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IRRIGATION VULNERABILITY ASSESSMENT REPORT

CHITWAN DISTRICT

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Version	A

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1 CHITWAN ASSETS/SYSTEM PRIORITIES

1.1 Chitwan District Irrigation Infrastructure

Records from the district office show that there is some 23,634 ha of irrigated land commanded by the systems built to date. Records also show that there is some 9245ha of irrigated land commanded solely by systems built by the farmers. However since1988support has been given to the district in improving irrigation systems through a variety of donor assisted and government projects. From 1989 – 1997 the Irrigation Sector Project (ISP) funded by ADB constructed and rehabilitated 11 number projects covering 2775ha. The follow up Second Irrigation Sector Project (SISP) from August 1997–December 2002 constructed and rehabilitated a further seven projects covering 462 ha. A subsequent extension of ADB assistance through the Community Managed Irrigated Agriculture Sector Project (CMIASP) from March 2006 to June 2013 worked on 3 projects covering 311ha. The government funded Medium Irrigation Project (MIP) to date, 4 projects have been constructed and rehabilitated covering 1551ha. The government is also funding the Non-conventional Irrigation Technology Programme (NITP) which to date 4 small area schemes covering 90 ha are constructed throughout the district.

Through co-ordination with the Department of Irrigation Focal Point and the respective District Irrigation Officers 3 irrigation systems were selected. A basis for choosing a particular irrigation system was based on one or more of the following criteria as shown below:

- The system to have suffered past damage due to an extreme event such as a flood, landslide, drought, etc.
- The system could be shown to be receptive to adaptive responses, i.e. the scheme was not totally defunct and rehabilitation works could be feasible undertaken to also include any climate change responses.
- To ensure that a representative sample of schemes was taken the selection process was to include where possible at least one government managed as well as one traditional farmer managed irrigation system.

The three systems chosen for the baseline asset study embraced the above criteria and included an existing farmer managed system, a scheme designed and constructed by the Government and a recently rehabilitated system.

1.2 Vulnerability Assessment Criteria for Priority Assets

1.2.1 Vulnerability Assessment Criteria

Climate change vulnerability in the irrigation context is a function of asset system's exposure to climate effects, sensitivity to climate effects, and adaptive capacity.

The exposure of the assets to climate threat was focused on its nature and extent and how it would affect the asset. Regarding temperature this concerned the overall increase and its magnitude throughout the year and how it would affect crop growth and irrigation water demand. For rainfall the timing of its increase and decrease at different times of the year was important on how much more or less water was required for irrigation. Rainfall intensity increases had a direct effect on possible crop damages and the likelihood of increased flash floods damaging irrigation infrastructure and generating landslides.

The sensitivity focused on the degree to which an asset would be affected by, or responsive to climate change exposure. Therefore for flash flood events the level of disruption and the length of time it took to return to normal flow conditions were considered. If damage was likely to irrigation infrastructure the degree to which the exposure to a threat would negatively affect the integrity or operation of the asset was evaluated looking at its design effectiveness, the materials used, construction quality, and the levels of maintenance and protective systems required.

The impacts were assessed through how the threats, or otherwise, would affect the operation and sustainability of the irrigation system and its ability to support agricultural production in the future.

Finally the adaptive capacity of the asset was assessed through consideration of the institutional capacity and access to technical and financial resources by the people or organisations directly responsible for the asset's management. Particular emphasis was given to the irrigation water user group's enthusiasm and commitment to the asset.

1.3 Priority Assets

Based on the VA criteria, three surface irrigation schemes have been selected as priority asset in Chitwan District. The detailed information of these assets are outlined in the baseline report for. Brief discussion on the assets and their components are outlined below:

1.3.1 Panch Kanya Irrigation System

The Panchakanya Irrigation System (PIS) is located in the Ratnanagar Municipality District of East Chitwan. The irrigation system has been in use since 1796 and until 1979 PIS has operated under the name 'Raj Kulo'. Onwards to 1996 it was operated by the government and in 1997 the system has been handed over to the community as it is until today operating as an autonomous farmer managed irrigation system (FMIS). Currently total area of Panchakanya area is 600 hectare of which 571 hectare is irrigated land and 31 hectare is non irrigated land. Currently PIS holds a total of 1612 households. The system depends on water from a spring fed pond source indirectly fed by the Kagheri River. Its command area is a totally flat area above and below the east west highway and is predominantly cultivated agricultural land. The expanding township of Ratnanagar however is now gradually encroaching on to some of this land. Paddy, wheat and vegetables are the crops grown in the project area.

The source of water for this scheme is the spring fed Panchakanya Ghole.The system depends on water from a spring source Panchkanya Ghole indirectly fed by the Kagheri River. In 1997 during a government-led resettlement program people from Padampur were relocated to Sagun Tole which is located within the catchment area of the PIS. The new settlers started abstracting surface and groundwater for both domestic and agricultural uses, deforested the land and built check-dams interfering with the water flow into the PIS. The resettlement program challenges the efficient and equal water distribution of the system therefore water rotation schemes are put in place.

Although the main structures built in the system are in satisfactory conditions the structures built so far are outdated and have been deteriorated day by day. At many places canals are found in damaged condition. The system also suffers from excessive seepage which causes a water shortage in the tail end. Growth of unwanted plants and weeds in the source Panchkanya Ghole also decreases the discharge significantly.

1.3.2 Pithuwa Irrigation System

Pithuwa irrigation system is a government-constructed farmer managed Irrigation System named after Pithuwa village, which falls within the command area of this project. Water has been tapped from the Kair Khola. Though a perennial source, the discharge of Kair Khola diminishes considerably during the dry months. At the point of abstraction in the Kair Khola, water is diverted to the Pithuwa irrigation system through canal intake structure by erecting stones/sand and brush. The canal network of the Pithuwa system extends through ward numbers one to nine of Pithuwa Village Development Committee.

The source river of this scheme is Kair khola. The watershed of 81sqkm has some 53sqkm covered by forest. During the monsoon the river carries a lot of sediment along with flash floods and the river bed has been aggrading every year. This shows that watershed is fragile in nature.

The overall canal structures built in the main canal are in satisfactory condition. During the monsoon season flash floods carry huge amounts of sediment resulting siltation in the approach canal and main canal. This reduces the carrying capacity of the canal due to the silt deposition in the canal bed. A permanent headwork with settling basin for sediment control into the main canal is necessary.

1.3.3 RiuTamta Ghagar Irrigation System

Riutamta Ghaghar is farmers managed irrigation system within the Ayodhyapuri village Development Committee (VDC) of Chitwan District, Narayani Zone and Central Development Region. The system provides irrigation facilities to 122 ha of CCA of ward no 4 and 5 of the aforesaid VDC. The total households benefited by this system are 283.The system was rehabilitated under CMIASP in 2011/12 with completion the following year. The cropping pattern of the scheme is monsoon paddy followed by wheat, oilseed, potato and other vegetables.

The source river is the Ghaghar Khola and is perennial in nature. The flow in the river is mainly contributed by sub surface flow during the dry season. An assessment of the minimum flows carried out during the feasibility study report preparation was 109 l/s on 15th April, 2010. The watershed of the Ghaghar Khola is about 135 square kilometers at the intake location. During monsoon Ghaghar Khola carries a lot of coarse sediment and confirms that the catchment area is fragile in nature. The catchment area is covered mostly by forest land.

In general the conditions of most of the assets of this system are satisfactory and serving their design purpose..The command area is levelled terrain. See Photo 1&2. The soils of the command area are characterized by sandy loam soil. The soil is moderately well to excessively drained and there are no water logging problems.

2 VULNERABILITY ASSESSMENT METHOD

2.1 Overview

The vulnerability assessment process started with identifying the particular threat to the asset from potential climate change effects. This was considered under the principal headings of possible changes and shift in the regular climate and a combination of meteorological and hydrological events. Information on the future parameters of these threats was supplied from the mathematical modeling team for future events in 2050.

Having identified the particular threats the exposure of these climate stress on a particular asset was assessed. This was influenced by considering long-term changes in climate conditions and by changes in climate variability, including the duration, magnitude and frequency of possible future extreme events.

The sensitivity to which the asset could be affected by or responsive to climate change exposure was then evaluated. The variables considered covered the design, materials, sitting and levels of maintenance required by the asset.

Using the CAM matrix enabled the final projected impact level of the threats on an asset to be defined given the levels of exposure and sensitivity that had been assessed. Finally the adaptive capacity of the asset in terms of its ability to prepare for a future threat and in the process increase its resilience and ability to recover from the impact was evaluated. By considering the impact level and the adaptive capacity of the asset the CAM matrix enabled a final vulnerability score to be derived.

2.2 Climate Change Threat Profiles Considered

The climate change threat profiles for Chitwan District were prepared by the Hydrological Modeling teams and the information had been passed on to all the experts prior to the field visit. A detailed report on these threat profiles is presented in **Annex A**.

The principal climate change threat profiles considered were as follows:

2.2.1 Increase in temperature

Average monthly maximum temperatures were predicted to increase throughout the year by 2^{o}C. This was significant as it would raise the evapotranspiration rate from the crops and hence result in a larger irrigation demands. Minimum temperatures were also predicted to increase by up to 3^{o}C between December and March. This could increase disease and pest problems in particular to winter vegetable crops.

2.2.1 Increase and Decrease in Precipitation

Monthly average rainfall was predicted to increase prior to and during the early monsoon period with a maximum increase of some 15% in July. This would be of benefit to the land preparation stages of the paddy crop and potentially reduce the irrigation demand at that time of year when river levels were at their lowest.

Monthly average rainfall was predicted to decrease during the period from November to March. This would increase the irrigation demand for the winter crops, particular wheat, potatoes and other vegetables. If no rainfall was to occur over this whole period then drought conditions could be considered as prevailing.

2.2.2 Increase in River Flows

Average monthly river flows were predicted to increase in July and August, with a maximum increase of 25% in July, whilst for the rest of the year they were to remain the same as at present. This would provide assurances of more guaranteed water availability in the rivers for irrigation particularly for the maximum demand period in July at land preparation stage for the paddy crop. Consideration however would have to be made in that larger river flows could bring with them a heavier sediment load requiring efficient systems to prevent its entry into the irrigation conveyance canals or pipes.

2.2.3 Flash Floods and Storms

Maximum storm intensities were predicted to increase from April to August with an increase of some 30% in July. In less well protected and steeply sloping watershed areas this would generate more extreme flash floods in the rivers bringing down with them correspondingly larger volumes of sediment including large boulders. This would have an adverse impact on the irrigation diversion and headworks to the conveyance systems causing physical damage as well as blockages of the canals.

Coupled with the increase in storm intensities there was more likelihood of the occurrence of high winds, hail and lightening. This would increase damage to standing crops and disruption to the infrastructure supplying the power to electrically operated pump systems.

2.2.4 Drought

Monthly average rainfall is predicted to decrease very slightly from November to March with almost no rainfall in extreme cases. This will affect the winter wheat and any vegetable crops being grown at that time which will then have to rely on receiving water from irrigation

2.2.5 Landslides

With all the surface and groundwater systems being in the terai area the threat from landslides was small. However those surface irrigation systems taking water from rivers emanating in the upstream watershed areas could experience the effects of landslides occurring in these hilly areas through increased sediment in the river flood flows.

3 VULNERABILITY ASSESSMENT RESULTS

The results of the vulnerability assessment are outlined in **Annex B** of this report. A summary of the significant assessments for each of the three assets within the Chitwan District is outlined below:

3.1 Pithuwa Irrigation System

3.1.1 Asset Description

The following table describes the important aspects of the system.

Asset Age	47 years old (implemented in 1967)
Operator	Water Users' Committee
Source	Kair Khola
Command Area	600 ha
Benefitted Household	More than 600
Diversion Structure	Free Intake
Head Work	gated headwork structure
Canal length	7.5 km
Branch Canal	16 nos
Canal drop structures	19 nos
Canal design discharge	1400 lps

Photo: 3.1 View of Watershed and Intake

Photo3.2: Canal in Repairing and Maintenance Work

Photo 3.3: Upstream View Silted Canal Intake

Photo: 3.4 Brick Lined Canal Over Designed Section

3.1.2 Vulnerability Assessment of Pithuwa Irrigation System

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity.

3.1.2.1 Threat: Increase in temperature (Command Area)

- The average monthly maximum temperature is predicted to increase by 2°C throughout the year.
- The average minimum temperature is predicted to increase by up to 3°C in the period from December to March.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer.

Exposure: MEDIUM

- Free Intake no RCC structures an lined canals
- The average monthly potential evapotranspiration (ETo) rate is predicted to increase by 0.3mm/day from August to February and irrigation demand will be slightly increased.

Sensitivity: LOW

- Though crop water demand increased with increase of temperature has no impact on design capacity of the intake and canal conveyance structures as the system was designed for the maximum CWR in October and this should not be a problem.

Impact: MEDIUM

- Crop water requirement and evapo-transpiration rates increases are relatively small it would have medium impact on the crops within the command area.
- The increase in temperatures during the winter months is likely to create more disease problems for vegetable crops.
- No significant impact on irrigation infrastructures.

Adaptive Capacity: MEDIUM

- Farmers have experience in changing cropping patterns,
- Good proximity to markets
- The area is suitable to grow a wide variety of crops.
- There has been assistance provided in agriculture extension service from local DADO
- Good financial incentive to invest in high value vegetable crop production

Vulnerability Scoring: MEDIUM

As per the guiding matrix below, the vulnerability for the increased in temperature is **MEDIUM.**

		Impact				
		Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Adaptive Capacity	*Very Low* *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.1.2.2 Threat – Increased/Decreased in Rainfall (Intake site/Command Area)

- Rainfall events occur more frequently than before. This would be of benefit to the land preparation stages of the paddy crop and potentially reduce the irrigation demand at that time of year when river were at their lowest levels.
- Monthly average rainfall was predicted to increase very slightly prior to and during the early monsoon period with a maximum increase of some 15% in July.
- Monthly average rainfall was predicted to decrease very slightly during the period from November to March. This would increase the irrigation demand for the winter crops, particular wheat, potatoes and other vegetables. If no rainfall was to occur over this whole period then drought conditions could be considered as prevailing.

Exposure: MEDIUM

- Every year flash floods washed away the temporary diversion structures
- High intensity rainfall occurs more frequently
- Longer duration rainfall events and more frequent rainfall runoff would cause soil erosion in the catchment and bringing high sediment loads with the floods.
- Rainfall intensity increases had a direct effect on possible crop damages and the likelihood of increased flash floods damaging temporary diversion structure and intake infrastructure.

Sensitivity: HIGH

- No permanent diversion structure, farmers erect bush and boulders across the river to divert irrigation water and sensitive to damage in each flood season.
- Diversion channel is temporary excavation of bed sediments and sensitive to damage and each flood season requiring yearly excavation.
- Intake structure is not protected by embankment and sensitive to damage from flash flooding.

Impact: MEDIUM

- Increase in rainfall will reduce irrigation demand during the monsoon period and decrease in rainfall will increase irrigation demand for the winter crops
- More rain will lead to more flows that bring significant sediment loads to the intake structure and trigger the collapse of the intake structure.
- Blockage of intake, leading to temporary restriction of irrigation water

Adaptive Capacity: Low

- WUA have some adaptive capacity to manage the distribution of water when there is less water.
- The WUA, DDC and DoI District office is also likely to have a low capacity to implement potential adaptation measures (primarily because of finance)
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the authorities.

Vulnerability Scoring: MEDIUM

As per the guiding matrix below, the vulnerability for the increased in rainfall is **MEDIUM.**

	Impact					
Adaptive Capacity		*Very Low* *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
	Very Low *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.1.2.3 Increased River Flow (Intake)

- Increased peak monthly average flow in wet season will increase by up to 25%.
- Increased flow is expected due to increase in rainfall
- Average monthly river flows are predicted to increase over the period from mid-April to mid-August, whilst the rest of the month there is little change.

Exposure: HIGH

- Kair Khola is dynamic with highly mobile sediments and aggrading bed.
- It increases sediment flow in the canal and increasing the cost of maintenance (canal cleaning).
- Average monthly river flow increases over the period from mid April to mid-August.
- Rainfall intensity increases had a direct effect on possible crop damages and the likelihood of increased flash floods damaging and blocking the intake structure.

Sensitivity: VERY HIGH

- Temporary diversion structures constructed every year is sensitive to damage in each flood season
- Diversion channel is temporary excavation of bed sediments and sensitive to damage and each flood season requiring yearly excavation.

Impact: VERY HIGH

- It increases sediment flow in the canal and increasing the cost of maintenance (canal cleaning).

- Increased river flow damages the temporary diversion structure and blockage of the intake and canal in each flood season and thereby interrupted the supply of irrigation water.

Adaptive Capacity: VERY LOW

- Increase in cost of O and M of irrigation system
- Farmers are not capable to manage the system
- Limited funds are available for repairs or replacement of structure.
- Technical capabilities are readily available within the authorities.

Vulnerability Scoring: VERY HIGH

As per the guiding matrix presented below, the vulnerability for the increased river flow is **VERY HIGH**

		Impact				
		Very Low Inconvenience (days)	*Low* Short disruption to system function (weeks)	*Medium* Medium term disruption to system function (months)	*High* Long term damage to system property or function (years)	*Very High* Loss of life, livelihood or system integrity
Adaptive Capacity	*Very Low* Very limited institutional capacity and no access to technical or financial resources	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low Limited institutional capacity and limited access to technical and financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium Growing institutional capacity and access to technical or financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High Sound institutional capacity and good access to technical and financial resources	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.1.2.4 Flash Floods (Intake)

1:100 year 10min storm intensities were predicted to increase by some 25% with the maximum occurring in July. In less well protected and steeply sloping watershed areas this would generate more extreme flash floods in the rivers bringing down with them correspondingly larger volumes of sediment including boulders and gravels. This would have an adverse impact on the irrigation diversion, intake and canal causing physical damage as well as blockages of the canals.

Exposure: HIGH

- Increase in bed load during flash floods – might block or damage the intake.
- Flash flood could damage the temporary diversion weir in each flood and thereby increase the cost of O &M.
- 100 year return period flood could increase in size by up to 25% Catchment area being mostly forested area but steep and liable to landslides.
- Increasing risk and severity of flash floods and increase flood duration during wet season.

Sensitivity: VERY HIGH

- Temporary diversion constructed every year is sensitive to damage in each flood season
- Diversion channel is temporary excavation of bed sediments and sensitive to damage and each flood season requiring yearly excavation.

Impact: VERY HIGH

- Blockage of intake, leading to suspension of irrigation flows to the main canal
- Sediment entering through the intake could block the main canal

Adaptive Capacity: VERY LOW

- Not easy to repair, and clean the intake and channel, and needs heavy machinery
- Farmers have difficulty in managing this irrigation system.
- DOI can support technically.
- Limited funds available for repairs of structure.

Vulnerability Scoring: VERY HIGH

As per the guiding matrix shown below, the vulnerability for the above system is **VERYHIGH.**

		Impact				
		Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Adaptive Capacity	*Very Low* *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.1.2.5 Threat: Drought (Command Area)

- Increasing trend of intense precipitation days i.e. more precipitation occurred in fewer days.
- The slightly reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops.

Exposure: MEDIUM

- Rainfall predicted to decrease from November to March
- The changing pattern of precipitation indicates that the drought period in winter could become longer.

Sensitivity: MEDIUM

- Change in cropping pattern and calendar

Impact: MEDIUM

- Could affect yields for wheat, pulses and potato crops
- Alternative cropping pattern could be introduced

Adaptive Capacity: MEDIUM

- Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops
- Active water user group and farmers willing to pay additional water costs if required

Vulnerability Scoring: MEDIUM

As per the guiding matrix below, the vulnerability is **MEDIUM**

		Impact				
		Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Adaptive Capacity	*Very Low* *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.2 Riu Tamta Ghagar Irrigation System

3.2.1 Asset Description

The following tables describe the important aspects of the Riu Tamta Ghagar Irrigation Project

Asset Age	Rehabilitated 2011/2012
Operator	Water Users' Committee
Source	Riu Tamta Ghaghar
Command Area	122 ha
Benefitted Household	283
Diversion Structure	RCC core wall across river
Intake	Double Orifice Type Intake
Canal length	2.7 km
Direct Outlet	11 nos
Foot Bridge	4 nos

Road Bridge	4 lps
Drain Inlet	1 no.
Tail End Structure	1 no.

Photo 3.5: Diversion Structure (Reinforced Cement Concrete Core Wall across River)

Photo 3.6: Orifice Type Canal Intake with Trash rack

Photo 3.7: Intake Structure with Sediment Trap

Photo 3.8: Guide Bund Breached and shows catchment area at U/S side

3.2.2 Vulnerability assessment on the systems

The vulnerability assessment analyses based on increases in temperature, increased rainfall, and drought are the same as presented for Pithuwa Irrigation System. The vulnerability assessment therefore concentrates on the significant different threats due to increased river flows and flash floods.

3.2.2.1 Increased River Flow (Diversion/Intake Structure/Embankment)

- Increased peak monthly average flow monthly average flow in wet season will increase by up to 25%.
- Increased flow is expected due to increase in rainfall
- Average monthly river flows are predicted to increase over the period from mid-April to mid-August, whilst the rest of the month there is little change.

Exposure: HIGH

- Ghaghar khola is a dynamic with highly mobile sediments and aggrading bed.
- It increases sediment flow and damaging embankment
- Sediment enters through the intake and increasing the cost of maintenance (canal cleaning).
- Average monthly river flow increases over the period from mid April to mid-August.

Sensitivity: HIGH

- Diversion structures and protective measures are sensitive to damage
- Embankment is sensitive to damage and requiring maintenance.

Impact: HIGH

- It increases sediment flow in the canal and increasing the cost of maintenance
- Increased river flows damage the embankment and thereby interrupted the supply of irrigation water.

Adaptive Capacity: MEDIUM

- Increase in cost of O and M of irrigation system
- Farmers are capable to manage the system
- Limited funds are available for repairs.
- Technical capabilities are readily available within the authorities.

Vulnerability Scoring: HIGH

As per the guiding matrix presented below, the vulnerability for the increased river flow is **HIGH**.

		Impact				
		Very Low Inconvenience (days)	*Low* Short disruption to system function (weeks)	*Medium* Medium term disruption to system function (months)	*High* Long term damage to system property or function (years)	*Very High* Loss of life, livelihood or system integrity
Adaptive Capacity	*Very Low* Very limited institutional capacity and no access to technical or financial resources	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low Limited institutional capacity and limited access to technical and financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium Growing institutional capacity and access to technical or financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High Sound institutional capacity and good access to technical and financial resources	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.2.2.2 Flash Floods (Diversion/Intake Structure/Embankment)

1:100 year 10min storm intensities were predicted to increase by some 25% with the maximum occurring in July. As 80% of the Ghaghar river watershed area is covered with forest there is less likelihood of severe erosion occurring than in other exposed catchment areas. However some sediment will still pass down with the flash floods though it is predicted that sediment concentrations will not significantly increase due to climate change

Exposure: HIGH

- Ghaghar river is dynamic with highly mobile sediments and aggrading bed .
- Avulsion is possible with increasing severity and frequency of flash floods.
- Flash flood could damage the guide bund and downstream protection work of diversion structure and thereby increase the cost of repairs.
- Increasing risk and severity of flash floods and increase flood duration during wet season.

Sensitivity: HIGH

- Diversion structure and protection measures/guide bund are sensitive to damage and requiring repair.
- Trash rack in place to stop debris entry through intake and a small sediment basin situated at the head of the main canal

Impact: HIGH

- Blockage of intake, leading to suspension of irrigation flows to the main canal
- Sediment entering through the intake could block the main canal
- Major impact is that the irrigation scheme loses its water supply source through avulsion of the river channel.

Adaptive Capacity: LOW

- Relatively easy to repair, and clean the intake and channel, cheap and can be done by local community
- Farmers managed this irrigation system easily and user group is very active.
- DOI can support technically.
- Limited funds are available for repairs.

Vulnerability Scoring: HIGH

As per the guiding matrix shown below, the vulnerability for the above system is **HIGH.**

		Impact				
		Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Adaptive Capacity	*Very Low* *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

3.3 PanchKanya Irrigation System

3.3.1 Asset Description

The following tables describe the important aspects of the Riu Tamta Ghagar Irrigation Project

Asset Age	Very old traditional system
Operator	Water Users' Committee
Source	Panchakanya Gole
Command Area	600 ha
Benefitted Household	1612
Diversion Structure	Weir across river
Intake	Double gated intake with scouring sluice
Canal length	5 km
Direct Outlet	10 nos

Photo 3.9: Panchkanya Irrigation System Headwork

The vulnerability assessment analyses based on increases in temperature, increased rainfall, increased river flows, flash floods and drought are the same as presented for Pithuwa and Riutamta Gaghar Irrigation Systems. Therefore similar impacts statements and vulnerability conclusions are reached for the Panchkanya system.

4 CHITWAN DISTRICT VULNERABILITY SUMMARY

4.1 Summary of Vulnerability Assessment Result

The vulnerability summaries for the irrigation systems studied in the Chitwan district are presented in the table below

CHITWAN DISTRICT VULNERABILITY SUMMARY

Climate Threat	Priority Asset Affected	Vulnerability		
		Panchkanya	Pithuwa	Riutamta Ghaghar
1. Increased Temperature	Command Area	M	M	M
2. Increased Rainfall	Intake / Command Area	M	M	M
3. Increased River Flows	Intake Structure	H	VH	H
4. Flash Floods	Intake Structure	VH	VH	H
5. Drought	Command Area	M	M	M

The summary matrix highlights that the Pithuwa Irrigation system was considered the most vulnerable out of the three case study systems analyzed within the district. This was principally due to the lack of a more permanent diversion structure in the Kair Khola incorporating sediment exclusion structures and a scouring sluice being a major drawback to efficient operation of the irrigation system. The diversion structure in the Kair Khola is a temporary excavation of bed sediments and will continue to be sensitive to damage each flood season requiring yearly excavation. Blockage of the intake as well as the potential for sediment entering through the intake blocking the main canal could well lead to regular suspension of irrigation flows to the command area.

4.2 Vulnerability Summary to Principal Climate Threats

Based on the vulnerability assessments performed within the Chitwan District, the following conclusions can be made on the vulnerabilities of the particular irrigation system assets to the principal climate threats.

THREAT	PRINCIPAL ASSET CONSIDERED	IMPACT	WHY IT IS VULNERABLE
Increase in temperature	Command Area.	In all three Irrigation schemes, water required at the intake slightly increased particularly for paddy land preparation The increase in temperatures during the winter months is likely to create more disease problems for vegetable crops. No significant impact on irrigation infrastructures.	Higher temperature will increase crop water demands and could affect choice of optimum cropping pattern.
Increased rainfall	Intake and Command Area	Increased rainfall is a benefit as it will reduce irrigation water demands during the monsoon period and assist groundwater recharge particularly in the post monsoon period	More rain during the monsoon period will lead to potentially greater soil erosion and more sediment in the river flows
Increased River Flow	Intake	It increases sediment flow in the canal and increasing the cost of maintenance (canal cleaning). More water available for irrigation Increased river flow damage the temporary diversion structure and thereby interrupted the supply of irrigation water.	More rain will lead to more flows that bring significant sediment loads and blockage of intake structures.
Flash Floods (Intake and Main Canal)	Intake	Increased intensity rainfall amounts during the monsoon period will induce flash floods, bringing with it debris to damage the diversion weirs and blocking the intake structures and stopping water reaching the command	Maximum storm intensities were predicted to increase during the monsoon period with an increase of some 25% in July. This would generate more extreme flash floods in the rivers bringing down with them correspondingly larger volumes of sediment including boulders and gravels. Flash flood could damage the temporary intake works or diversion weir and headworks.

THREAT	PRINCIPAL ASSET CONSIDERED	IMPACT	WHY IT IS VULNERABLE
Drought	Command Area	Could affect yields for wheat, pulses and potato crops Alternative cropping pattern could be introduced.	Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops.

4.3 Lessons and Application to Other Assets

Chtwan district has both farmers managed irrigation system (FMIS) and agency managed irrigation systems that give an opportunity to understand the impacts of Climate Change threats on these type of assets. Assets of the system have suffered past damage due to an extreme event such as a flood, landslide, drought, etc.

Since the similar type of infrastructure can be seen across the district, this means, the same impacts, vulnerability and adaptation plans can be applied to other irrigation projects within the district. Majority of the irrigation systems are experiencing similar sort of exposure, sensitivity towards the CC threats and the adaptive capacity of the local authorities towards emergency management is more or less the same.

All the irrigation development divisions and sub-divisions are struggling with lack of funds and support to combat climate change related threats and events. The problems associated with the operation and maintenance are common issues.

4.4 Linkages to Other Sectors

The threats from climate change on the irrigation command areas should also be consider by the District Agricultural Development Office. The vulnerabilities, in particular to increased temperature and rainfall, should instigate advice to farmers on any changes to cropping patterns, time of planting, or crop husbandry needs to overcome any problems. Similarly advice on what protection measures or change in crop varieties to withstand storm damage would be useful.

At the same time advice could be given to the farmers on how to maximize on any potential benefits that could be realized from future the climate change projections.

ANNEX A: CLIMATE THREAT PROFILES

1. Summary of the Chitwan Climate Change Impacts

Chitwan district area is 2'268 km^2. The watershed area inside the district boundaries considered in this study is 1,720 km^2. Total model watershed area is 17,778 km^2 but the total watershed area is much larger as the Northern parts of the watershed are not considered here.

According to the PRECIS climate projections the mean daily maximum temperature is expected to rise about 2 °C and annual maximum temperature 2.5 °C. Minimum temperatures are expected to rise about 2 to 3 °C depending on the month. Consequently there is slight expected rise in potential evapotranspiration of about 0.3 mm/d.

Wet season average precipitation change is about 3 to 15 % depending on the area. Annual maximum precipitation is expected to rise about 10 to 20 %. Also 50 year precipitation event is expected to increase by some 30% in some areas of the district. Dry season average precipitation is expected to increase about 10 to 15 % in major part of the district.

The largest maximum pluvial (rainfed) flooding increase is expected in the western parts of the district. The increase is about 50% but it in absolute terms it is only 10 cm.

Expected erosion increase due to climate change is only about 4%.

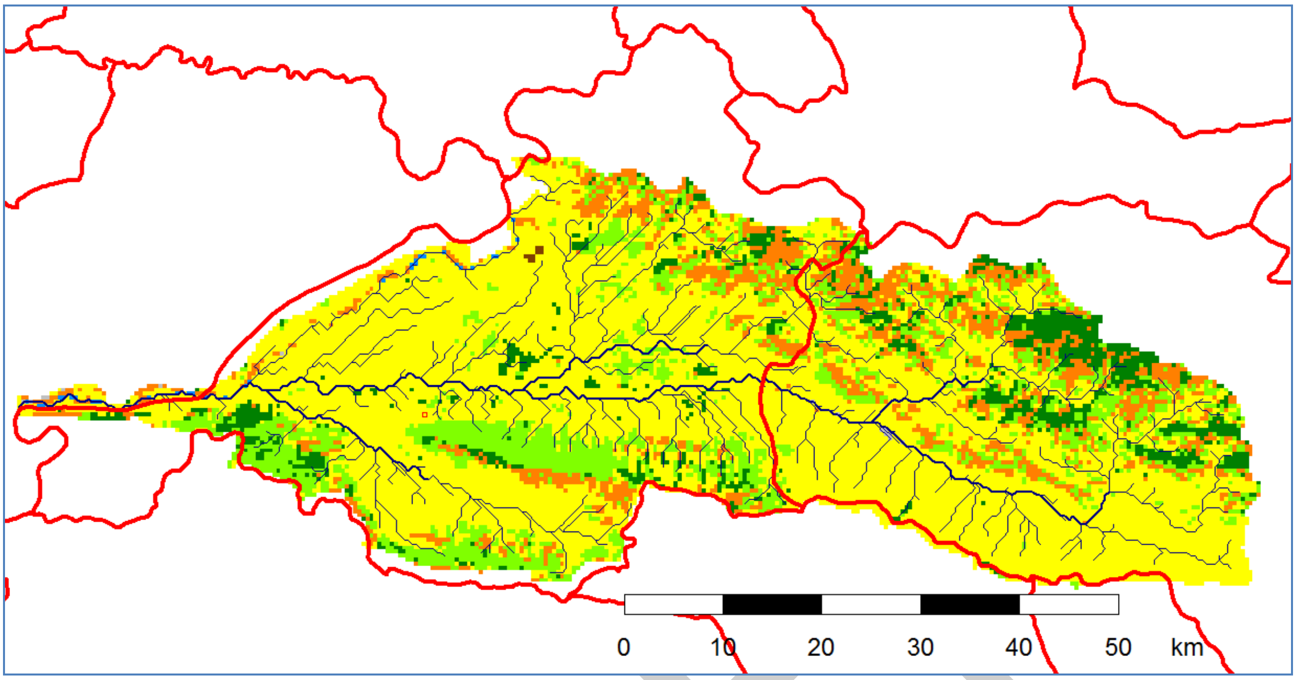
River flows will have only minor changes except for July when discharge is expected to increase about 25%.

2. Chitwan Model Overview

Chitwan model area corresponding to the Chitwan district watershed is shown in 1. The model grid resolution is 410 m. There exits some caveats in respect to the model grid:

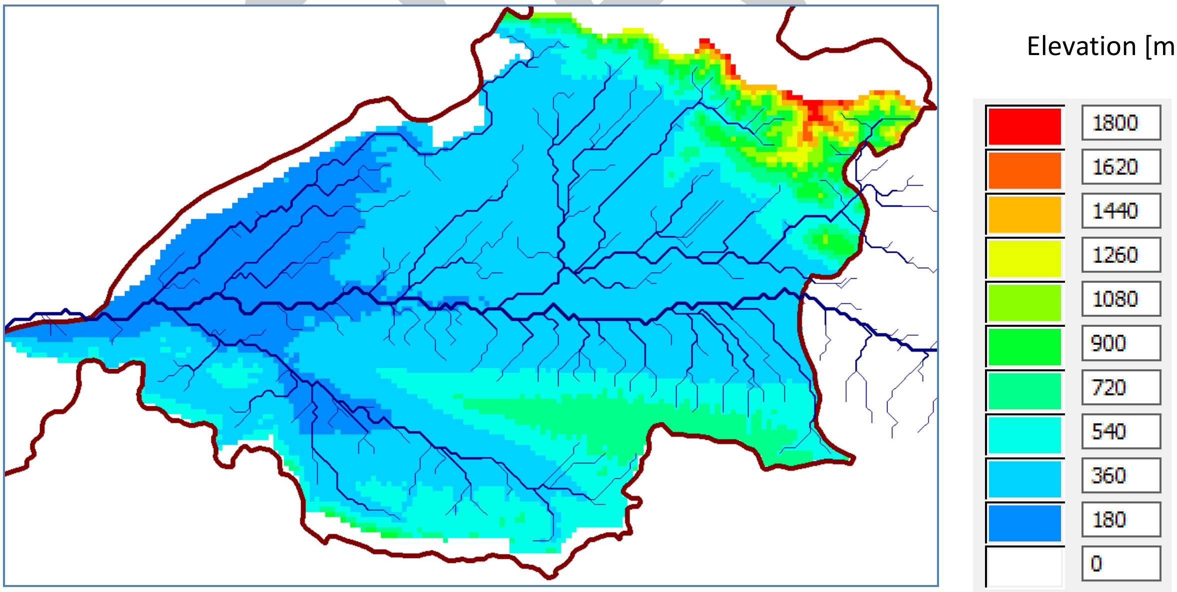
- Watershed area delineation has been done manually
- Elevation, land use and soil data is obtained from global datasets
- Approximate geo-referencing has been used
- Narayani River watershed is not included in the model and the river results are not considered.

Figure 1. Chitwan watershed model area.



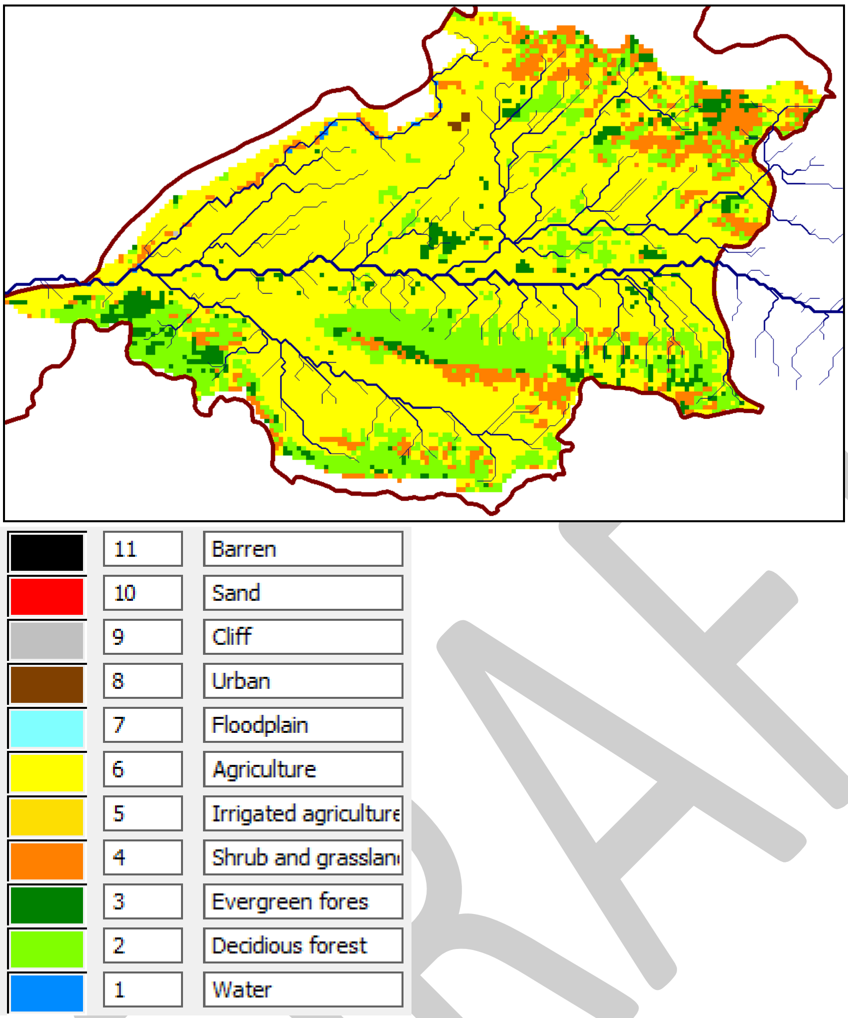
Chitwan district grid elevations reach from 140 m to 1770 m:

Figure 2. Model grid elevations for the Chitwan district.



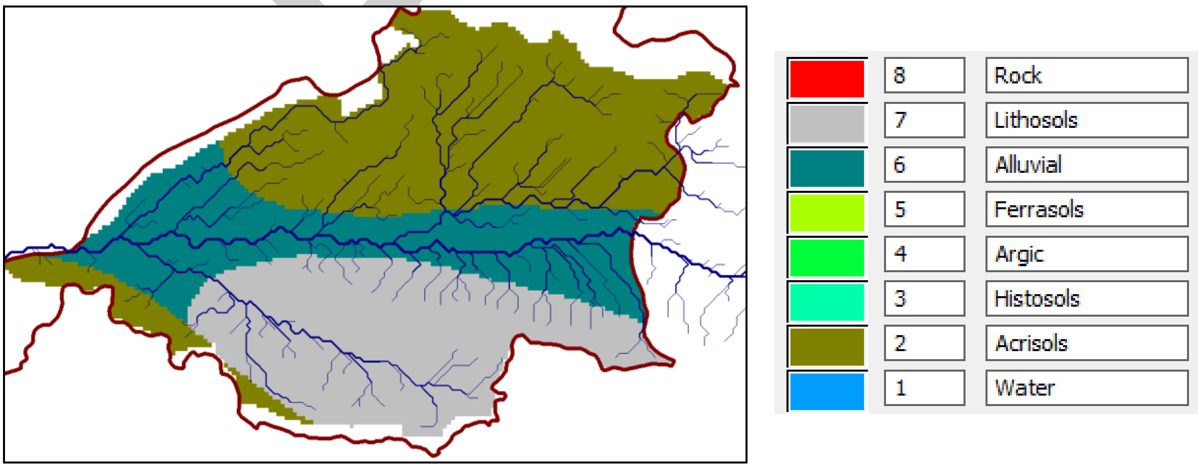
The land use is dominated by agriculture:

Figure 3. Model grid land use classes for the Chitwan district.



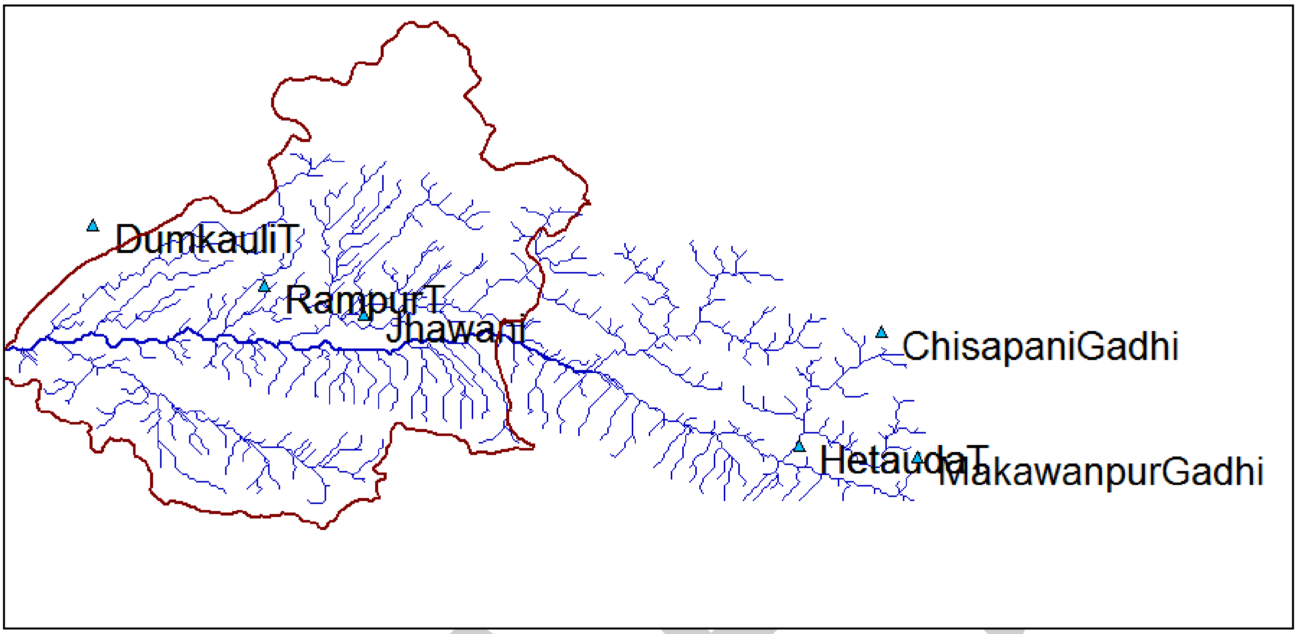
Acrisols, alluvial and lithosols are the dominant model grid soil classes for the Chitwan district (Figure4).

Figure 4. Model grid soil classes for the Chitwan district.



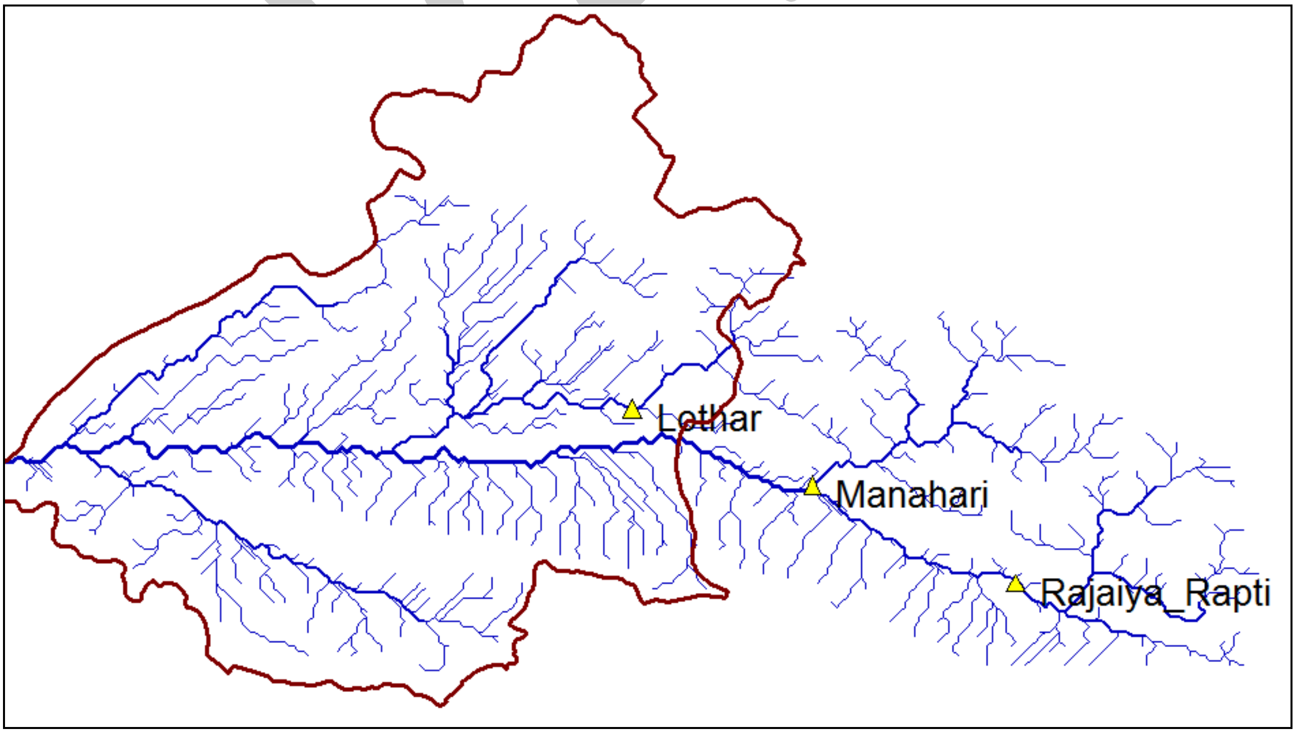
Chitwan model meteorological stations are presented in Figure5.

Figure5. Model meteorological stations.



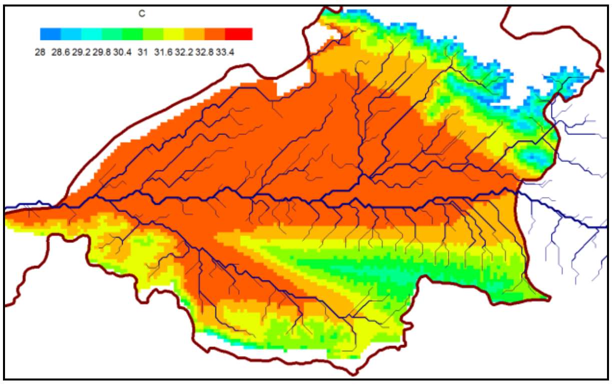
River stations used for the model calibration are shown in Figure6.

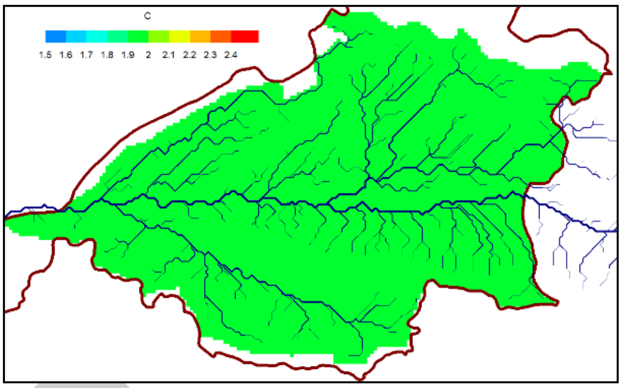
Figure6. River stations for the Chitwan model calibration.



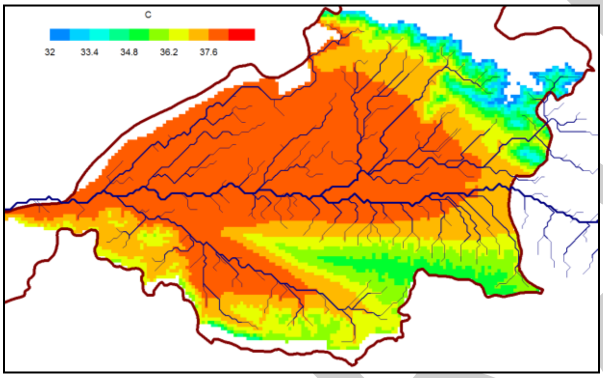
Maps for Hotspot Identification and Impact Overview

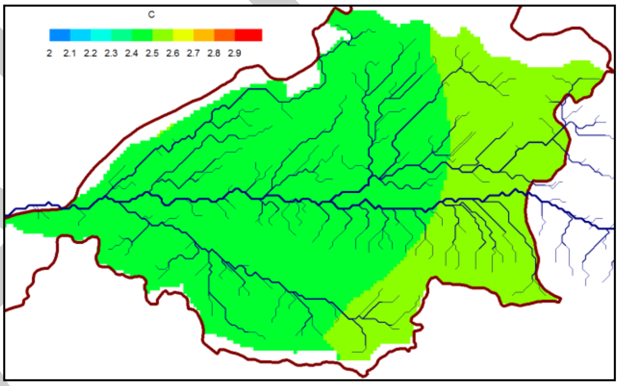
Wet season mean daily maximum temperature [°C] and change in 2050.



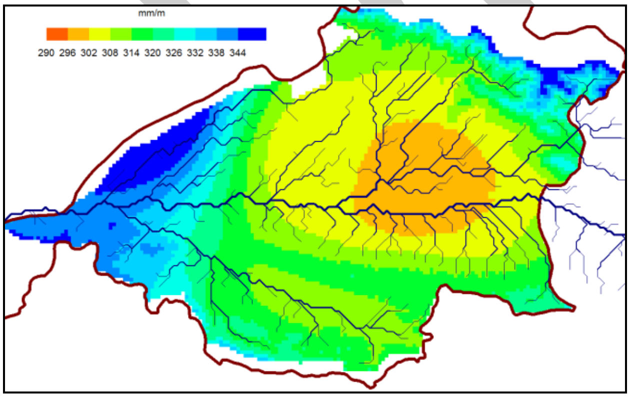


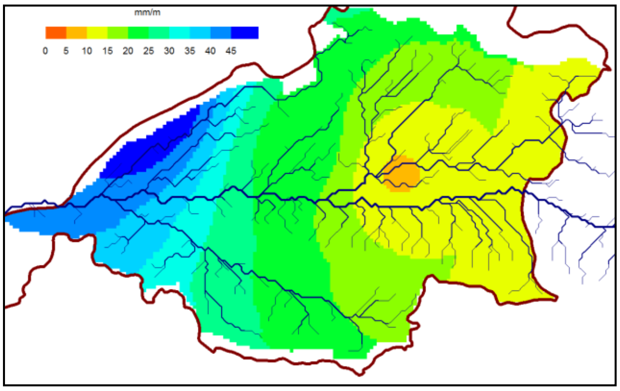
Wet season mean annual maximum temperature [°C] and change in 2050.



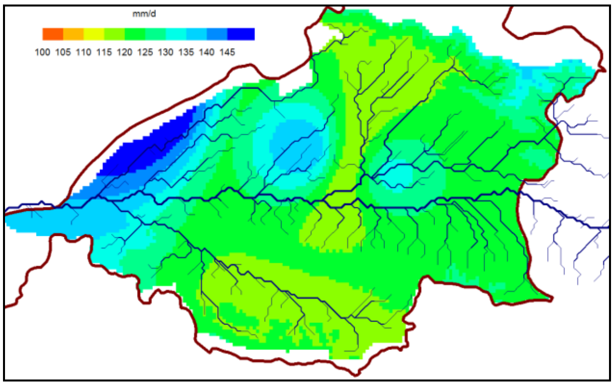


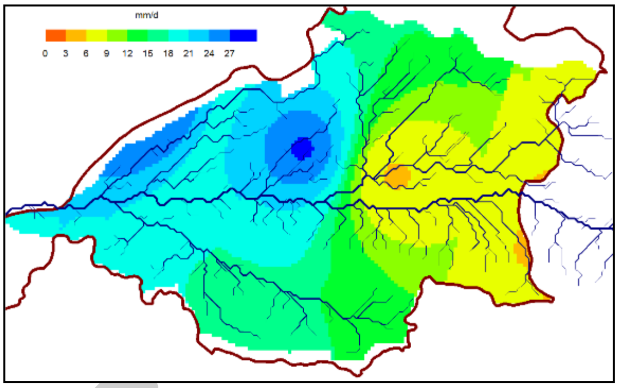
Wet season mean monthly precipitation [mm/m] and change in 2050.



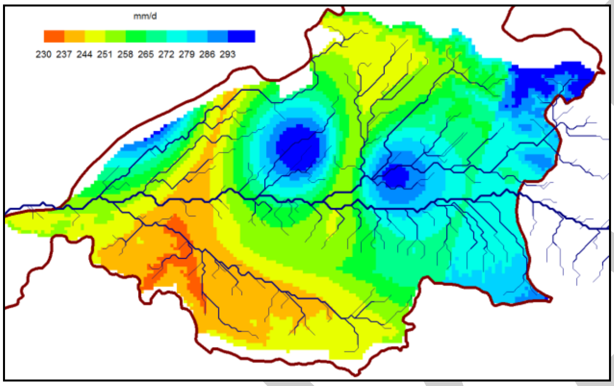


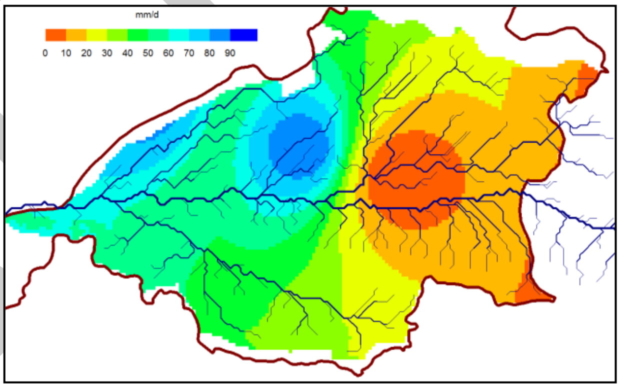
Wet season mean annual maximum precipitation [mm/d] and change in 2050.



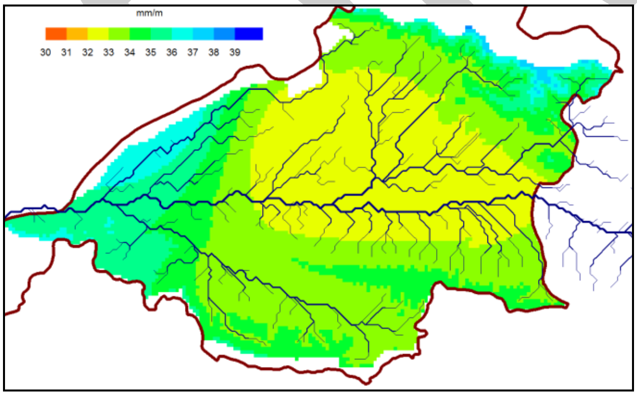


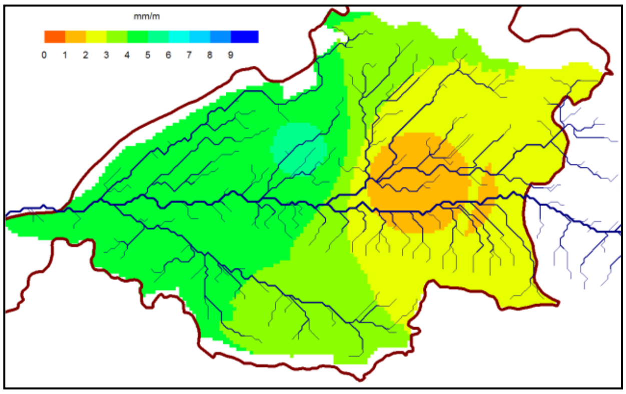
50 year precipitation event [mm/d] and change in 2050.



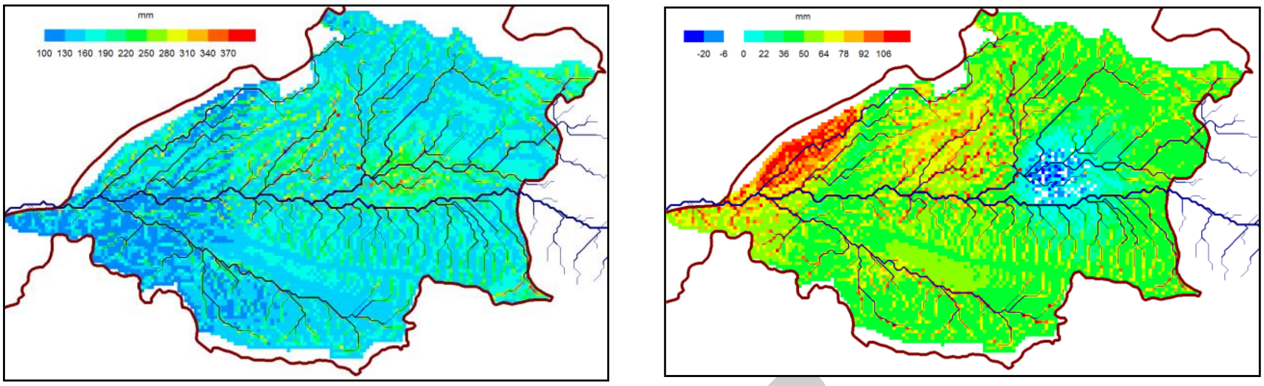


Dry season mean monthly precipitation [mm/m] and change in 2050.

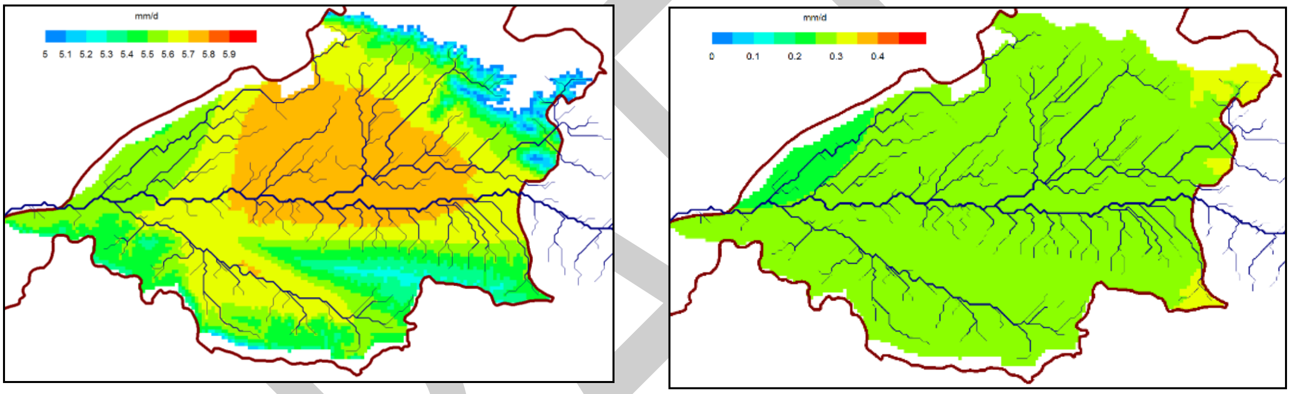




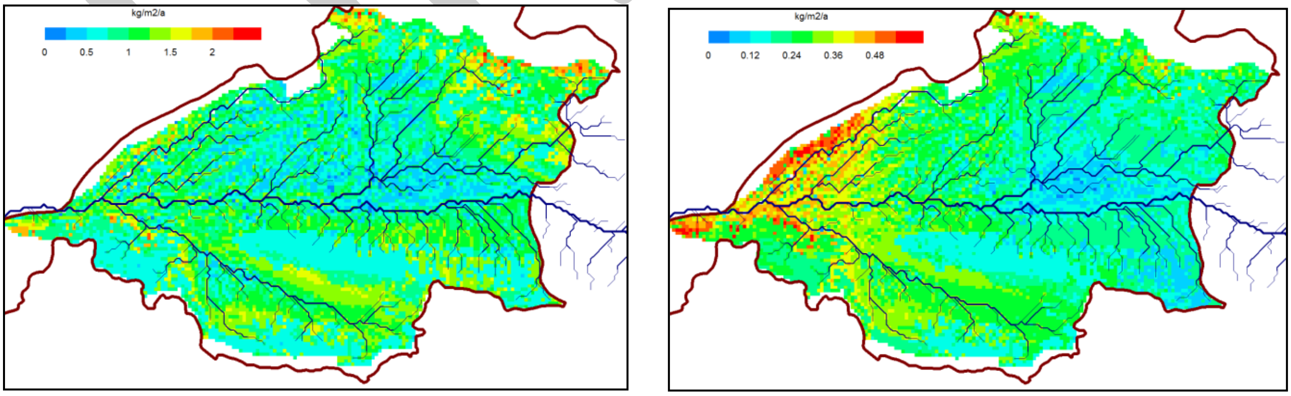
Maximum pluvial flooding [mm] and change in 2050.



Dry season potential evapotranspiration (PET) [mm/d] and change in 2050.



Average annual erosion rate [kg/m^2/a] and change in 2050.



Site and Sector Specific Information

Figure presents model locations for Lothar, Ts6 and Ts7 time series outputs. The elevations for the stations are 219, 181 and 144 m. The corresponding upper catchment areas are indicated in Figure. The catchment areas are 190, 2,005 and 2,730 km^2.

Figure 7. Chitwan model time series output locations.

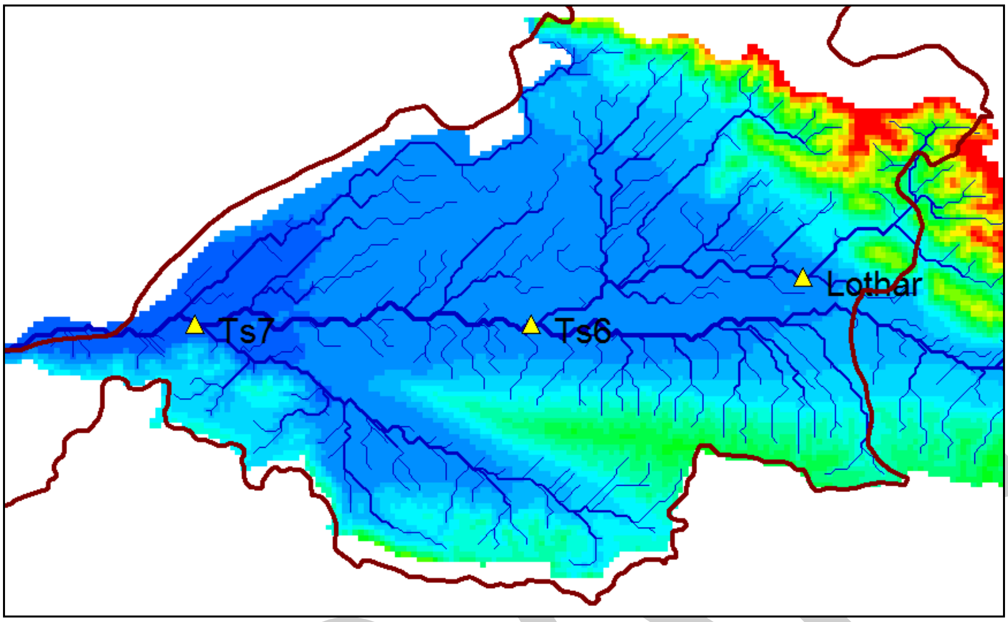
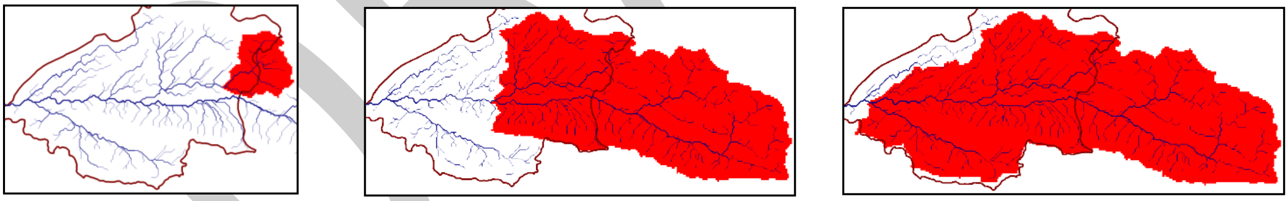
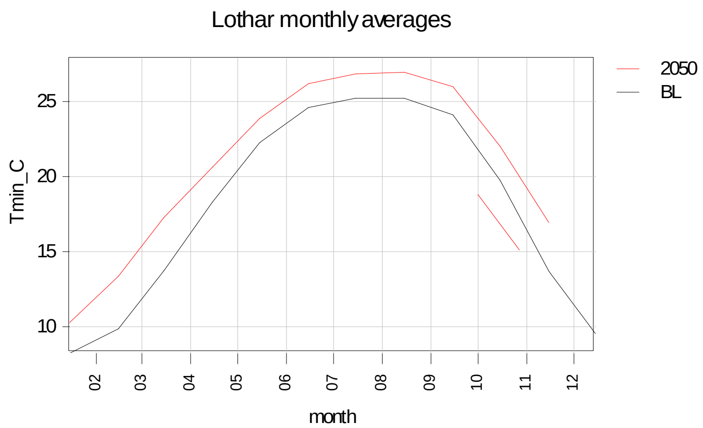


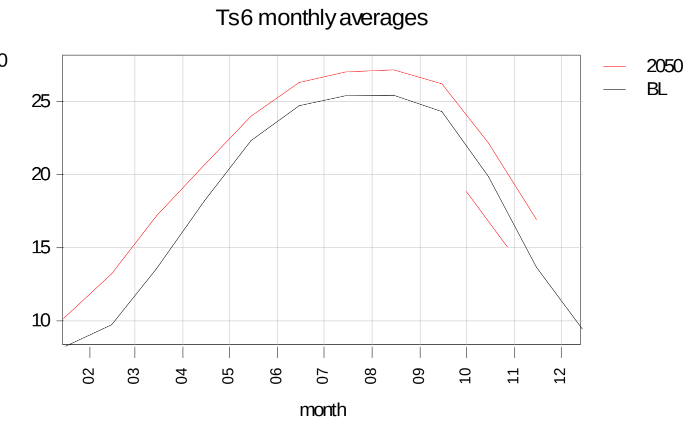
Figure 8. Upper catchment areas for the Lothar, Ts6 and Ts7 output locations.



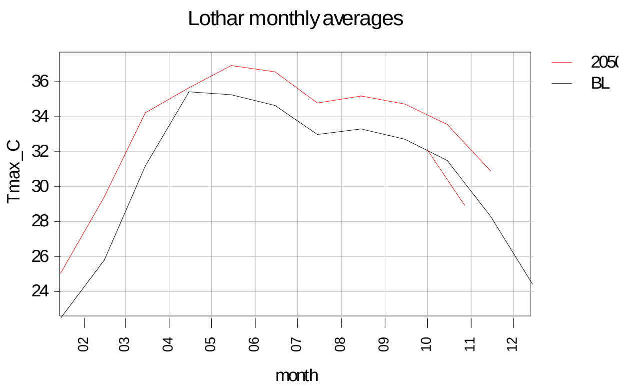
The Climate threat profile information for the two case study sites are represented by the model output locations from Lothar and Ts6

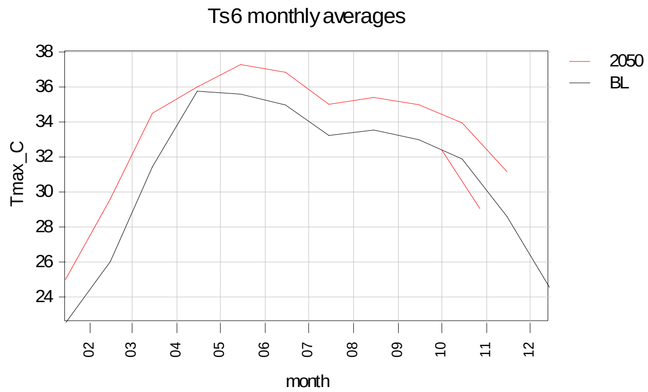
Minimum Temperature (^{o}c)



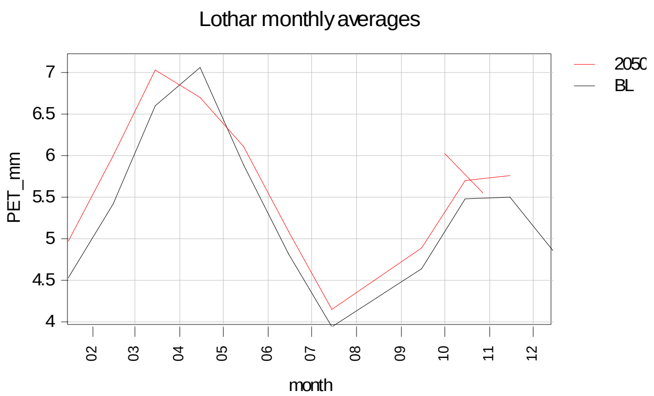


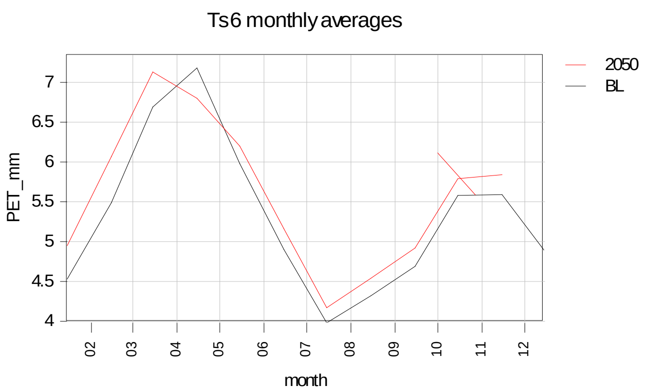
Maximum Temperature (^{o}c)



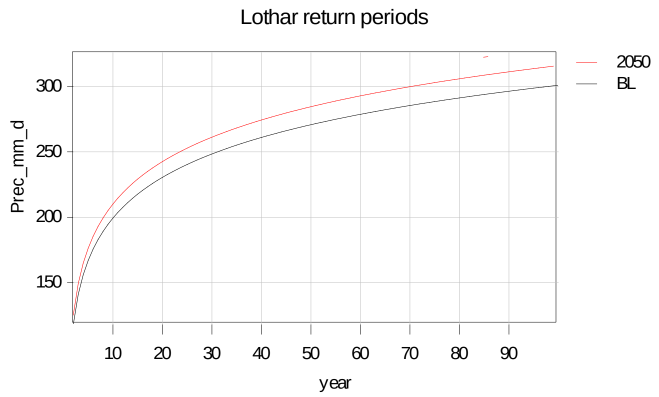


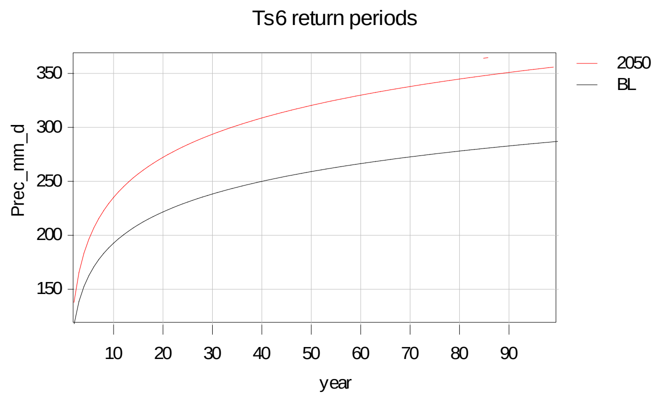
Potential Evapotranspiration (mm/day)



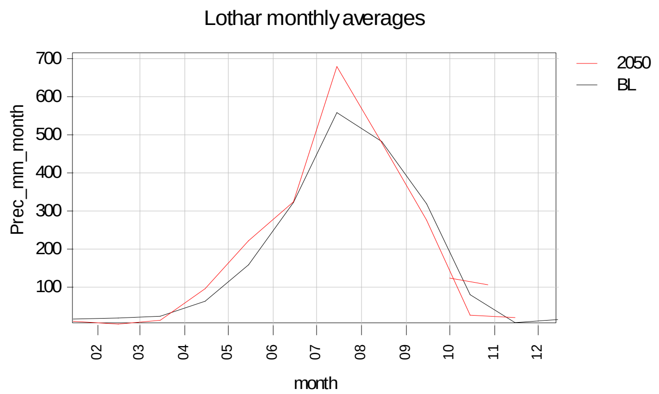


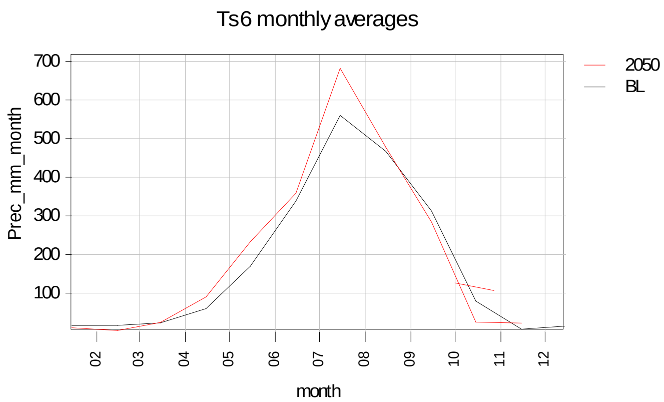
Precipitation Return Periods (mm/day)



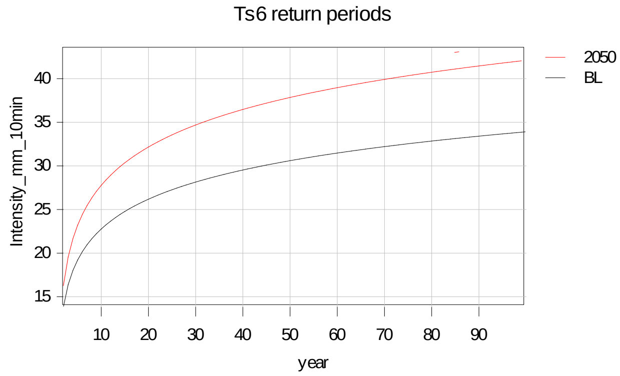


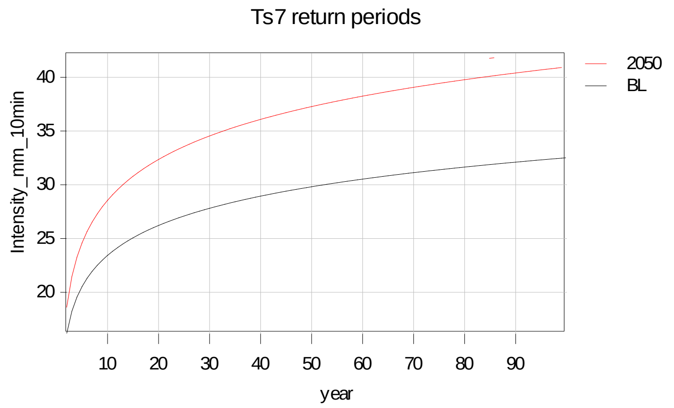
Precipitation (mm/month)



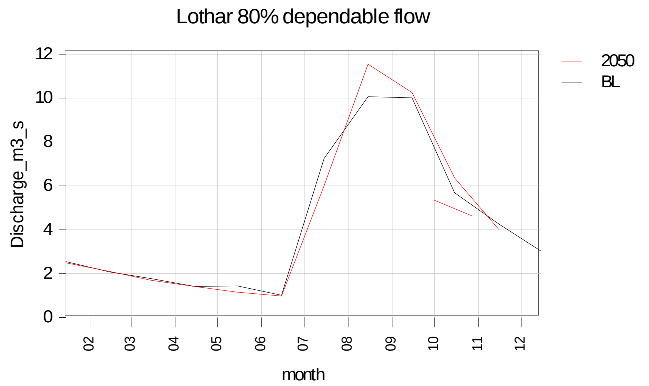


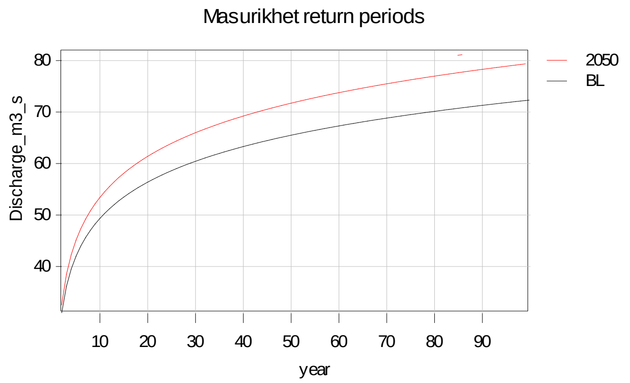
Rainfall Intensity Return Periods (mm/10min)



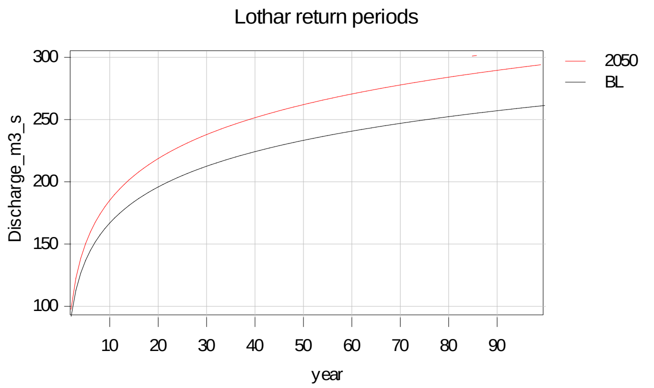


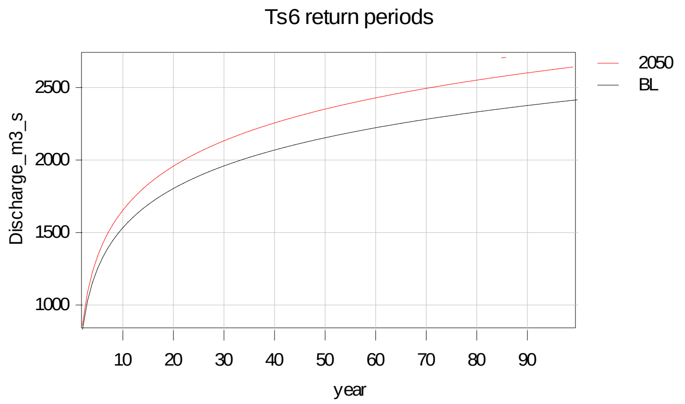
80% Dependable River Discharge (m^3/sec)



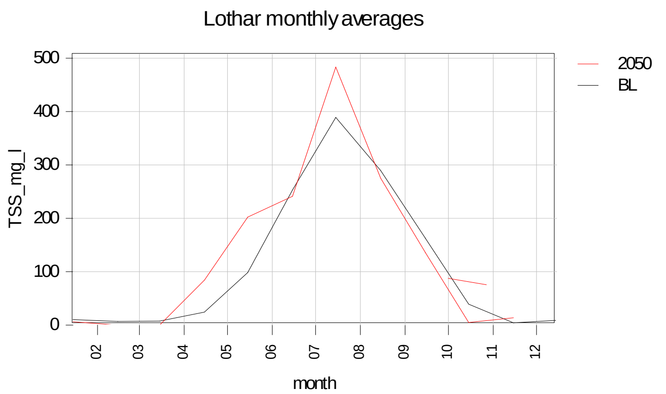


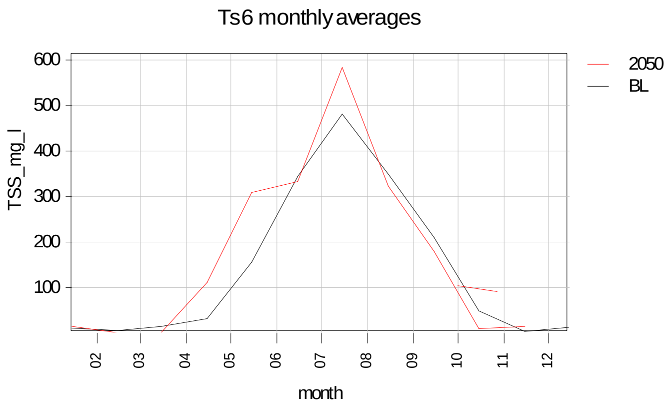
River Flows (m^3/sec)





Total Suspended Solids in Rivers (mg/litre)





ANNEXB: VULNERABILITY ASSESSMENT MATRICES

Asset – Pithuwa Irrigation System with 600ha command area. Major elements are:

- Temporary diversion structure
- Canal intake structure with gate
- Main Canal Lined with capacity of 1400 l/sec, and length of 7.5km
- 16 no of branch canals with head regulator and cross-regulator, 19 no of drop structures

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increase in Max. temperature and evapotranspiration	▪ Increased crop water demand	[1,2,3] M	L	M	• Water required at intake slightly increased particularly for paddy land preparation • More chance of disease to winter vegetable crops	M	M
Increased Rainfall	▪ Precipitation increase during early and mid-monsoon period	[4]M	H	M	• Could reduce water demand during the monsoon period	L	M
Increased River Flow (intake)	▪ Most significant increase during monsoon period	[5]H	VH	M	• It increases sediment flow in the canal • Damages the temporary diversion structure	VL[6]	**VH**

[1] Average monthly maximum temperature increase by 2^{o}C throughout the year

[2] Average monthly ETo increases by 0.3mm during January to March and July to August

[3] Average minimum temperature increases by up to 3 degree in the period from December to March. Likely to create more disease problems for vegetable crops

[4] Monthly average daily rainfall increases slightly during early monsoon period with maximum increase of 30% in July.

[5] Average monthly river flows to increases over the period from July to September. From November to March surface flow in the Khola ceases and requires weir to trap sub-surface flow.

[6] increased sediment flow and damages temporary diversion weir every year in each flood

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Flash Floods (Intake)	▪ Increase in bed load during flash floods – might block or damage intake ▪ Boulders and sand brought down by floods could damage temporary diversion weir	[7]H	[8]VH	VH	• Blockage of intake, leading to suspension of irrigation flows to the main canal • Sediment entering through the intake could block the main canal	[9]L	VH
Drought	▪ Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops	[10]M	M	H	▪ Could affect yields for wheat, pulses and potato crops ▪ Alternative cropping pattern could be introduced	[11]M	M

Linkages with other sectors

1. DADO not active in the area to provide farmers with extension services

[7]100 year return period flood could increase in size by up to 25% Rainfall intensity will increase by 15%. Catchment area mostly forested area but steep and liable to landslides
[8]The Khola bed requires better protection from larger boulders or stronger gabion baskets
[9]Very expensive to construct permanent diversion weir and beyond the farmers' capability. Design required. Sediments collected in main canal can be manually shifted
[10]Rainfall predicted to slightly decrease from November to March.
[11]Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops