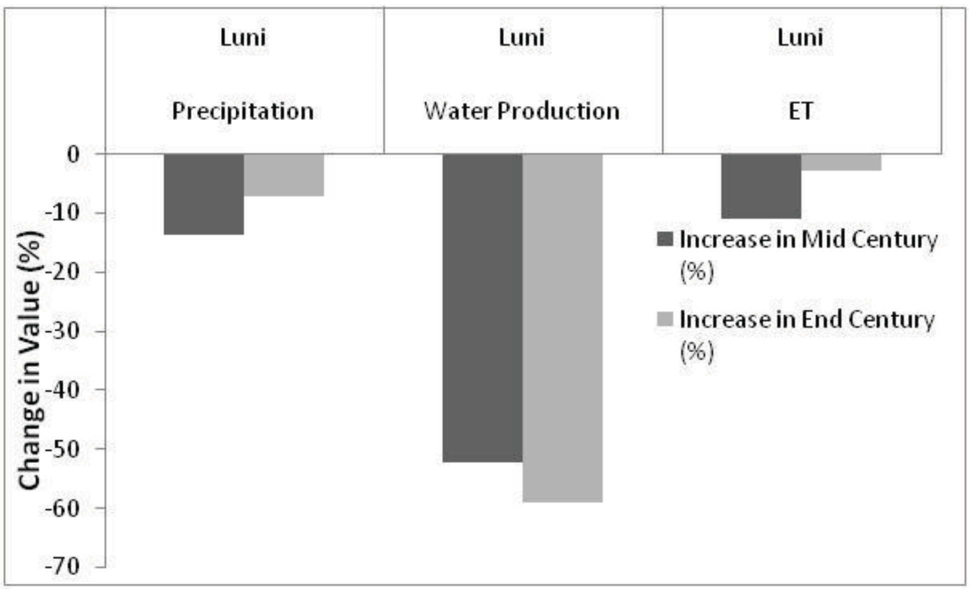

Fig. 1: Variations of water yeild with precipitation and evapotranspiration considering mid century and end century scenario for Luni River Basin (Gosain 2011).

A 5-10% decrease in marginal rainfall is observed in Luni Basin from Fig. 1 and Fig. 2 considering the 50 year estimation or the mid century estimations. Approximately 10% improvement in water yield has been observed for the mid century calculations in Fig. 3. But this increase in water yield at all basins is not so prominent with the 100 year model. The indent of monsoon on Luni River Basin was found to control agricultural health during the monsoon season but sometimes in the post-non-monsoon period too [Bhuiyan and Kogan 2010].

Agricultural drought intensity and its duration in Luni vary widely depending upon moisture and thermal stresses [Bhuyian and Kogan 2010]. Bhuyian and Kogan (2010) also illustrate that a good monsoon helps in maintaining vegetation health during following seasons. They also enumerated that agricultural production as well as yield in Luni basin is found to be more sensitive to moisture and thermal stresses in the immediate season after a spell of drought. Groundwater availability in the Luni river basin is extremely difficult due to lack of recharge conditions and aeolian sand cover. Aeolian soil cover forms potential deep aquifers. These aquifers produce water at the rate of 25-40 liters per second [CGWB 2006]. From the above discussions, the Aravalli ridges in the east with semi-arid climate form the recharge zone in the Luni basin.

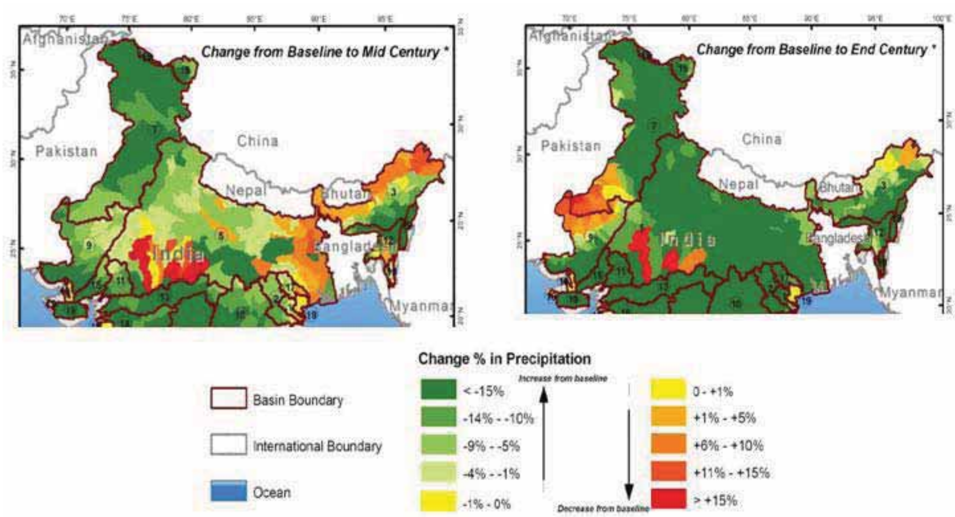

Fig. 2: Percentage Change in Precipitation in North Western India [Gosain 2011].

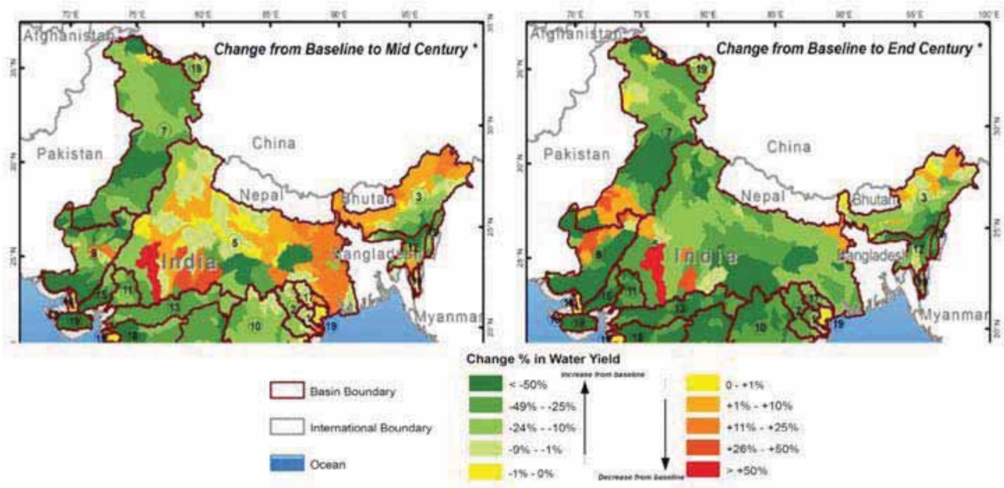

Fig.3: Major change in water yield in Northwest India [Gosain 2011].

During the past 8 centuries, at least 17 large floods have occurred in Luni. Further in the last 200 years, at least three very large floods occurred at Luni basin including the one in 1979 [Kale et al. 2000]. These floods were not random in time and a clustering of floods between 1000 and 500 years is a possibility [Kale et al. 2000].Slackwater flood deposits are fine grains of sands and silts that settle out in areas of reduced flow velocity during large flood [Kale et al., 2000]. Luni river basin is dotted with several of these deposit sites with dimensions of ~ 5-7 m and 20-80m away from the present bank [Kale et al, 2000]. Fig. 4 illustrates similar deposits recently taken.

Fig.4: A panoramic view of slack deposits in Luni River Basin near Luni Village as of August 9th 2012. [Courtesy: IIT Jodhpur]

These deposits are indications of unusually large floods several years ago. Surveys of potential palaeo-flood sites lead to the identification of slackwater flood sediments in the basin. Textural differences in the soil, and multiple slackwater deposits of varying thickness suggest that the Luni deposits are of fluvial origin and derived from Aeolian sands [Kale et al. 2000]. A deep study into these deposit reveal alkaline salts and metallic impurities in these fluvial deposits [Bohra 2007]. A major presence of zinc and alkali metals aptly signify of the local name ("Luni" means salts) of the river. A recent photograph of the soil as well as water collection certifies this comment in the Fig. 5 below.

Fig. 5: The white coloration in the soil denotes presence of zinc in high quantities. [Photo as of 9th August 2012, Luni Village area]

Hundreds of textile and other industrial manufacturing locations dump their effluents into dry Luni making it even saltier. Furthermore large areas of Luni river basin is affected by rapid soil degradation [Rodell et al. 2009]. The information of soil moisture illustrates westward expansion of arid regime [Singh et al 2005]. With increase in population and extensive farming practices ground water in Luni river basin area is depleting thus under threat of desertification [Rodell et al. 2009, Goswami and Ramesh 2008].

Monsoon is having a strong negative trend over the last decades providing evidence of change in land use due to anthropogenic requirements . Post-Monsoon precipitation has increased in Rajasthan due to increased influence of El-nino oscillations [Niyogi et al. 2010]. El-Nino occurs when the surface temperature is warmer than normal (0.5-0.6^{o}C) in Western Pacific Ocean and lower than normal in Eastern Pacific Ocean [Hasthenrath, 1995, Philander 2001]. The warm water currents travel to the east where it blocks the rising cold water causing temperature to behave abnormally [Fedorov et al. 2003]. This abnormal warm ocean triggers weather changes associated with El-Nino. When El-Nino develops in August (more than 2^{o}C in the Pacific) as is the situation at present in 2012 rainfall over Indian subcontinent get affected with overall decrease in monsoon rains but for Western India rainfall increases [IT, 2012]. There are no reliable models that can predict El-Nino correctly [Fedorov et al. 2003]. Irrigation, development of vegetation, surface temperature, and precipitation are correlated [Lee et al, 2009].

Due to lack of meteorological sensors near to Luni river basin, the area relies on approximation of climate data for its daily climate forecasting. There is a need to solve the problem of scarcity in empirical data on rainfall, relative and specific humidity, wind speed and evapo-transpiration.

Wetlands influence regional rain patterns (Taylor, 2010). Changes to water use upstream of wetlands could influence weather region-wide. One example is the Niger Inland Delta, a network of tributaries, channels, lakes, and swamps located in Mali just south of the Sahara desert. These wetlands typically appear in September when the Niger River floods due to upstream rainfall. This flooding can then influence regional rain patterns through feedback with the atmosphere (Taylor 2010). This example imitates the ephemeral nature of Luni basin and construction of water harvesting structures will help local climate in Luni basin.

Wetlands provide significant climatic and ecological benefits [Wei et al, 2011, Wei et al, 2012].. In Luni river basin, more than 700 water harvesting structures have been revived in Rajasthan by Tarun Bharat Sangh of Dr. Rajendra Singh and other NGOs such as Jal Bhagirathi Foundation. These water harvesting structures such as kuia, johad etc.are wetlands. These may be greatly influencing the extreme weather changes in the Luni river basin.

Very high soil percolation rates pose another big challenge to water management. Soil infiltration rates show wide variation across Rajasthan from approximately 0.60 cm/hour to 33 cm/hour [Kumar et al, 2010, 8]. The water resources in Rajasthan are not adequate to meet the rising water demands from the domestic, agriculture and industrial sectors; and climate change will act as an additional stress to water availability in the state [Narain et al. 2005, 9]. The west-flowing rivers of Kutch, Saurastra and Luni which occupy about 60 per cent of the area in Rajasthan are likely to face conditions of acute water stress. Increase in evapo-transpiration for the state of Rajasthan has been identified as one of the key impacts of climate change on water resources [Gosain, 2011, 10].

A recent study of Bandi river draining itself to the Luni, revealed low water quality due to excessive discharge of effluents from textile industries in Pali [Rathore 2010]. The Bandi water had sodium (2163 mg/L), sulphate (943 mg/l), chloride levels of 1702 mg/l, chemical oxygen demand (993mg/l) etc. which are far more discharge standards set by the Bureau of Indian Standards [Rathore, 2010]. Further to this it is reported that situation of the Luni River basin has been worse due to discharge of industrial effluent containing heavy acidic toxins [TOI, 2012, 1]. Recently in February 2012, the honorable Rajasthan High Court banned dumping of treated industrial effluent into Luni River Basin in Balotra [TOI, 2012, 1]. This directive has reaffirmed the prior instructions of the Rajasthan Pollution Control Board (RPCB) banning discharge of treated effluent in the Luni river. RPCB alerted about the detrimental effects of basin pollution on groundwater and the ecology of the Luni river.

From the above discussions the questions that will arise in the mind are, what will be the change in evapo-transpiration rate with increase in pH of water as well as water absorbing terrains. Does this also affect climate? Can this electro-kinetic changes in Luni river water be incorporated in the LRBCM. Is the water getting over-exploited? What is the irradiation level at Luni and does this effect increase in salinity of the soils? How much of Luni river basin climate is affected by El-Nino? Can the new model proposed in this document predict changes in local weather due to increase in wetland cover in Luni river basin?

Describe the work that has already been done at National level

A study carried out by CAZRI Jodhpur, India between 1984-92 indicates that there have been significant changes in agriculture, industrial development and urban expansion. Reports indicate that the groundwater resources in most of the zones of Luni are under stress due to overexploitation [Bohra 2007]. This may be another indicator of increase in areas under the arid regime.

Climate is characterized by the exchange of heat, moisture and momentum between Earth's surface and atmosphere. Land-atmosphere interaction is dominated by the rapid biophysical and biogeochemical processes that exchange momentum, energy, water, carbon dioxide and other chemical constituents between the land surface and the atmosphere [Yang 2004].

Local surface cover governs air temperature variations of any area [Eliasson & Svensson, 2003]. Surface properties, such as texture, colour, roughness, moisture regime and the type & density of vegetation canopy play the dominant role in determining surface atmosphere energy exchanges. Through latent heat transfer, the air temperature tends to decrease as the amount of vegetated area around the sites increases. These land cover effects are slightly stronger at night than during the day, and they weakened as the amount of cloud cover or the wind speed increases, especially at night [Yokobori & Ohta, 2009]. Land use by altering surface water and energy use changes albedo. Soil moisture and surface roughness will not impact monsoon climate much locally in the river basin in Western India [Bollasina and Nigam 2011]. Further, latent heat flux in summer is already low (10 W m^{-2} , equivalent to an evaporation;0.3 mm^{-d}) in arid area of the Luni [Bollasina and Nigam, 2011]. In some aspects, the anomalies induced locally by the expansion of the Thar Desert contrast with the findings over other regions (e.g., the Sahel) where a warming is simulated [Bollasina and Nigam, 2011].

The major questions that arise after the above commentary are, what assumption will be incorporated in the RCMLRB to modify it to better predict local weather information at Luni river basin. How can land use changes be incorporated in the new multivariate multi-parameter models? Can we assume latent heat flux instead of specific heat flux for Luni river basin calculations?

Methodology

(*Describe clearly the experiment; observation and data collection; and analysis)*

The study area (Luni river basin) includes a geographical area extending between latitudes 23^o 41’ and 27^o 05’and longitudes 71^{o}04’ and 74^{o}42’. It is scarcely populated. The main land cover consists of bushes, desert and agricultural land. Land use is rain dependent. The hydrographic network of the Luni river basin is composed of a set of ungauged ephemeral tributaries which are operational during heavy precipitation events. The catchment hydrological response is dominated by a traditionally long dry season in which even large rain events may produce little or no response at Luni river outlets. This is apart from lone flooding events spaced over two to three decades in this region.

a. **Land cover** : IRS-P5 Cartosat-1 satellite is dedicated to stereo viewing for large scale mapping and terrain modeling applications. The IRS-P5 provides high resolution stereo data with a spatial resolution of 2.5m and 10bit quantization. Land use/cover map will be generated over Luni river basin (37363 km^2) using IRS-WiFS data. Multi-date SPOT NDVI data will be used to prepare NDVI profiles of various land cover classes. The data acquired can be rectified to sub-pixel accuracy. An attempt will be made by studying the NDVI profiles to stratify the different vegetation classes keeping in mind hydrological requirements of land cover classes.
b. **Soil Map:** Luni river basin soils sheet of National Bureau of Soil Survey (NBSS and LUP, Udaipur) and soil region map of National Atlas & Thematic Mapping Organization (NATMO, Kolkatta) with different group of soil will be used to generate soil texture map. Soil textures will be used to prepare hydrological soil group map considering the soil infiltration and drainage characteristics. Area under different hydrological soil groups will be calculated and validated with the reported area.
c. **Topography:** The terrain surface needs to be studied using DEM data (sources of elevation information) provided by the Shuttle Radar Topography Mission (SRTM) [NASA, 2011], As with most other DEM sources, the data requires significant levels of pre-processing to ensure that there are no spurious artifacts in the data such as pits, spikes and patches of no data that would cause problems in later analysis [Saura et al, 2003]. In the case of the SRTM data, these patches of no data are filled, preferably with auxiliary sources of DEM data, like-topographical maps. For Luni river basin, the SRTM as well as the topography map will be studied in parallel.
d. **Soil property Mapping:** Soil survey will be carried out for using toposheet and cadastral maps.The scanned toposheet and image will be geocoded, subset will be created with the help of watershed boundary using ERDAS imagine 8.7 software. After intensive traversing,

pedon (soil of 1-10 m^2 area) locations were selected in the watershed depending upon soil heterogeneity in physiography. Freshly dug pedons will be studied for their morphological features. In between pedons, number of surface samples were collected to ascertain soil homogenity. Measurement of soil properties in these pedons will be

Physical properties:

Particle size analysis

Particle size distribution of soil samples will be determined by pipette method using sodium hexametaphosphate as dispersing agent. From the dispersed suspension an aliquot of the suspension will be pipetted out from specified depth at specific time intervals. The total soil obtained by repeated decantation of suspension will be dried and weighed and passed through 0.05 mm sieve. The fraction that was finer than 0.05 mm will be added to silt determined initially by pipetting to have a particle size class as per USDA system. Sampling at a specific time will provide particles still in suspension and will be finer than the previous samples.

Bulk density (Mg/m^3)

Bulk density is recorded by clod method. The bulk density of clods, or coarse peds, is calculated from their mass and volume. The volume is determined by coating the clod with a water-repellent substance (melted paraffin) and by weighing it first in air, then again while immersed in a liquid of known density, making use of Archimedes' principle.

Maximum water holding capacity Measurement and Calculation

Place a Whatman #2 filter paper on the screen inside the Hilgard soil cup and find the mass to the nearest 0.01g. Fill the cup gently with oven dried soil and find the mass to the nearest 0.01g. Place the cup into a shallow pan of water allowing only the bottom few centimeters of the cup to become wet. Allow the soil to become saturated from the bottom of the cup to the surface. Remove the cup from the pan of water and place it in a humid enclosure until drainage is complete.

Soil Moisture Content

The soil moisture regime determines the role of land-atmosphere coupling for regional climate [Koster et al. 2004, Science]. The soil moisture content may be expressed by weight as the ratio of the mass of water present to the dry to the dry weight of the soil sample, or by volume as ratio of volume of water to the total volume of the soil sample. To determine any of these ratios for a particular soil sample, the water mass must be determined by drying the soil to constant weight and measuring the soil sample mass after and before drying. The water mass (or weight) is the difference between the weights of the wet and oven dry samples.

The criterion for a dry soil sample is the soil sample that has been dried to constant weight in oven at temperature between 100 to 110^{o}C.

All the data collected spatially will be stored and managed in a GIS through base maps projected as layers in ARCGIS 9.2.

Chemical properties

pH

Measure a volume of soil from 10 to 20 mL, or mass of soil from 10 to 20 g, and add it to a sample cup. Volume is measured with a soil sampling scoop. Mass can be measured with a scale or estimated from a volume measurement accounting for the density of soil. Dispense a particular volume of 0.01 M $CaCl_2$ to soil that is equal to the volume or mass of soil. Stir the soil and solution vigorously and allow slurry to set from 15 minutes to 1 hour. Ensure room temperature is between 20 and 25^{o}C before proceeding with pH measurement. Calibrate pH meter and electrode using pH 4 and 7 buffers. Place electrode in the soil slurry to measure pH. Measurement may be taken with or without continuous stirring. If measurement is made without continuous stirring, stir the sample with a stir bar before placing electrode in the sample. Allow adequate time for pH to reach a stable reading. Stability can be ascertained by pH meter settings for manual measurements or software settings for automated instruments

Electrical conductivity

Air dried and 2mm sieved soil (20 cc) is taken and mixed with 40ml water and left to stand for 4 hours. Without stirring the sample, filter the solution through a Whatman No. 41 (11 cm) paper and collect the extract in a funnel tube or other suitable container. Standardize the conductivity meter. Move the probe up and down in the solution several times to dislodge any bubbles on the electrode surfaces. Measure the electrical conductivity of the extract contained in the funnel tube

Organic carbon

A measured volume of potassium dichromate solution (a strong oxidising agent) is added to a sample of dry, finely ground soil. Concentrated H_2SO_4 is added to the reaction mixture to generate heat. The organic carbon in the soil is oxidised to CO_2 by the dichromate, which itself is reduced. At the end of the reaction period, the solution is diluted with distilled water. The dichromate which has not been used to oxidise soil carbon is determined by titrating against ammonium iron sulphate (a reducing agent). Soil organic carbon content is calculated from the unused dichromate in solution.

Exchangeable cations

Exchangeable cations will be extracted by neutral normal ammonium acetate. Calcium and magnesium in the extract will be determined by Versenate titration. Sodium and potassium will be determined by flame photometry .

Cation exchange capacity

The cation exchange capacity (CEC) of the soil will determined by equilibrating the soil, with neutral normal sodium acetate solution and the excess salts were removed by 95 per cent isopropyl alcohol [NBSS and LUP, 1984]. The sodium gets adsorbed. The adsorbed sodium will be replaced by equilibrating with neutral normal ammonium acetate solution and the concentration of sodium in the leachate will be measured by Flame Photometer and the CEC was calculated.

e. Local Evapo-transpiration (ET)

Penman-Monteith Combination method derived by combining the energy required to sustain evaporation and removal of vapor is to be used for the calculation of ET (mm/day). This relation can be standardized for daily time steps [ASCE 2005].The ET for an irrigated agricultural farm area in Luni river basin can be then defined by the relation,

$$ET_{ref} = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273}(e_s - e_a)u_2}{\Delta + \gamma(1 + C_d u_2)}$$

Where: R_n is the net solar radiation at the crop surface (MJm-2d-1), G is the heat flux density of the soil, γ is the psychrometric constant (kPa/^{o}C), T is the mean daily temperature at 1.5 to 2.5m height, C_n is a numerator constant that changes with type of crops, e_s is mean saturation vapor pressure at 1.5-2.5m height (kPa) and e_a is the mean actual vapor pressure at 1.5-2.5m height (kPa), u_2 is the mean daily wind speed at 2 m above soil surface (m/s), Δ is the slope of the saturation vapor pressure and temperature curve, and C_d is denominator constant for the reference crop. Through plant cover or vegetation, the carbon and water cycles are inter-related in a regional climatic system.

R_n the net solar radiation, is calculated as

$$R_n = R_{ns} - R_{nl} = (1 - \alpha)R_s - R_{nl}$$

Where: R_{ns} is the net short wave radiation ($MJm^{-2}d^{-1}$), R_{nl} is net long wave radiation leaving the earth's surface ($MJm^{-2}d^{-1}$), α is albedo or radiation reflection coefficient, R_s is measured or calculated solar or short wave radiation received at the Earth's surface ($MJm^{-2}d^{-1}$).

Global Climate Modeling

The ECHAM5 is the 5^{th} generation atmospheric general circulation model developed at the Max Planck Institute for Meteorology (MPIM) in a series of ECHAM models evolving from spectral weather prediction models of the European Centre for Medium Range Weather Forecasts (ECMWF), These models basically solve Navier Stokes Partial Differential Equations for mass, continuity and energy balance for flow within the Earth's atmosphere. It is to be noted that atmospheric climate has inherently higher non linear effects (basically higher Reynolds numbers), low Froude number (flows are slow compared to gravity wave speeds), dominant energy source (short wave radiations from the sun) and rotation (low Rossby number).

A set of novel changes differentiate ECHAM5 from the ECHAM4 (Roeckner et al., 1996). The new formulations include the advection scheme for positive definite variables such long wave radiation code and cloud cover parameterization. Separate treatment for cloud water and cloud microphysics is also included in the ECHAM5. The inclusion of orographic effects in the order of sub-grid scale also provides ECHAM5 an edge over other climatic models. This is the main reason why ECHAM5 is selected for usage in the experiments that needs to be performed. Major changes are also brought in land surface processes and land surface dataset.

Downscaling

Since the need for a local climatic study of the Luni river basin there is a need for a far finer spatial resolution than provided by ECHAM5. Therefore downscaling will signify an alternative path to correlate the sample area in the atmosphere under study and its response. Analytical downscaling can be performed at meso-scale or fine resolutions such that local climatic features can be well simulated with synoptic information from ECHAM5. This nested downscaling method will be computationally demanding and not easily accessible for research.

The downscaling will be performed in a project headed by IIT Delhi. Not compromising on the quality of research empirical downscaling can be performed. It is also the most practical approaches for Luni river basin area since currents developments due to climatic change needs to be addressed and sensitivity is very high at Luni River basin . Therefore Luni river basin regional climate model (LRBRCM) seeks to derive a quantitative relation between the circulation effects on the Luni river basin area and its local micro-climate. It is required that Rajasthan provides its spread of microclimatic regions within the desert where a change in climate is experienced. This information will be collected and disseminated by IITJ for further downscaling modifications to be carried out on a larger scale downscaling as is going to be performed by IITD.

The main grounds for downscaling; The local-climate scale is a function of the global synoptic circulation. That is, results from the global circulation model become inputs to downscaling modeling strategy.

The steps for the downscaling are as follows;

1. The study area (Luni river basin) includes a geographical area extending between latitudes 23^{o} 41’ and 27^{o} 05’and longitudes 71^{o}04’ and 74^{o}42’.
2. Surface climate variables are gridded on to the spatial data available from the IRS-WiFS and meteorology laboratories around Rajasthan (these variables will have inherent influence of micro climatic changes due to water harvesting, pollution, chemical pollution of the soil, land cover and agricultural-human implications).
3. The Luni river basin climate variables are to be arranged in columns such that their correlations can be studied effectively and eigen values and eigen vectors can be calculated. This will help in generation of independent variable time series.
4. The component loadings of the observed data and the global climatic variables for Luni river basin can be studied for hidden empirical relationships.
5. Derivation of transfer functions from the independent variables created from the analysis.
6. Testing the new stochastic multivariate regression relationship using sensitivity analysis. And comparing its strength and weaknesses with available dynamical stochastic models such as the Saravanan Model (explains the strong decadal spectrum of sea-surface temperature in a specific region), Hassellman model of climate variability,

Major aspect regarding soil-climate characteristics at the Luni River Basin

Dry soils initially may favor hot summer temperatures because several feedback mechanisms maintain drought and amplify the coupling between drought and heat, through physical relations between soil moisture, temperature, precipitation and possibly dynamics [Quesada et al. 2012]. These feedbacks may take place in conditions when evapo-transpiration is limited by soil-moisture availability, which is typically the case in Luni river basin. When such conditions prevail at the end of the spring season, warm southerly wind episodes may help propagating feedbacks up to central Rajasthan, leading to extreme mid-summer temperatures there.

In order to investigate whether this condition holds on the scale of Luni river basin, the analysis of climatic parameters from the historic Luni river basin trends and blended observed data may be carried out. This may be carried out using quantile regression. Quantile regression may provide a quantitative probabilistic seasonal prediction of climatic phenomenon at the Luni river basin with time [Quesada et al. 2012]. It may aim to estimate conditional quantile values calculated at each part of a climate response variable distribution from a regression as a function of a conditional climate parameter.

Ground Water Availability Modeling and Discussion on Recharge Strategies using wetlands Affecting Micro Climate

Physically distributed hydrologic models use parameters related directly to the physical characteristics of the Luni river basin and spatial variability in both physical and meteorological conditions. MIKE SHE-MIKE 11 hydrological modeling system is considered. This will consider six process components such as exchange between aquifers and Luni river, evapotranspitation in Luni basin, Saturated and unsaturated zone, overland channel flow and subsurface flows. The key to this approach of hydrologic forecasting and analysis is to understand the size and land use characteristics of the tributaries of the Luni river and also Luni river independently.

Input data such as Luni river catchment characteristics can be provided through discretization of the horizontal catchment into orthogonal network of grid squares. Hydraulic parameters of the Luni soil, depth with respect to sea level, rainfall, potential evapotranspiration can be easily illustrated. Evapotranspiration acts as a water sink in the upper soil layer and root zone portion of the unsaturated zone.

In general, for vertical flow, the driving force for transport of water in the unsaturated zone is the vertical gradient of the hydraulic head, which includes both a gravity and a pressure component. In the unsaturated zone the pressure head is negative due to capillarity. Vertical variation in soil properties can be described in a number of horizontal layers of variable heights for each grid. Based on the continuity equation and Darcy's law, vertical flow in the unsaturated zone can be described by the so-called Richards equation. The Richards equation requires two functions - one for the pressure head as a function of saturation and the other for the hydraulic conductivity, also as a function of saturation. MIKE 11 can be helpful in representing other various structures that can influence flows such as weirs.

A wetland or kuia or johad sub-irrigation system at Luni river basin will allow to capture, treatment, storage, and reuse of runoff and subsurface drainage waters from farms, in turn providing both environmental and agricultural production benefits. Natural processes in the wetland treat the water by removing some of the nutrients, pesticides, and sediment. Sub-irrigation, in comparison to conventional subsurface drainage, reduces the amount of nitrate that is released offsite. The yield benefits of sub-irrigation have been well established for crops such as corn, soybeans, navy beans, and sugar beets. Other potential environmental benefits from wetland sub-irrigation system include additional wetland vegetation and wildlife habitat, decreased flooding potential downstream, and more carbon sequestration in soil.