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IRRIGATION VULNERABILITY ASSESSMENT REPORT

BANKE DISTRICT

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TABLE OF CONTENTS

1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Banke District Irrigation Infrastructure

The District Irrigation Office records show there is some 6,672 ha under irrigation. 4,116ha is solely under farmer managed irrigation systems, while 2,556ha since 1988 has undergone rehabilitation through donor and government funded projects. The Sikta Irrigation Project, the largest on-going irrigation development project in the country, with construction starting in 2007, will irrigate some 33,766 ha on the right bank and 9,000ha on the left bank of the West Rapti River when completed. The Groundwater Resources Development Board report that for the Banke District there are 53 deep tubewells covering an irrigated area of 2,010 ha and 1748 shallow tubewells irrigating 4,297ha.

Through co-ordination with the Department of Irrigation Focal Point and the respective District Irrigation Officers and Groundwater Resources Board staffs in the Banke District a maximum of 4 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.
- In addition in the surface irrigation systems one deep tube well and one shallow tube well system were to be taken.

The four systems chosen for the baseline asset study embraced the above criteria and included an existing farmer managed system, a recently rehabilitated system, a deep and a shallow tubewells 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 ofthe 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, one surface irrigation scheme and one tube well system have been selected as priority assets in Banke District. The detailed information on each asset is outlined in the baseline report for Banke district. Brief discussion on the asset and its components are outlined below

1.3.1 Chisapani Naubasta Irrigation Scheme

The system is a surface irrigation scheme original constructed by the farmers and rehabilitated in 1996 under the ILC project. The command area is 306ha and benefits 575 households. The crops grown are monsoon paddy followed by a combination of wheat, potatoes, pulses and oilseed. The overall cropping intensity is 180%. The potato crop is of particular importance as this area was known as the resource centre for seed potato in the region and is close to the cold storage facility at Kohalpur.

The intake site is located just upstream of where the Kohalpur/Surket road crosses the Man khola. The main canal passes under this road and continues along a meandering path for a total idle length of 1.5km, some of it along the base of a small sand hill area, before reaching the command area. This hilly area is prone to landslides. Due to a recent flood this monsoon period the weir structure across the Man Khola has partially collapsed so that water from the Khola is now unable to enter the main canal. Overall the condition of the headworks and main canal are poor as the farmers are despondent about not receiving water in the future.

In view of the above, the intake structure is considered to be the vulnerable asset under rainfall induced flash floods that trigger small –scale landslide.

1.3.2 Chisapani Deep Tubewell No-3

This tubewell is part of a cluster of 6 installed between 2007 and 2011 under the APP programme. Each tubewell commands 40ha and there is a spacing of some 600m between individual wells. Deep tubewell No 3 has a 11 member water user group of which 2 are women. There are 100 households served by this tubewell. 10ha of its command area has been taken over by a poultry farm for egg production. Crops grown on the remaining area are monsoon paddy, 50% being of a hybrid variety. In the winter 75% of the agricultural area goes under wheat, with the remaining 25% covered with a mixture of oilseed, pulses and potatoes.

The source of water for this tubewell comes from the Ganges aquifer which stretches right up into this area. This provides a good strong yield of up to 35l/sec. Due to the depth of the well the pump is drawing water from its quality is good.

1.3.3 Binauna Shallow Tubwell Cluster

This scheme consists of a cluster of 10 shallow tubewells near the village of Chachar Pharka in the Binauna VDC. In four adjoining VDC's in the area there are similar shallow tube well clusters. Each tubewell commands some 2.5ha and is shared by 3 to 4 farmers. All farmers in the area are indigenous Tharu. Crops grown in the command area are 100% paddy followed by wheat, oilseeds, pulses and some vegetables

The source of water for this tubewell cluster comes from the Ganges aquifer. This provides a reliable yield of some 20 l/sec. The water table in the area according to local farmers has been constant for the last 50years rising to a maximum level of 3m below ground level during the monsoon and falling to 5m in the May/June period

1.3.4 Kiran Nala Irrigation Scheme

The system is a lift pump scheme built in 1997 under the ILC project. It commands 205 ha and serves 207 households. Crops grown in the command area are monsoon paddy, followed by 50% wheat and the remaining 50% being mostly oilseed crops, though some potato, pulses, onions and sunflower are also grown

The source of water for this scheme is the Kiran Nala. Its command area is totally within the terai area below the east west highway and is predominantly cultivated agricultural land. The expanding townships of Nepalgunj and Kohalpur however are now gradually encroaching on to some of this land. During the monsoon, floods pass through this Nala whilst for the rest of the year spring discharges maintain a constant flow at the pump station site

A concrete weir across the Nala maintains a constant height of water at the pump intake site. Water from the river enters a sump away from the river's edge where intake pipes lift water via 5 pumps in the pump house into the main canal. There are three 50l/sec and two 25l/sec electric driven pumps

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

The climate change threat profiles for Banke District were prepared by the Hydrological Modeling teams and the information had been passed on to all the experts prior to the field visit. The threat profile is annexed 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 $2.15^{\circ}C$. 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 some $3^{\circ}C$ between December and March. This could increase disease and pest problems in particular to winter vegetable crops.

2.2.2 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 30% 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.

2.2.3 Increase in River Flows

Average monthly river flows were predicted to increase from July to September 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.

2.2.4 Flash Floods and Storms

Maximum storm intensities were predicted to increase from April to August with an increase of some 50% 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.

2.2.5 Drought

Monthly average rainfall is predicted to decrease 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. However irrigation water should be available as flows in the Man Khola should not be significantly reduced at this time as they are being fed by spring flows from a quite high groundwater table. A medium impact on crop production is assessed and as farmers is not interested in changing their cropping pattern or adopting more efficient ways of saving water these results in a medium vulnerability.

2.2.6 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 Churia hills 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 four assets within the Banke District is outlined below:

3.1 Chisapani Naubasta Irrigation Scheme

3.1.1 Asset Description

The following table describes the important aspects of the system. Below Figures illustrates the condition of source and why they are vulnerable to CC threats.

Asset Age	14 years old (built in 1996)
Operator	Water Users' Committee
Source	Man Khola
Command Area	306ha
Benefitted Household	575
Diversion Structure	67 m Concrete core wall
Head Work	Gated scour sluice in front of single gated headwork structure
Hume Pipe Road Crossing	One
Canal Systems	Lined and Earthen

Photo: 3.1 Core and Cut-off Walls across Man Khola

Photo 3-2 Failure of Diversion Core Wall Constructed across the River

Photo 3.3: Headworks Gate into Lined Main Canal

3.1.2 Vulnerability Assessment

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

- Increase in average maximum temperature by up to 2.15^{0}C in the summer.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 30^{0}C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

Exposure: MEDIUM

- Average monthly maximum temperature increase by 2.15^{o}C throughout the year.
- Average monthly ETo increases by some 0.3mm during reaching a maximum of 0.5mm in August.
- Average minimum temperature increases by up to 3 degree in the period from December to March.

Sensitivity: LOW

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

Impact: MEDIUM

- Water required at intake slightly increased particularly for paddy land preparation
- Higher temperature will increase crop water requirements and could affect choice of optimum cropping pattern.
- Likely to create more disease problems for winter vegetable crops.

Adaptive Capacity: MEDIUM

- There has been assistance provided in agriculture extension advice from local DADO
- Farmers are willing to respond to local agricultural market opportunities
- 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/Command Area)

- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years. 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 increase prior to and during the early monsoon period with a maximum increase of some 30% in July.

- 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.

Exposure: LOW

- The intake and the diversion structure are exposed to increased rainfall event.
- Longer duration rainfall events and more frequent rainfall runoff would cause soil erosion in the catchment and bringing high sediment loads with the floods.

- More rain distributed over a period may reduce the water demand during the period

Sensitivity: LOW

- The initially installed protective measures were washed away due to flood events; hence, no good protective measures were in place such as downstream of the diversion weir.
- Need redesign of diversion structures

Impact: LOW

- Increase in rainfall will reduce irrigation demand during the monsoon period and decrease in rainfall will increase irrigation demand for the winter crops
- Since the command area is slightly sloped land water absorbed by the land is negligible

Adaptive Capacity: HIGH

- Farmers are capable of managing minor repair maintenance of the structures caused by increased rainfall
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the authorities.

Vulnerability Scoring: LOW

As per the guiding matrix below, the vulnerability for the increase in rainfall is **LOW.**

		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*

3.1.2.3 Increased River Flow (Intake)

- Increased flows in Man Khola is expected due to increase in rainfall
- Increasing wet season flow in the Man Khola and earlier peak flow – it is expected that peak monthly average flow will occur one month earlier in July and increase by up to 5%

- Average monthly river flows are predicted to increase over the period from July to September, whilst the rest of the year there is little change.

Exposure: MEDIUM

- Average monthly river flow to increases over the period from July to September.
- From November to March surface flow in the Khola ceases and only sub-surface flows trapped by the core wall are available.

Sensitivity: HIGH

- Level of maintenance is very poor
- Protection works washed away
- The head works structure is to be rehabilitated

Impact: MEDIUM

- Irrigation water not able to enter the main canal after the discharge is reduced
- Diversion weir is partially collapsed preventing water from the source river (Man Khola) entering the canal.

Adaptive Capacity: VERY LOW

- Farmers have no capacity to repair the collapsed head works
- Limited funds are available for repairs or replacement of structure.

Vulnerability Scoring: HIGH

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

		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*

3.1.2.4 Flash Floods (Intake)

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.

Exposure: HIGH

- The initially installed protective measures were washed away due to flood event
- Boulders and sand brought down by flash floods could damage diversion weir
- 100 year return period flood could increase in size by up to 30%. Rainfall intensity will increase by 20%. Catchment area in the Churia Mountains 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

- Redesign of diversion weir design required
- Required better protection works with larger boulders or gabions at the downstream of the diversion weir core wall.
- Maintenance of collapsed core wall required.

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: LOW

- No protective measures were in place such as downstream of the diversion weir.
- Very expensive to rectify damaged diversion weir and beyond farmers' capability.
- Limited funds available for repairs or replacement of structure.
- Redesign of diversion weir is required.
- Sediments collected in main canal can be manually shifted

Vulnerability Scoring: VERY HIGH

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

		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*

3.1.2.5 Threat: Storms (Command Area)

- Increased rainfall intensity over cropped area
- Maximum storm intensities were predicted to increase from April to August with an increase of some 50% in July

Exposure: HIGH

- With the increase in storm intensities there was more likelihood of the occurrence of high winds and hail. This would increase damage to standing crops.
- The storm also may cause the flood in the river locally and damage the head works further as it occurs during monsoon i.e. August

Sensitivity: MEDIUM

- Wind and hail storm damage to winter wheat and vegetable crops the most significant.
- Landslides caused by the local intense rainfall may damage the canals

Impact: HIGH

- Crops could be damaged and difficult to harvest
- Level terraces will absorb increased rainfall

Adaptive Capacity: MEDIUM

- Higher risk of financial loss with high value crops being irrigated

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the command area 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*

3.1.2.6 Threat: Drought (Command Area)

- Decreasing trend in the number of rainy days and increasing trend of intense precipitation days i.e. more precipitation occurred in fewer days.
- Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops.

Exposure: MEDIUM

- Rainfall predicted to remain the same from November to March
- The changing pattern of precipitation indicates that the drought period is not really changing.

Sensitivity: MEDIUM

- Change in cropping pattern and calendar
- Irrigation water are available as the flow in the Man Khola is being fed by spring flows

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*

3.1.2.7 Threat: Landslides

- Landslides occur where main canal passes near sand hills
- Localised intense rainfall likely to increase landslide risk

Exposure: (MEDIUM))

- Channel could be blocked
- Sediments transported into the fields
- Impact on loss of water supplied and crop yield decreased

Sensitivity (LOW)

- Cleaning of the landslide could be done just after its occurrence as the landslide area is not far from the village.
- Water users committee are capable to remove the landslides easily

Impact: (MEDIUM)

- Blockage of the canal will prevent irrigation of the command area
- Medium Impact on crop yield.

Adaptive Capacity: (MEDIUM)

- DOI can support technically
- Management committee can remove the landslides easily
- Protective measures may be needed if the impact is high
- Limited financial resources available in the project (scheme)

Vulnerability: (MEDIUM)

As per the guiding matrix, the vulnerability of main canal pipe line for landslide 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 Chisapani Deep Tube Well #3

This Chisapani deep tubewell no-3 is part of a cluster of 6 installed between 2005 and 2011 under the APP programme. Each tubewell commands 40ha and there is a spacing of some 600m between individual wells. The vulnerability assessment analyses based on increase in temperature, increased rainfall, water table rise, storms and drought

3.2.1 Asset Description

The following tables describe the important aspects of the existing Chisapani Deep Tubewell No-3

Chisapani Deep Tubewell No-3	
Source	Groundwater
Asset Age	Over 7 years
Operator	Water Users Committee
Tank Type and Capacity	$30m^3$ concrete storage tank above pump house containing electrical controls
Depth of boring and casing	160 m steel cased with screen
Pump type and capacity	Submersible pump delivering discharges of up to 35l/sec
Distribution System	Buried distribution pipes deliver irrigation water to outlet chambers containing alfalfa valves at 100m intervals
Canal Type	Unlined canals from the outlet chambers deliver water to the fields

Photo: 3.4: Deep Tubewell No 3

3.2.2 Vulnerability assessment of Chaisapani Deep tubewell No.3

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

3.2.2.1 Threat: Increase in temperature

- Increase in average maximum temperature by up to 2^0C in the summer.

- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 30^{0}C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

Exposure: MEDIUM

- Average monthly maximum temperature increase by 2^{o}C throughout the year.
- Average monthly ETo increases by some 0.3mm during reaching a maximum of 0.5mm in August.
- Average minimum temperature increases by up to 3 degree in the period from December to March.

Sensitivity: LOW

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

Impact: MEDIUM

- Water required at intake slightly increased particularly for paddy land preparation
- Higher temperature will increase crop water requirements and could affect choice of optimum cropping pattern.

Adaptive Capacity: MEDIUM

- There has been assistance provided in agriculture extension advice from local DADO Is it assured
- Farmers are willing to respond to local agricultural market opportunities
- 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*

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

- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years. 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 increase prior to and during the early monsoon period with a maximum increase of some 30% in July.

- 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.

<u>Exposure: LOW</u>

- The tube well is exposed to increased rainfall event.
- Longer duration rainfall events and more frequent rainfall runoff would cause top soil erosion in commanded area. Simultaneously the increased rainfall has positive impact on ground water recharge.
- Rainfall intensity increases had a direct but low effect on possible crop damages

<u>Sensitivity: LOW</u>

- Small amount of soil erosion in command area and soil coming along with run-off water from upland has very low negative impact on the system operation.

<u>Impact: LOW</u>

- Increase in rainfall will reduce irrigation demand during the monsoon period and decrease in rainfall will increase irrigation demand for the winter crops
- Longer duration rainfall events and more frequent rainfall runoff would cause top soil erosion in commanded area. Simultaneously the increased rainfall has positive impact on ground water recharge.

<u>Adaptive Capacity: HIGH</u>

- Farmers are capable of funding minor maintenance and minor repair costs
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the authorities.

<u>Vulnerability Scoring: LOW</u>

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

		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*

3.2.2.3 Water Table Levels Rise (Tubewell)

Water table in the area presently rises during the months of August to October by some 1.5m. The rest of the year it gradually falls to a low point in July.

Exposure: LOW

- The water table is predicted to rise throughout the year with a maximum rise of 0.3m. However there is predicted to be no rise in July when it is at its lowest.
- Further aquifer development is possible during the post monsoon period.

Sensitivity: LOW

- Reduces pumping power requirement and opportunities for greater groundwater yields
- Possibilities for expanding irrigation area and more cash crop production

Impact: LOW

- More irrigation water for crop production
- Less pumping head required.

Adaptive Capacity: HIGH

- Local farmers are eager to find the condition of such water table rise in the tube wells, and do not have to bear much cost or physical effort, it is highly adaptable
- Pumping costs reduced and possibilities for further aquifer development

Vulnerability Scoring: LOW

As per the guiding matrix shown below, the vulnerability for any water table rise is **LOW.**

		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*

3.2.2.4 Threat: Storms (Command Area)

- Increased rainfall intensity over cropped area
- Maximum storm intensities were predicted to increase from July to August with an increase of some 30% in July

Exposure: HIGH

- Lightning may hit the transformers and disturb the electricity supply

Sensitivity: MEDIUM

- Wind and rain could damage the crop and vegetable crops.

Impact: HIGH

- Crops could be damaged and difficult to harvest
- Level terraces will absorb increased rainfall

Adaptive Capacity: MEDIUM

- Active water user group and farmers willing to repair any small damages
- Do not have the capacity for large repairs to pumps.

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability to storms 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*

3.2.2.5 Threat: Drought (Command Area)

- Decreasing trend in the number of rainy days in winter.
- Rainfall in the winter period will remain the same reducing opportunities for recharging the ground water storage if pumping levels increase.

Exposure: MEDIUM

- Rainfall predicted to remain the same from January to April
- Ground water recharging rate in winter is decreasing.

<u>Sensitivity: MEDIUM</u>

- Change in cropping pattern and calendar

<u>Impact: MEDIUM</u>

- Could affect yields and cropping intensity for wheat, pulses and potato crops

<u>Adaptive Capacity: MEDIUM</u>

- Farmers are interested in changing their cropping pattern at present to introduce higher value cash crops but need further motivation
- Active water user group and farmers willing to pay additional water costs if required

<u>Vulnerability Scoring: MEDIUM</u>

As per the guiding matrix below, the vulnerability to drought 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*

3.3 Binauna Shallow Tubewell

Binauna shallow tubewell consists of a cluster of 16 shallow tubewells near the village of Chachar Pharka in the Binauna VDC. In four adjoining VDC's in the area there are similar shallow tube well clusters. Each tubewell commands some 2.5ha and is shared by 3 to 4 farmers.

3.3.1 Asset Description

The following tables describe the important aspects of the existing Binauna Shallow Tubewell Cluster

Binauna Shallow Tubewell Cluster	
Source	Groundwater
Asset Age	5-10 years

Operator	Water Users Committee
Depth of boring	25m steel cased with 10 m long screen
Pump type and capacity	Pump delivering discharges of up to 20l/sec
Canal Type	Unlined canals from the outlet chambers deliver water to the fields

3.3.2 Vulnerability assessment of Binauna Shallow Tubewells

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

3.3.2.1 Threat: Increase in temperature

- Increase in average maximum temperature by up to 2^0C in the summer.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 30^0C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

Exposure: MEDIUM

- Average monthly maximum temperature increase by 2^oC throughout the year.
- Average monthly ETo increases by some 0.3mm during reaching a maximum of 0.5mm in August.
- Average minimum temperature increases by up to 3 degree in the period from December to March.

Sensitivity: LOW

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

Impact: MEDIUM

- Water required at intake slightly increased particularly for paddy land preparation
- Higher temperature will increase crop water requirements and could affect choice of optimum cropping pattern.
- Likely to create more disease problems for winter vegetable crops.

Adaptive Capacity: MEDIUM

- There has been assistance provided in agriculture extension advice from local DADO Is it assured
- Farmers are willing to respond to local agricultural market opportunities
- 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*

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

- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years. 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 increase prior to and during the early monsoon period with a maximum increase of some 30% in July.

- Monthly average rainfall was predicted to remain the same during the period from November to March. This might 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: LOW

- The tube well is exposed to increased rainfall event.
- Longer duration rainfall events and more frequent rainfall runoff would cause top soil erosion in commanded area. Simultaneously the increased rainfall has positive impact on ground water recharge.
- Rainfall intensity increases had a direct but low effect on possible crop damages

Sensitivity: LOW

- Small amount of soil erosion in command area and soil coming along with run-off water from upland has very low negative impact on the system operation.

Impact: LOW

- Increase in rainfall will reduce irrigation demand during the monsoon period and decrease in rainfall will increase irrigation demand for the winter crops
- Longer duration rainfall events and more frequent rainfall runoff would cause top soil erosion in commanded area. Simultaneously the increased rainfall has positive impact on ground water recharge.

Adaptive Capacity: HIGH

- Farmers are capable of funding minor maintenance and minor repair costs
- Material, equipment and spare-parts are locally available.
- Technical capabilities are readily available within the authorities.

Vulnerability Scoring: LOW

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

		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*

3.3.2.3 Water Table Levels Rise (Tubewell)

Water table in the area presently rises during the months of August to October by some 1.5m. The rest of the year it gradually falls to a low point in July. It reduces pumping power requirements with opportunity of greater water yield. In case of further aquifer development irrigated area can possibly increase.

Exposure: LOW

- The water table is predicted to rise throughout the year with a maximum rise of 0.3m. However there is predicted to be no rise in July when it is at its lowest.
- Further aquifer development is possible during the post monsoon period.

Sensitivity: LOW

- Reduces pumping power requirement and opportunities for greater groundwater yields
- Possibilities for expanding irrigation area and more cash crop production

Impact: LOW

- More irrigation water for crop production
- Less pumping head required.

Adaptive Capacity: HIGH

- Local farmers are eager to find the condition of such water table rise in the tube wells, and do not have to bear much cost or physical effort, it is highly adaptable

Vulnerability Scoring: LOW

As per the guiding matrix shown below, the vulnerability for any water table rise is **LOW**

		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*

3.3.2.4 Threat: Storms (Command Area)

- Increased rainfall intensity over cropped area
- Maximum storm intensities were predicted to increase from April to August with an increase of some 50% in July

Exposure: HIGH

- With the increase in storm intensities there was more likelihood of the occurrence of high winds and hail. This would increase damage to standing crops.
- The commanded area on the bank of the Rapti River is liable to erosion from overspill during floods in the Rapti.

Sensitivity: MEDIUM

- Wind and rain could damage the crop and vegetable crops and the land adjacent to the River.

Impact: HIGH

- Crops and land could be damaged to some extent

Adaptive Capacity: MEDIUM

- Active water user group and farmers willing to repair any small damages
- Do not have the capacity for large repairs

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability to storms 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*

3.3.2.5 Threat: Drought (Command Area)

There is decreasing trend in the number of rainy days in winter. With no increase in rainfall predicted during the winter period causes the opportunity for increasing the recharging capacity in the ground water storage is limited.

Exposure: MEDIUM

- Rainfall predicted to remain the same from November to March

- Little opportunity for ground water recharging rate in winter

Sensitivity: MEDIUM

- Opportunity to change cropping pattern and calendar

Impact: MEDIUM

- Could affect yields and cropping intensity for wheat, pulses and potato crops

Adaptive Capacity: LOW

- Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops. It may be possible with appropriate motivation
- Active water user group and farmers will have to pay additional water costs if required
- Cheap Chinese diesel pumps are used which are more unreliable and in the long run generate higher maintenance costs if extra pumping is 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*

3.4 Kiran Nala (Lift) Irrigation Scheme

3.4.1 Asset Description

The following table describes the important aspects of the system

Asset Age	**17 years old (built in 1997)**
Operator	**Water Users' Committee**
Source	**Kiran Nala**
Command Area	**205ha**

Benefitted Household	**207 ha**
Diversion Structure	**Concrete weir, flushing channel**
Head works	**Gated intake to pump sump. Five pumps lifting water into canal**
Other Structures	**4 No. Division Boxes, 3 No. Road culverts,**
Canal Systems	**Lined (1.3 km) and Earthen (3 km)**
Main Canal Capacity	**200 lps**

Intake (Khola)

Sump-Well

Pump House

Irrigation Canal

3.4.2 Vulnerability assessment of Kiran Nala (Lift) Irrigation Scheme

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

3.4.2.1 Threat: Increase in temperature

- It is found that the increase in average maximum temperature is up to 2^{0}C in the summer.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 30^{0}C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

Exposure: MEDIUM

- Average monthly maximum temperature increase by 2^{o}C throughout the year.

- Average monthly ETo increases by some 0.3mm during reaching a maximum of 0.5mm in August
- Average minimum temperature increases by up to 3 degree in the period from December to March.

Sensitivity: LOW

- The increase in cropwater demand is very less (1mm only) increase of temperature has no impact on design capacity of the intake structures and canal..

Impact: MEDIUM

- Water required at intake slightly increased particularly for paddy land preparation
- Higher temperature will increase crop water requirements and could affect choice of optimum cropping pattern.
- Likely to create more disease problems for winter vegetable crops.

Adaptive Capacity: LOW

- There has been assistance provided in agriculture extension advice from local DADO
- Farmers are willing to respond to local agricultural market opportunities
- 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*

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

- Rainfall events occur more frequently than before, 50 years events now occur at every 35 years. 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 increase prior to and during the early monsoon period with a maximum increase of some 30% in July.

Exposure: LOW

- The intake and the diversion structure are exposed to increased rainfall event.
- Rainfall intensity increases had a minor effect on possible crop damages and the on irrigation infrastructure.

Sensitivity: LOW

- Minor soil erosion in source river and commanded area
- Minor repair and maintenance of diversion structure needed

Impact: LOW

- Increase in rainfall will reduce irrigation demand during the monsoon but need some additional maintenance cost

Adaptive Capacity: HIGH

- Farmers are capable of maintaining and repairing the minor damages caused.

Vulnerability Scoring: LOW

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

		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

3.4.2.3 Increased River Flow (Intake)

- Increased flow in the River (Kiran Nala) is expected due to increase in rainfall in the catchment.
- Flow is increased on the river in the wet season flow.

Exposure: MEDIUM

- Average monthly river flow to increases over the period from July to September.
- From November to March surface flow in the Khola is severely reduced.
- Spring flows contribute to increased discharges.

Sensitivity: MEDIUM

- Maintenance of the diversion structure may be required
- Downstream flow on right (intake) bank is to be regularized

Impact: MEDIUM

- Little impact on crop production.
- Pumping heads would be reduced.

Adaptive Capacity: MEDIUM

- Farmers may not be capable to repair damages to the intake and pump sump
- Additional funds required for repairs or replacement may be beyond farmers means

Vulnerability Scoring: MEDIUM

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

3.4.2.4 Flash Floods (Intake)

- Maximum storm intensities were predicted to increase from April to August with an increase of some 30% in July.
- The catchment area is relatively flat. No big boulders are expected to come in the river. However soil sediment is possible.

<u>Exposure: MEDIUM</u>

- The intake as well as the pump house is exposed to the flash flood threat.
- Increase in bed load during flash floods might block the intake.
- 100 year return period flood could increase in size by up to 30%. Rainfall intensity will increase by 20%. Catchment area is relatively flat cultivated lands so runoff speeds will be reduced.

<u>Sensitivity: MEDIUM</u>

- Well-designed weir across the Nala with scouring sluice and intake structure is well maintained
- If the sediment entering in the pump sump is not removed this may damage the pumps

<u>Impact: MEDIUM</u>

- Blockage of pump intake, leading to temporary restriction of irrigation water
- Sediment entering through the intake could damage the pumps

<u>Adaptive Capacity: LOW</u>

- Sediment entering into the canal can easily be removed by the farmers
- The farmers don't have capacity to repair the pumps damaged by the flood and sediments

<u>Vulnerability Scoring: MEDIUM</u>

As per the guiding matrix shown below, the vulnerability due to flash floods 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*

3.4.2.5 Threat: Storms (Command Area)

- Increased rainfall intensity over cropped area
- Maximum storm intensities were predicted to increase from April to August with an increase of some 30% in July

Exposure: HIGH

- With the increase in storm intensities there was more likelihood of the occurrence of high winds and hail. This would increase damage to standing crops.
- During storms the lightning may hit the transformers and electricity supply may be disturbed

Sensitivity: MEDIUM

- Wind and hail storm damage to winter wheat and vegetable crops the most significant.

Impact: HIGH

- Crops could be damaged and difficult to harvest
- Level terraces will absorb increased rainfall

Adaptive Capacity: MEDIUM

- Risk of financial loss with high value crops being irrigated
- Farmers not capable of repairing the transformers without assistance

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability due to storms 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*

3.4.2.6 Threat: Drought (Command Area)

- Decreasing trend in the number of rainy days and increasing trend of intense precipitation days i.e. more precipitation occurred in fewer days.
- Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops.

Exposure: MEDIUM

- Rainfall predicted to stay the same from November to March
- The water needed to irrigate the Rabi crop is available in the source river (Kian Nala)

<u>Sensitivity: MEDIUM</u>

- No major change of cropping pattern needed during winter
- Irrigation water is to be managed in better ways to adjust the variation of discharge in the Nala.

<u>Impact: MEDIUM</u>

- Water availability is reduced during winter however the ground water level is well maintained and this should prevent any shortage of water for the crops

<u>Adaptive Capacity: MEDIUM</u>

- Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops
- Active water user group and farmers are trained for alternate water schedule to be adopted

<u>Vulnerability Scoring: MEDIUM</u>

As per the guiding matrix below, the vulnerability due to drought 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*

4 BANKE DISTRICT VULNERABILITY SUMMARY

4.1 Vulnerability Comparison

Based on the VA performed within Banke District, the following conclusions can be made on the assets and their components:

BANKE DISTRICT VULNERABILITY SUMMARY

Climate Threat	Priority Asset Affected	Vulnerability			
		Chisapani Naubasta (306 ha)	Chisapani DTW#3	Binauna STW (10*2.5 ha)	Kiran Nala Lift (205 ha)
1. Increased Temperature	Command Area	M	M	M	M
2. Increased Rainfall	Command Area	L	L	L	L
3. Increased River Flows	Intake Structure	H			M
4. Flash Floods	Intake Structure	VH			M
5. Water Table Levels Rise	Tubewell		L	L	
6. Storms	Command Area	H	H	H	H
7. Drought	Command Area	M	M	M	M
8. Landslides	Main Canal	M			

The summary matrix highlights that the Chisapani Naubasta Irrigation system was considered the most vulnerable out of the four case study systems analyzed within the district. This was principally due to the khola it was taking water from already experiencing fast flowing flash floods in the monsoon period bringing down high sediment loads which would increase. The existing diversion weir is already damaged and further flood damage could well occur which may be beyond the capacity and financial resources of the farmers to repair

4.2 Vulnerability Summary to Principal Climate Threats

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

THREAT	PRINCIPAL ASSETS	IMPACTS WITHIN IRRIGATION SYSTEMS	WHY IT IS VULNERABLE
Increased Temperature	Command Area (All systems)	Higher temperature will increase crop evapotranspiration rates particularly during the monsoon period and less instances of fogs during the winter.	1) In all the four Irrigation schemes, water required at the intake slightly increased particularly for paddy land preparation 2) Higher winter temperatures will encourage quicker growth of crops
Increase in monthly rainfall	Command Area (All systems)	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	1) Rainfall will increase only during the monsoon period and by a maximum of 30% in July 2) It could reduce water demand during the monsoon period 3) The rest of the year little change in rainfall amounts 4) More rain during the monsoon period will lead to potentially greater soil erosion and more sediment in the river flows. 5) Greater monsoon rainfall helps to raise groundwater table by up to 0.2m during post monsoon period
Increased River Flows	Intake Structures (Chisapani Naubasta and Kiran Nala)	Increases in river flows during the monsoon period will bring more sediment into the main canal and could damage the pumps at Kiran Nala	1) Very little change in the 80% dependable river flows 2) River flows only to increase during the monsoon period providing more water for irrigation 3) 10% increase in 1:100 year flood events expected 4) Increased flows could damage diversion weir and intake structure.in both the systems and bring with it more sediment 5) In Kiran Nala, less pumping head shall be required during the monsoon
Flash Floods	Intake Structure (Chisapani Naubasta and Kiran Nala)	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 area	1) A 10% increase in the 1:50 year rainfall event will increase the intensity of flash floods during the monsoon period 2) Increase in bed load during flash floods might block or damage intake in both Chisapani Naubasta and Kiran Nala Irrigation System 3) In Chisapani Naubasta boulders and sand brought down by floods could further damage the gabion diversion weir 4) Pumps could be damaged by sediment entering pumping sump

THREAT	PRINCIPAL ASSETS	IMPACTS WITHIN IRRIGATION SYSTEMS	WHY IT IS VULNERABLE
Ground Water Table Rise	Tube wells (Chisapani Deep Tubewell No3 and Binau Shallow Tubewell Cluster)	Pumping heads will be reduced in the post monsoon period and potentially there will be more water available for irrigating winter crops	1) Water table is predicted to rise during the post monsoon period by up to 0.2m 2) There will be no increase in water table prior to the start of the monsoon so water availability at that period will remain the same
Storms	Command Area (All systems)	For all systems increased high intensity rainfall events coupled with hail stones and high winds will potentially damage crops within the command areas.	1) There will be some 7% increase in 1:100 year rainfall intensity over a 10min period 2) Storms expected to increase during monsoon period only 3) Being flatter land in the terai fields should absorb the increased rainfall, though drainage systems may become temporarily inundated due to the low gradients
Drought	Command Area (All systems)	The reduction in rainfall events during the early winter period may create a temporary higher irrigation water demand for wheat and vegetable crops even though the rainfall amounts overall remain the same.	1) Rainfall amounts will remain the same throughout the winter period though there will be a slight decrease in the number of rainfall events in November/December 2) The rest of the year there will be no increase in drought threats 3) Reduced rainfall events in winter period creates a temporary higher water demand for irrigated crops which may affect yields
Landslide	Main Canal System (Chisapani Naubasta irrigation system only)	Landslide could block the main canal at Chisapani Naubasts only as all other systems are in the flat terai areas	1) The increase in high intensity storms during the monsoon season will increase the risk of landslide events 2) This of particular concern where the main canal passes along the toe of some sand hills.

4.3 Lessons and Application to Other Assets

Banke 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 the different types of assets. Assets of the system have already suffered past damage due to an extreme events such as a flood, landslide and droughts.

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 climate change 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 technical support to combat climate change related threats and events. The problems associated with the operation and maintenance of the systems 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 Banke Climate Change Impacts

Banke total catchment area is 7,297 km^2 of which the district area covers only 1,837 km^2 (total district area is larger). Consequently the climate change impacts for the main district Rapti River are dominated by the upper catchment changes.

According to the PRECIS climate projections the mean daily maximum temperature is expected to rise about 2 °C and annual maximum temperature 3 – 3.5 °C. Minimum temperatures are expected to rise 2 – 2.5 °C on the average. Consequently there is slight expected rise in potential evapotranspiration of 0.2 – 0.7 mm/d depending on the month and location.

Wet season average precipitation changes are largest, about 10%, in the North-Western mountain area. Annual maximum precipitation changes are minor. Also expected 50 year precipitation event change is small, less than 5%. Dry season average precipitation changes are small in absolute terms, from -3 mm/d to +3 mm/d depending on the location.

Maximum pluvial (rainfed) flooding is expected to increase in the central area of the district about 40% but in absolute terms the change is small, about 5 cm.

Average erosion is expected to increase 20 %.

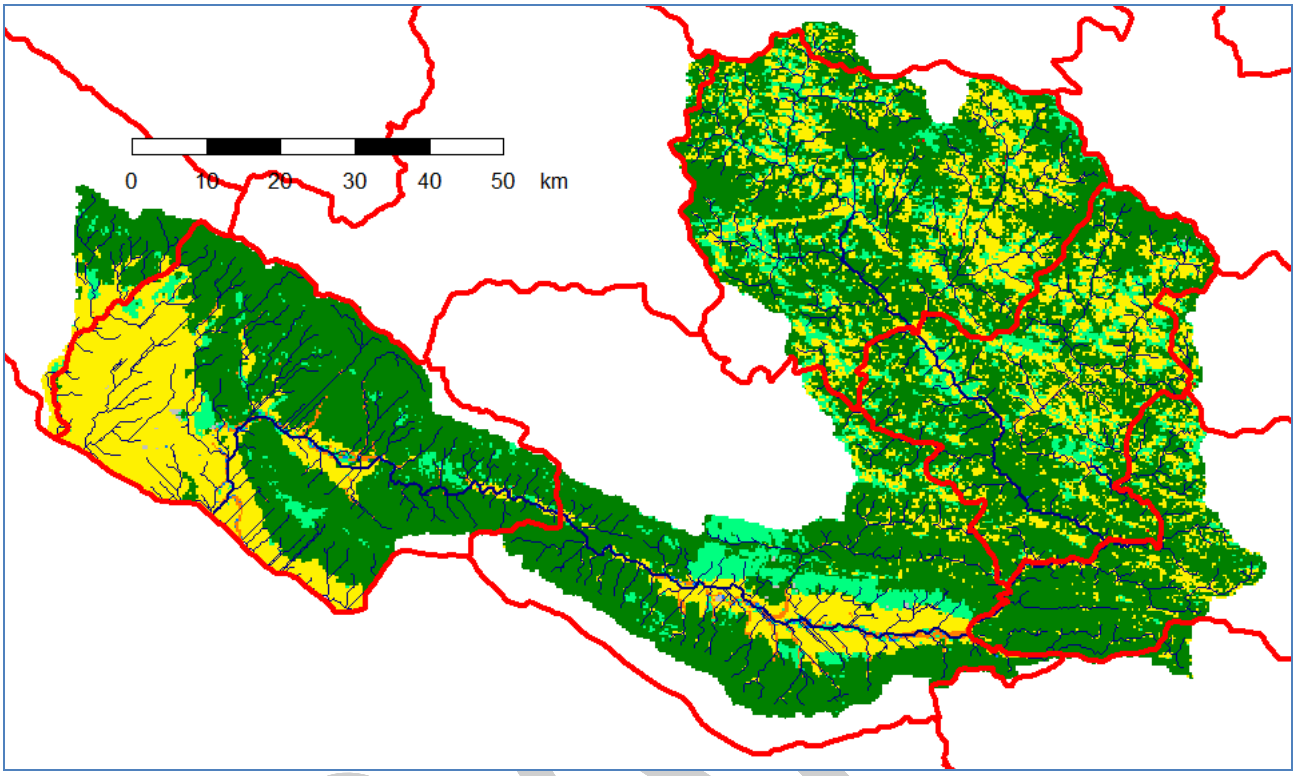
Rapti River Kusum station design floods are expected to decrease as well as dependable flow in some months, most clearly in May and November. November dependable flow decrease is reflected also by very large increase of flow variability/ standard deviation. Monthly average discharges either decrease or increase slightly depending on the month. In the more local stations at Dhakeri and Masurikhet flow changes are small except average July flow is expected to increase by 40%.

Largest TSS (Total Suspended Solids) concentration changes are in the Kusum station.

2 Banke Model Overview

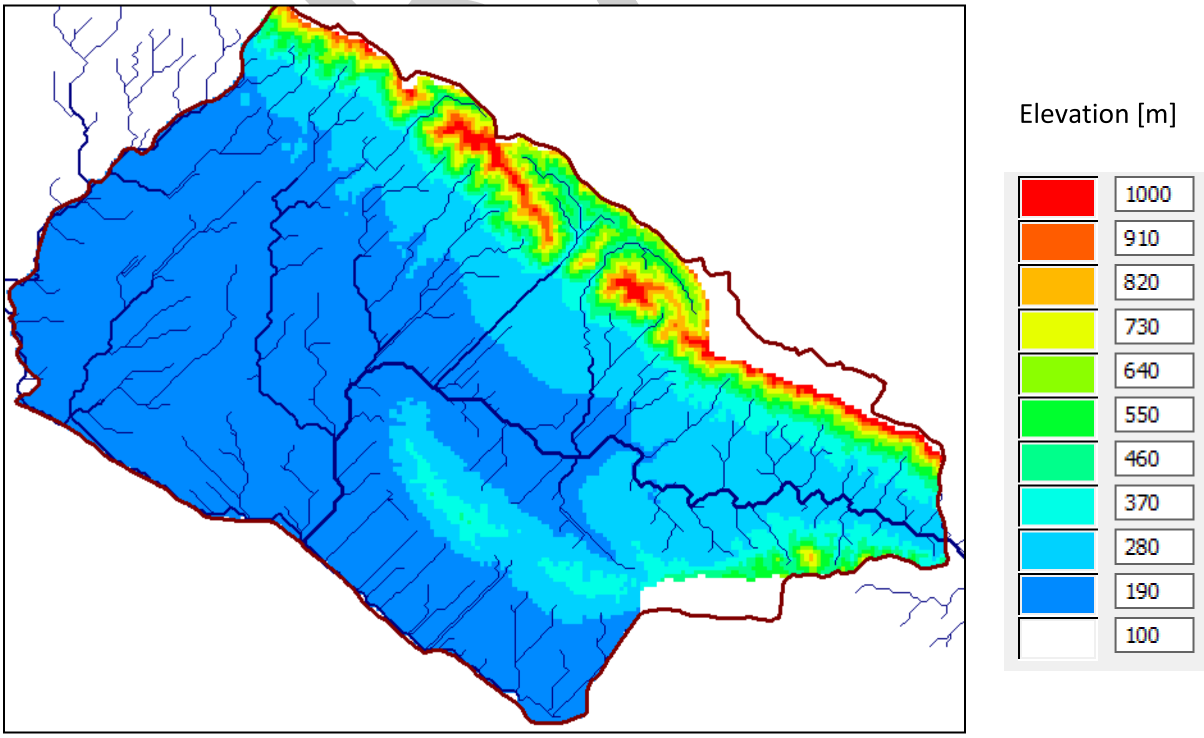
Banke model area corresponding to the Banke district watershed is shown in Figure 1. Banke model grid resolution is 300 m.

Figure 1. Banke Watershed Model Area.



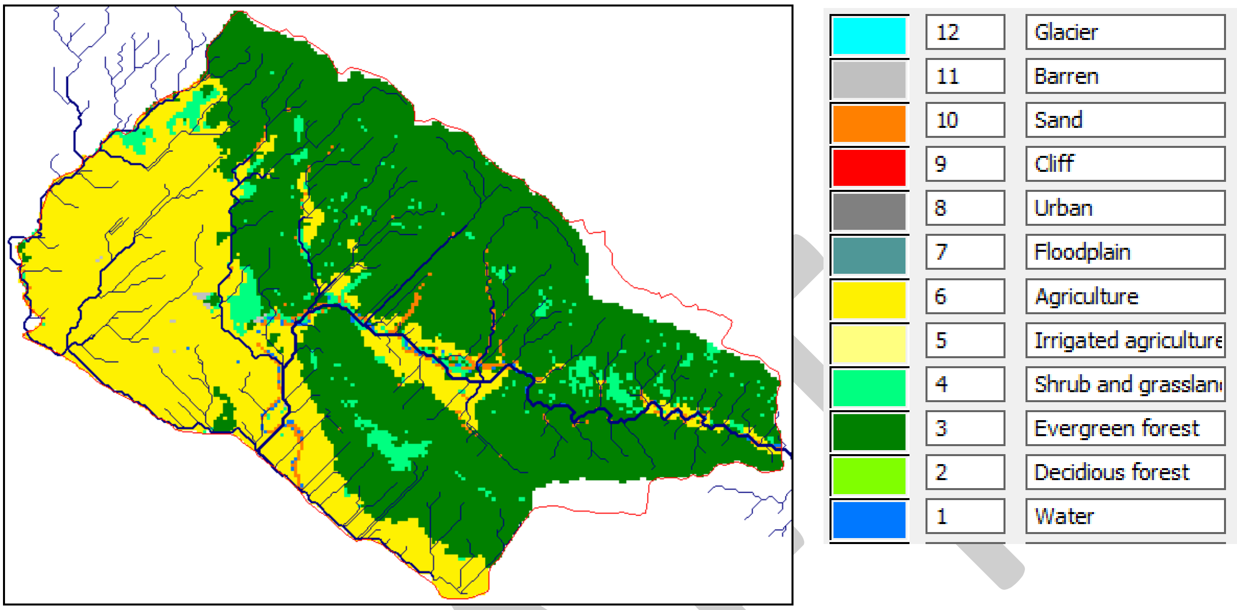
Banke district grid elevations reach from 130 m to 1000 m:

Figure 2. Model Grid Elevations for the Banke District.



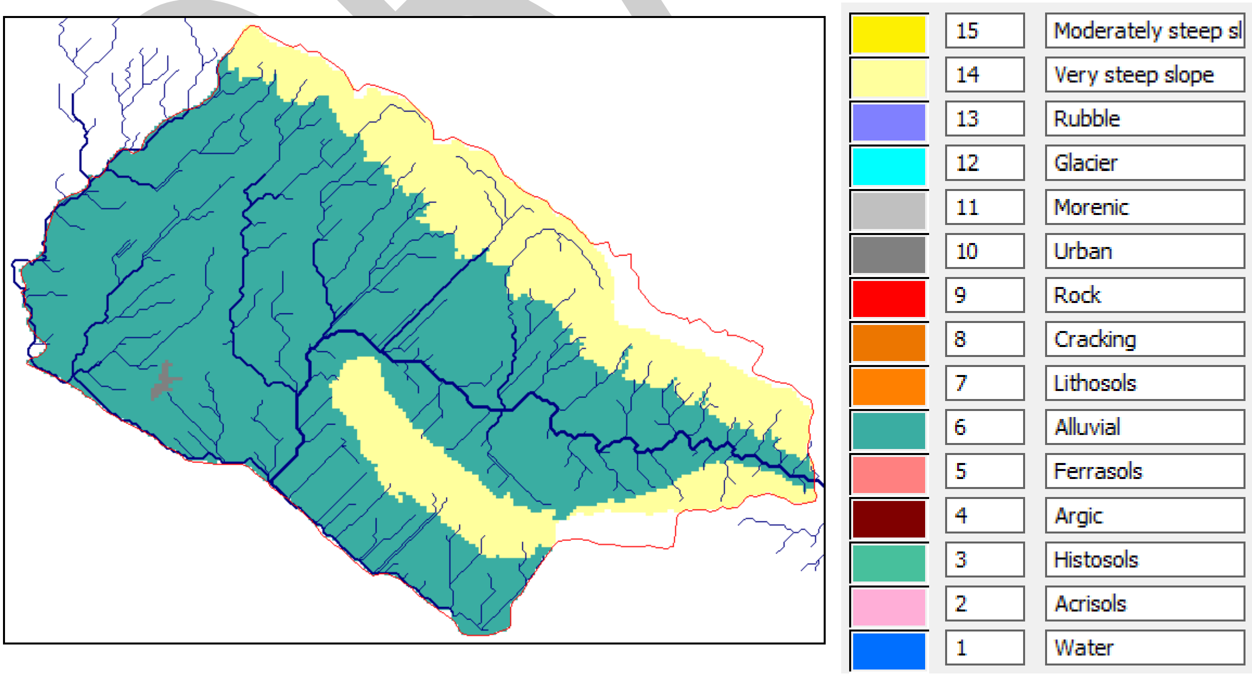
The land use is dominated by forest and agriculture:

Figure 3. Model Grid Land Use Classes for the Banke District.



Alluvial soils are the dominant model grid soil class in the Banke district (Figure 3). Also very steep slopes in the Churia mountain foothills have significant presence in the district although it is not strictly speaking a soil class.

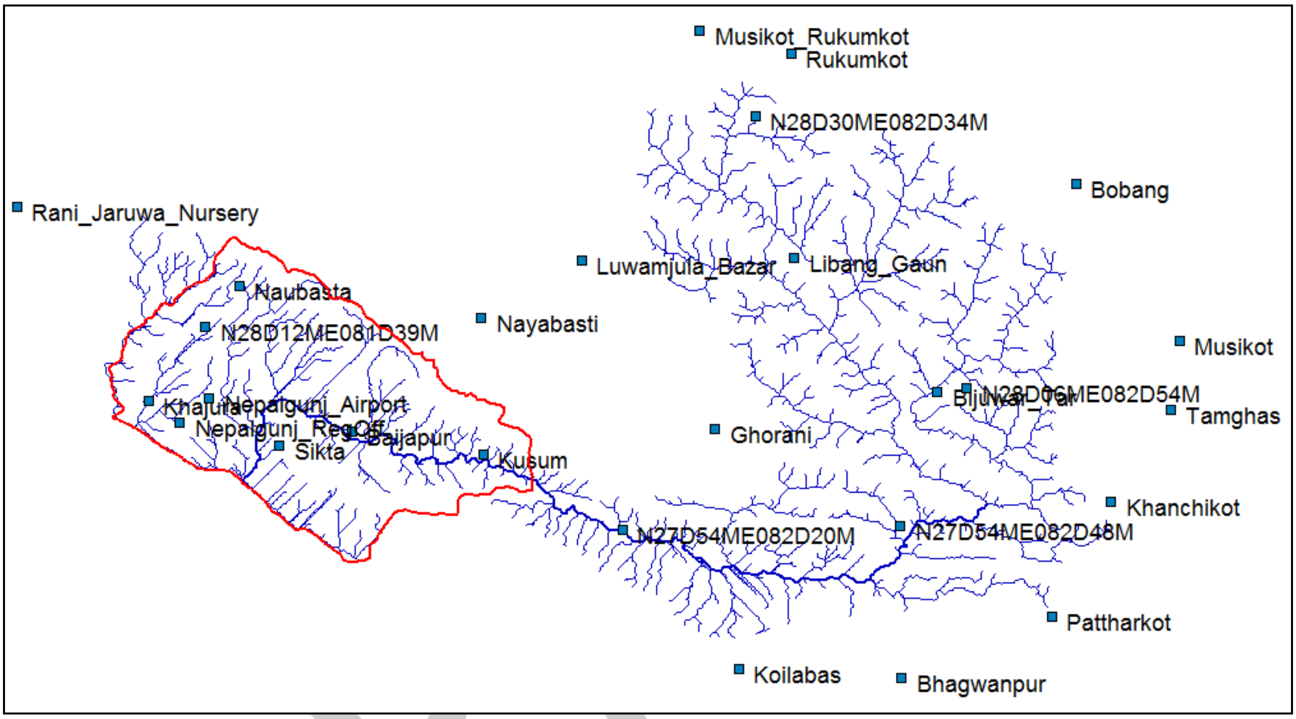
Figure 4. Model Grid Soil Classes for the Banke District.



Banke model meteorological stations are presented in Figure 4. Because temperature monitoring time series were not available re-analysis data was used instead for temperature.

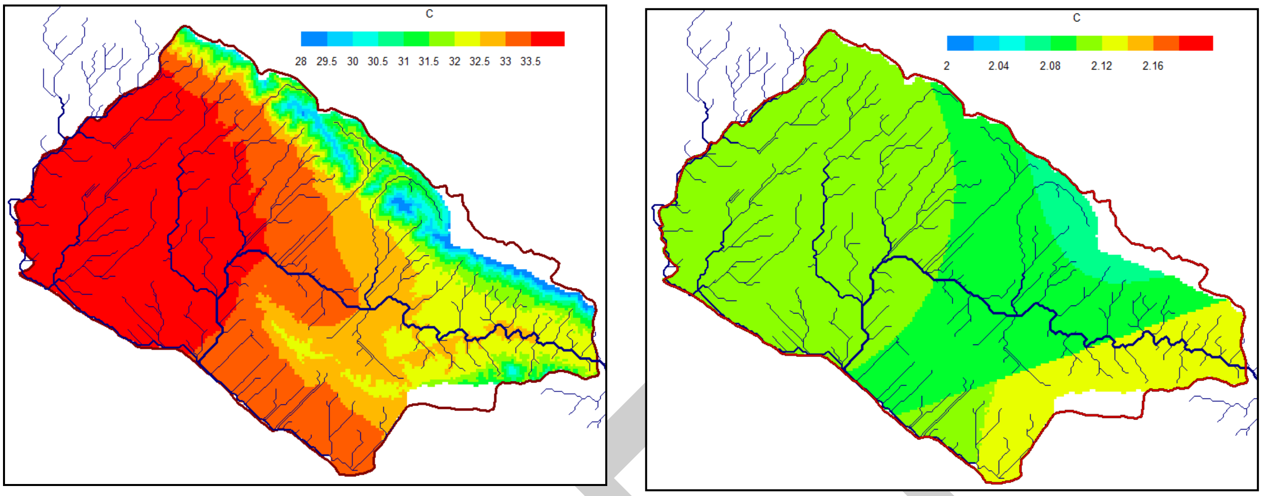
Figure 5. Model Meteorological Stations.

“N2…”-stations are temperatures from re-analysis data, other stations are Nepal national precipitation monitoring stations.

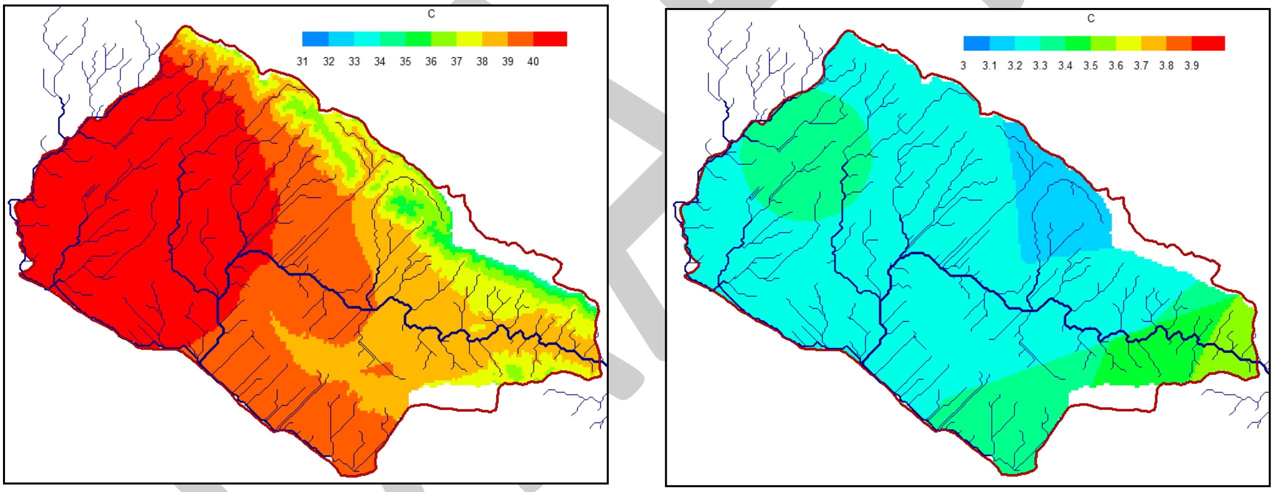


3 Maps for hotspot identification and impact overview

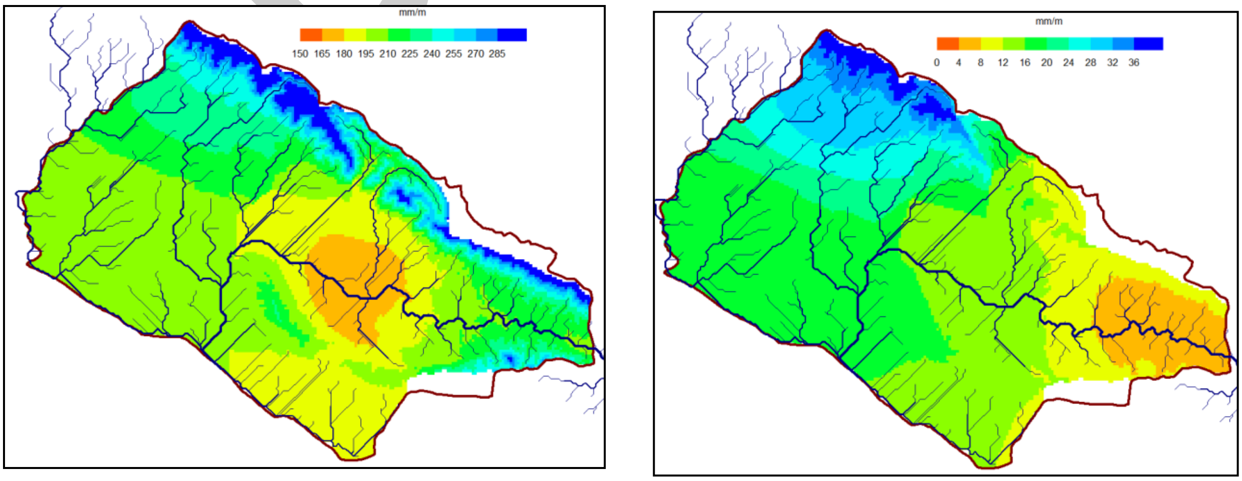
Wet season mean daily maximum temperature [°C] and change in 2050.



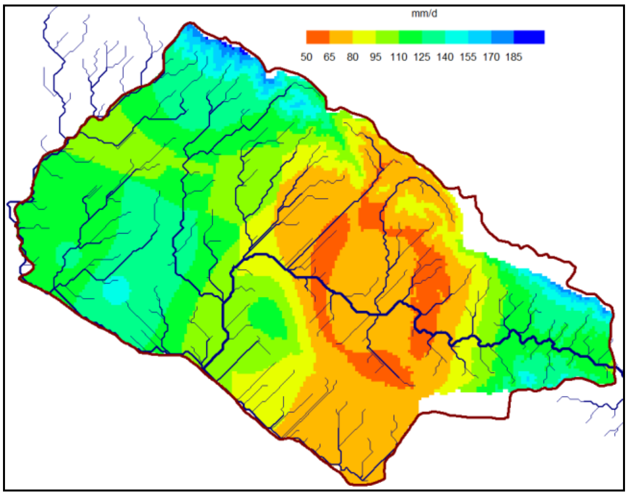
Wet season mean annual maximum temperature [°C] and change in 2050.

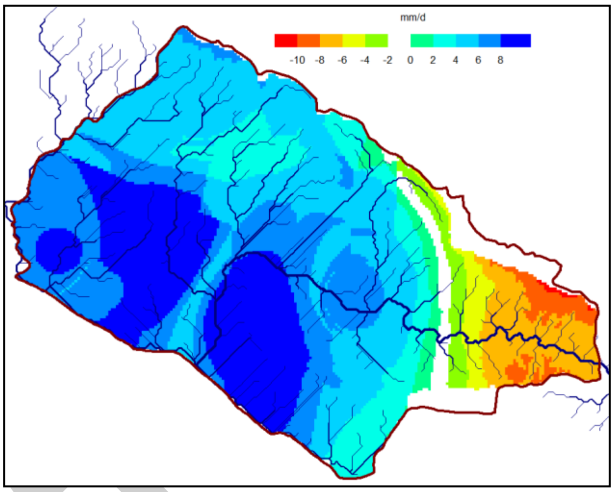


Wet season mean monthly precipitation [mm/m] and change in 2050.

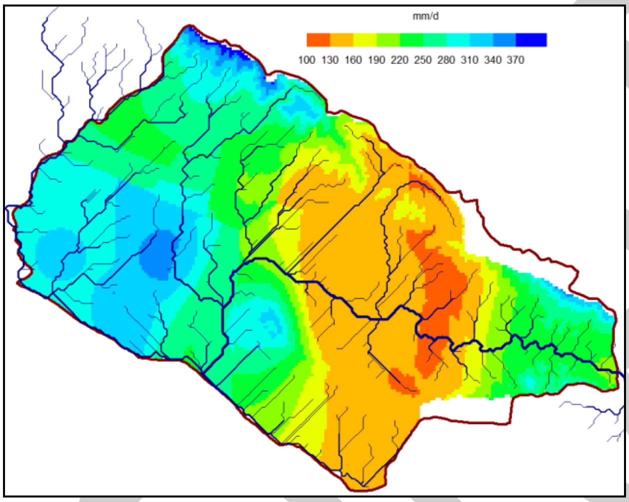


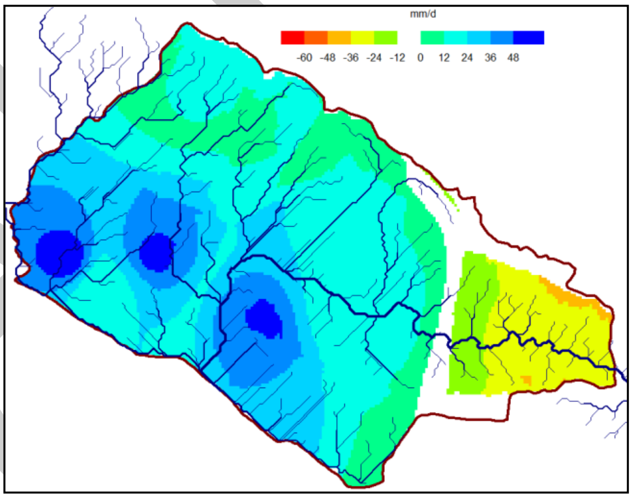
Wet season mean annual maximum precipitation [mm/d] and change in 2050.



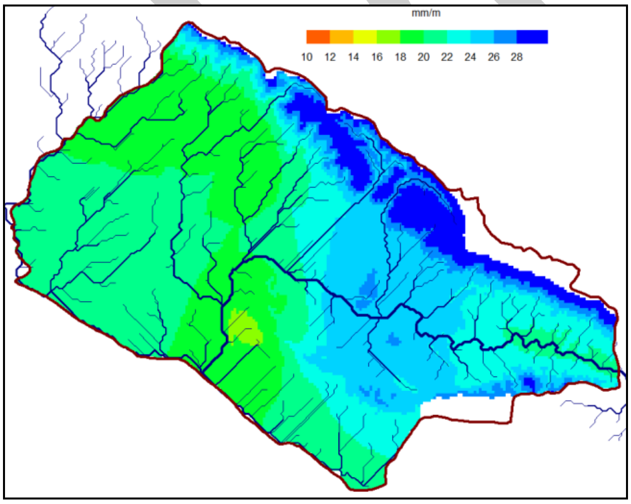


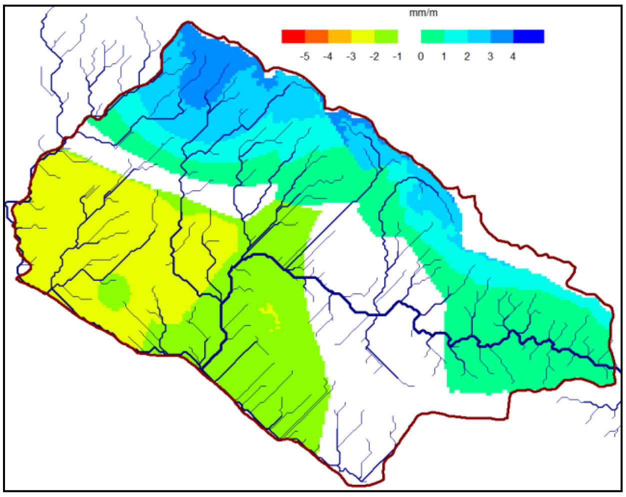
50 year precipitation event [mm/d] and change in 2050.



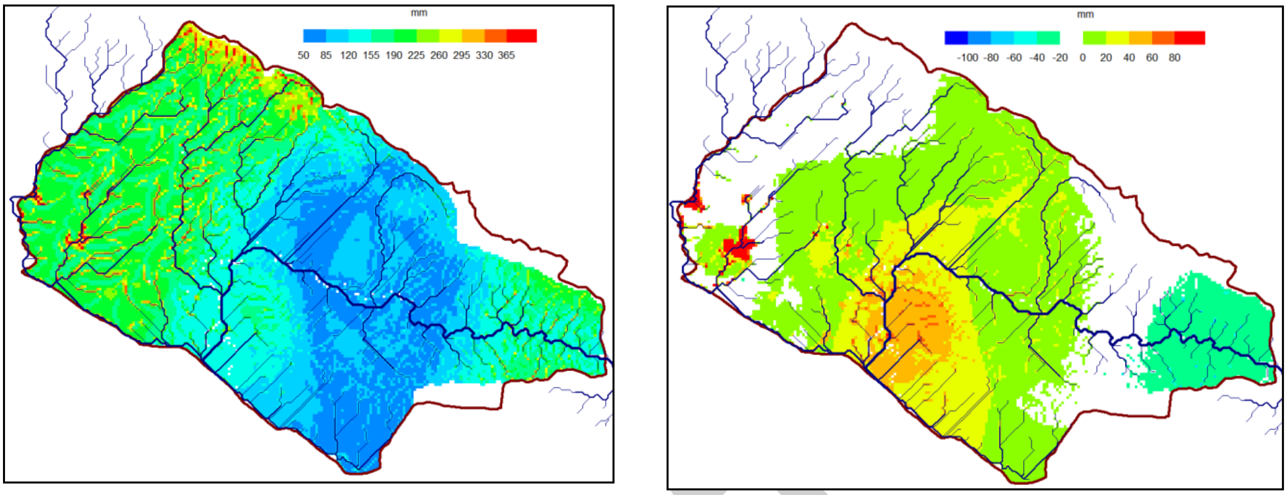


Dry season mean monthly precipitation [mm/m] and change in 2050.

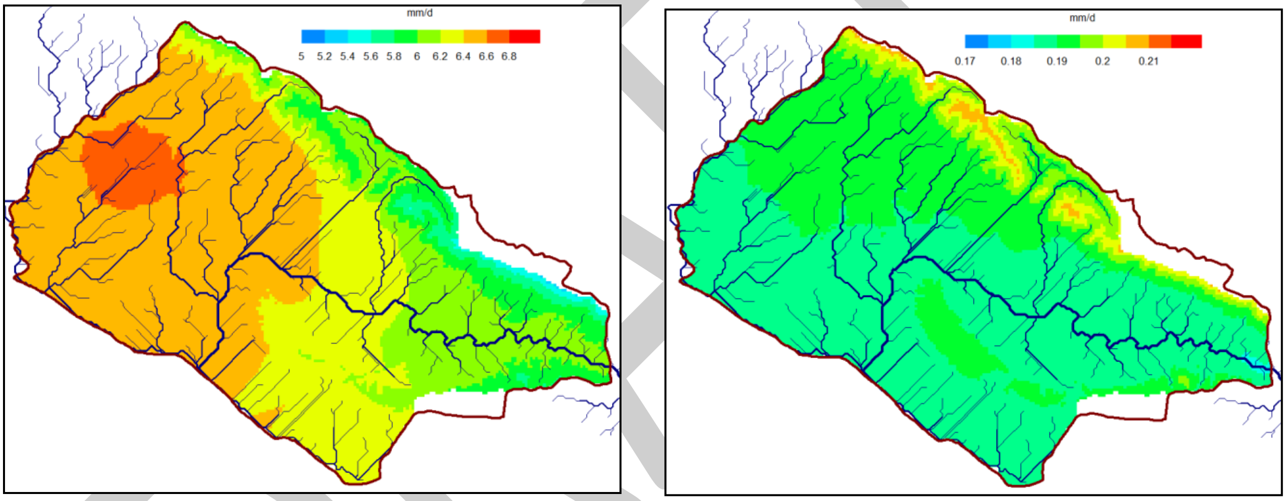




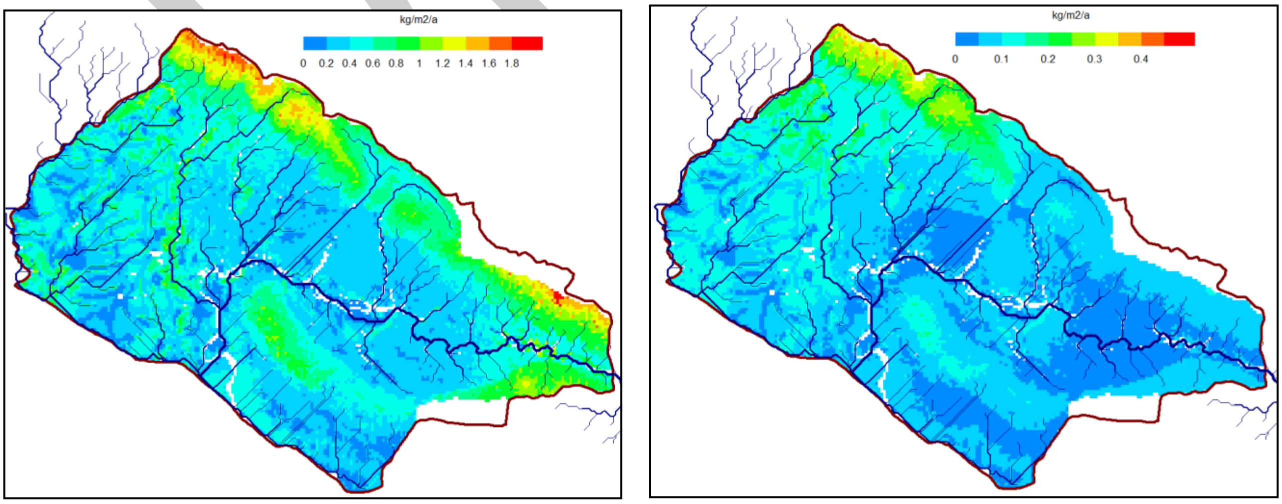
Maximum pluvial flooding [mm] and change in 2050.



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



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



4 Particular Site specific information

Figure 5 presents the model output locations for the time series. Three locations, Masurikhet, Dhakeri and Kusum, are selected for further processing and presentation in this document. The elevations for the stations are 166, 157 and 206 m. The corresponding upper catchment areas are indicated in Figure . The catchment areas are 52, 50 and 5,339 km^2.

Figure 6. Banke Model Output Locations.

Sites where the profile outputs are presented are indicated with red points

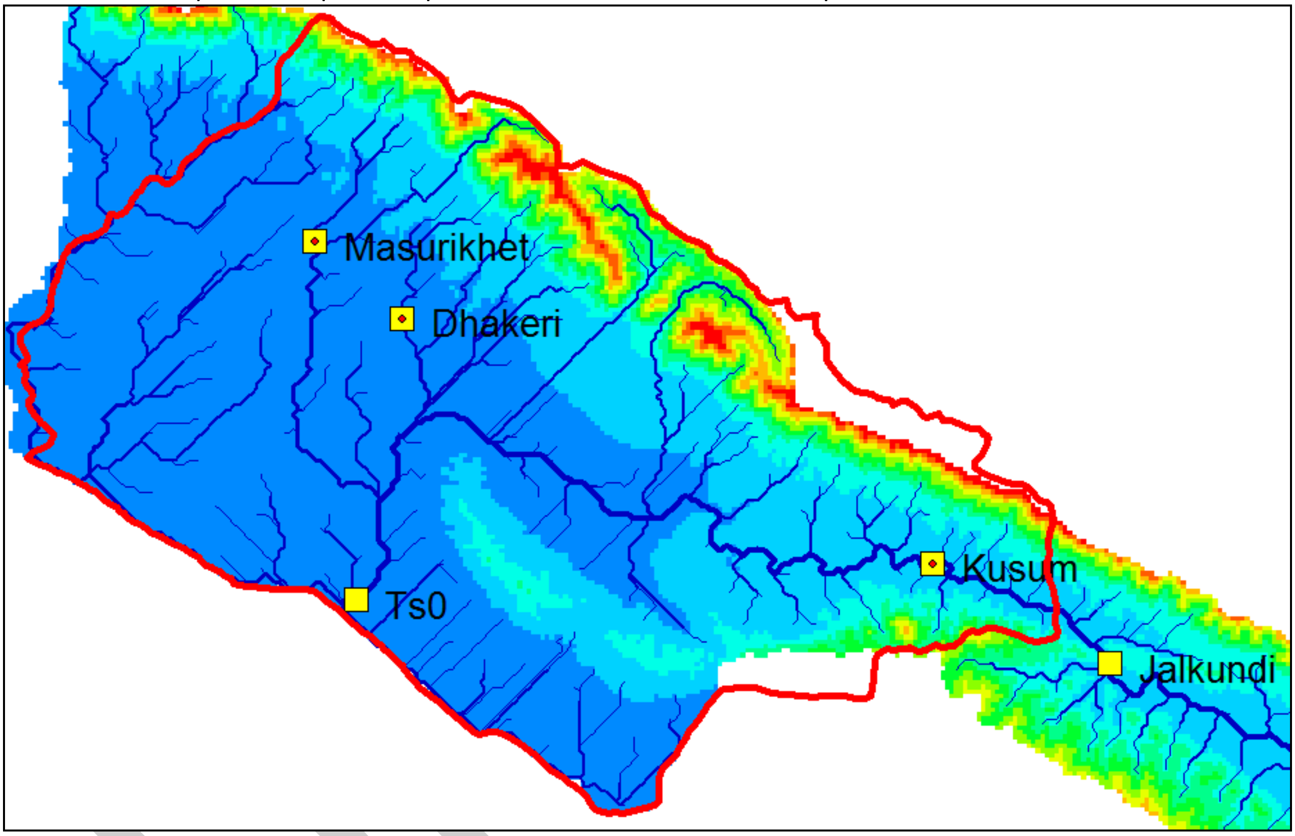
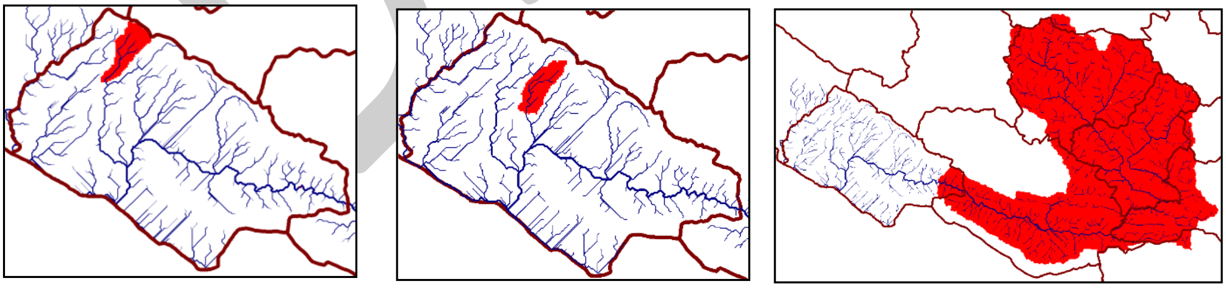


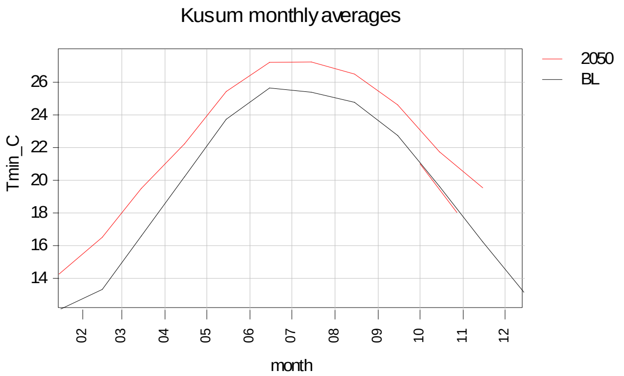
Figure 7. Upper Catchment Areas for the Masurikhet, Dhakeri and Kusum output locations.

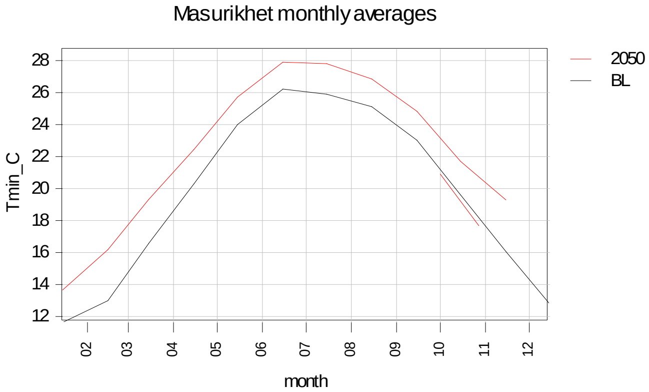


The Climate threat profile information for the case study sites are represented by the model output locations as follows

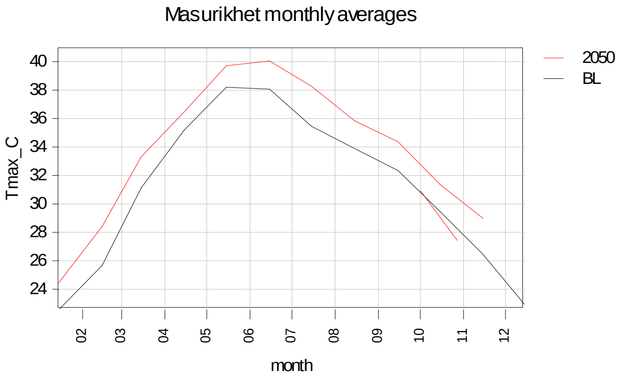
Kusum Station:	Binau Shallow Tubewell Sites:
Masuriket Station:	Chisapani Naubasta, Chisapani Deep Tubewell No 3
Dhakeri Station:	Kiran Nala

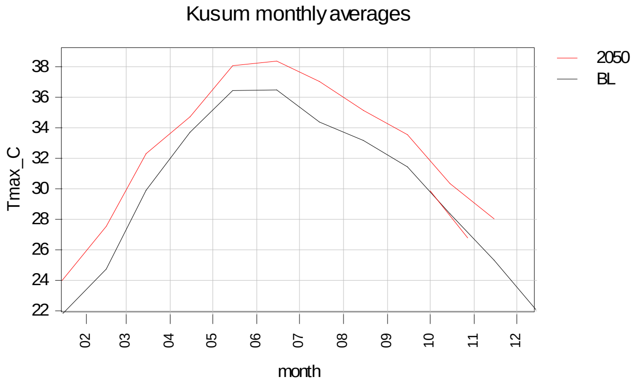
Minimum Temperature (°c)



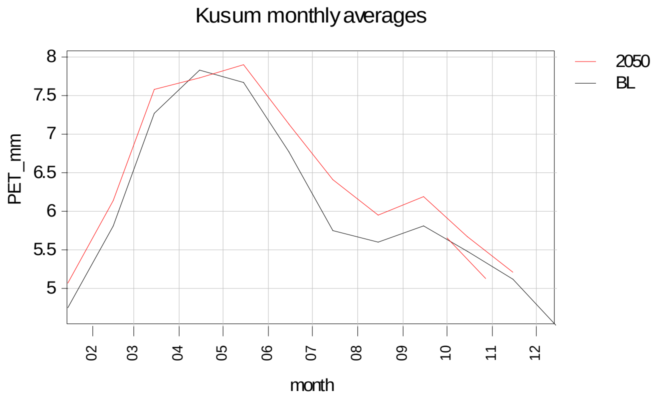


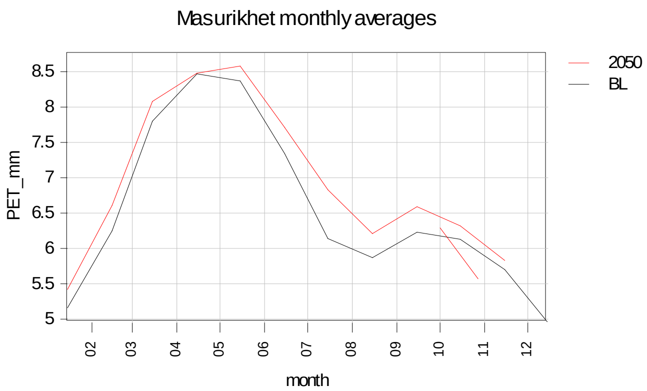
Maximum Temperature (°c)



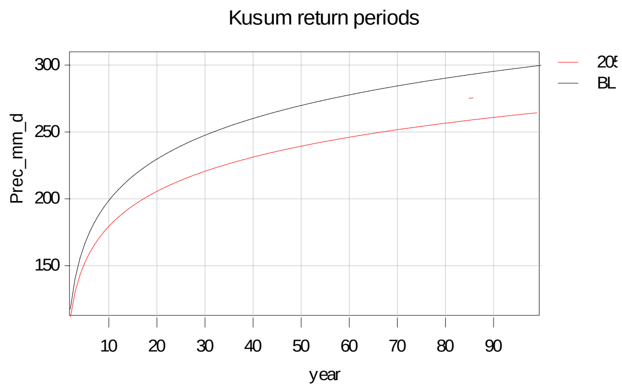


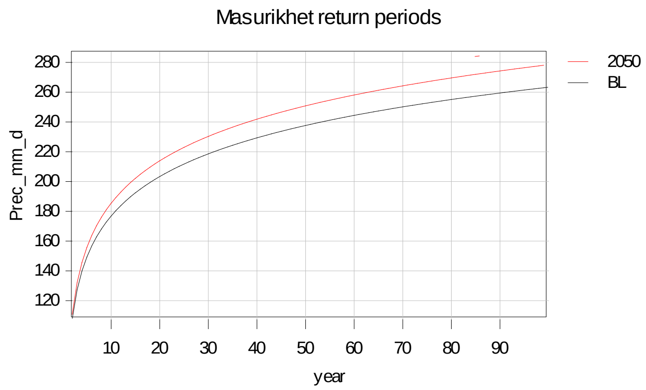
Potential Evapotranspiration (mm/day)

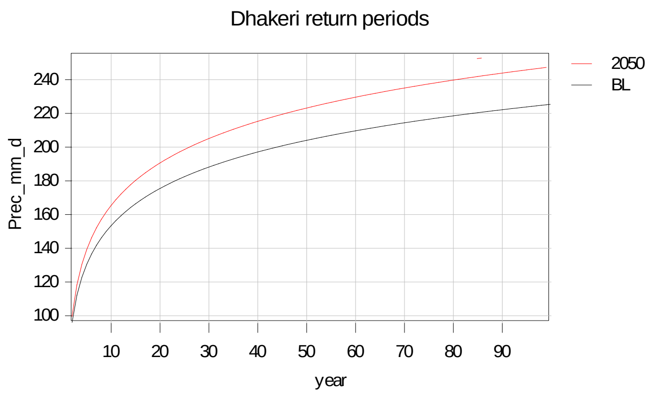




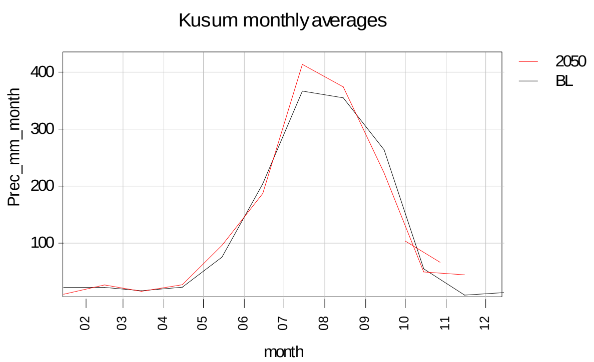
Precipitation Return Periods (mm/day)

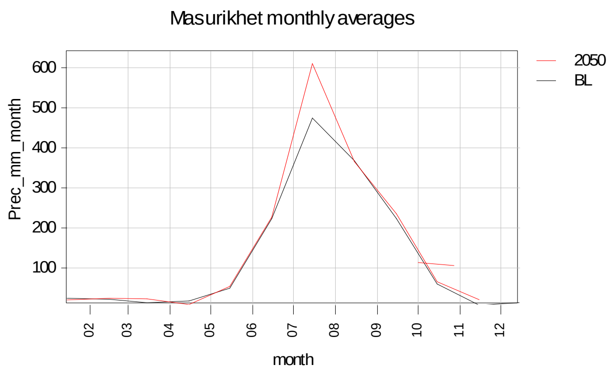


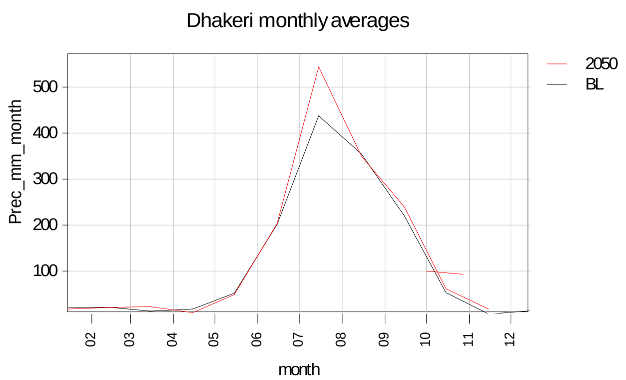




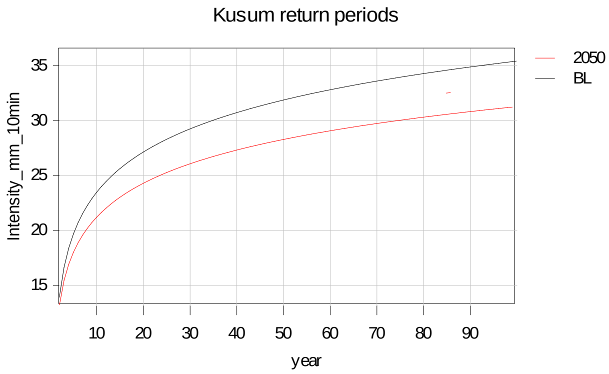
Precipitation (mm/month)

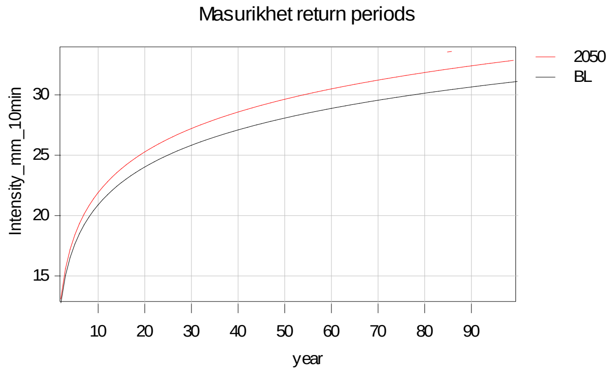


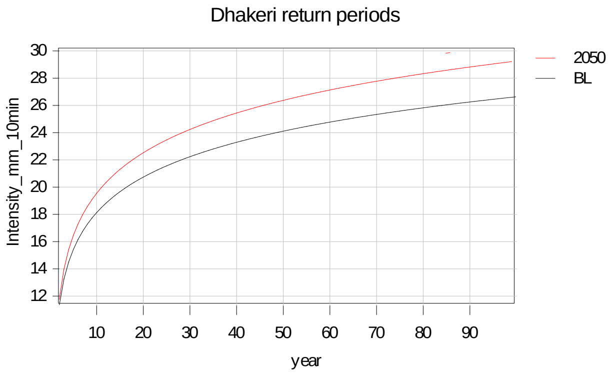




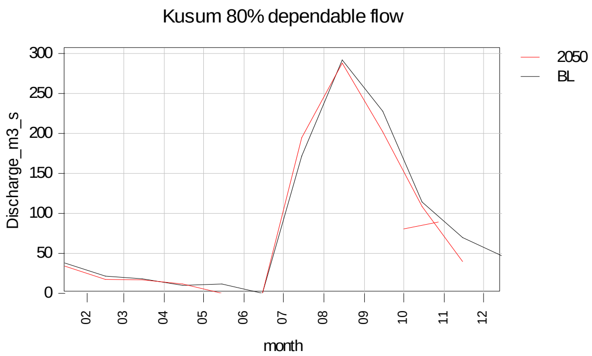
Rainfall Intensity Return Periods (mm/10min)

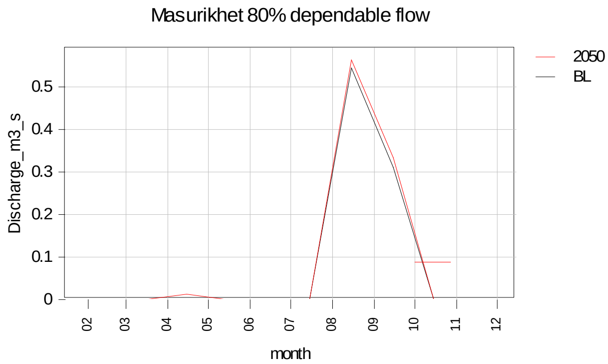


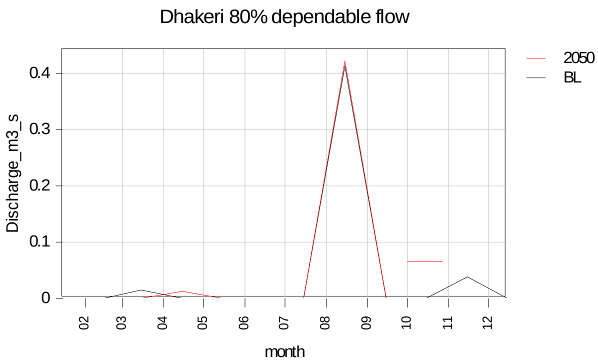




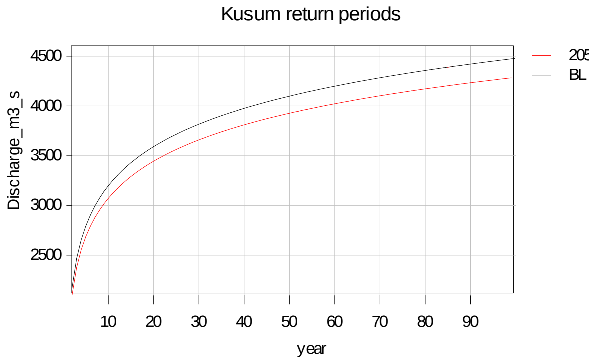
80% Dependable River Discharge (m^3/sec)

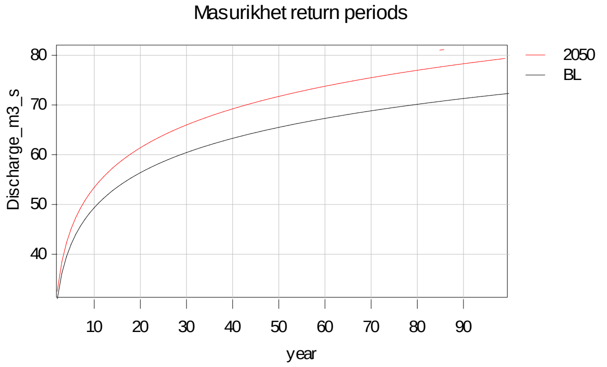


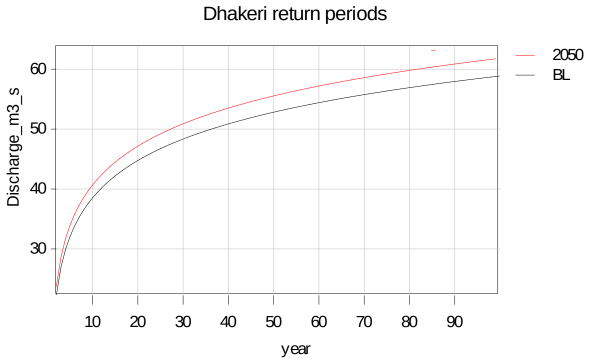




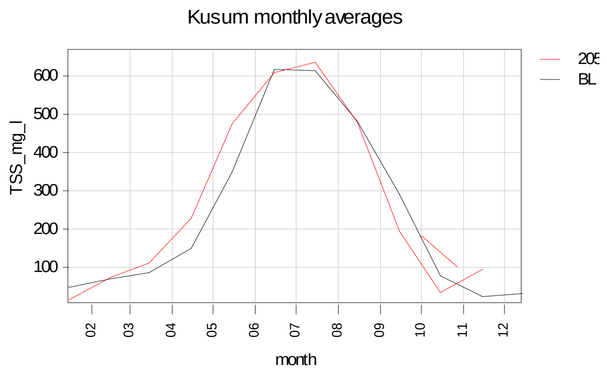
River Flows (m^3/sec)

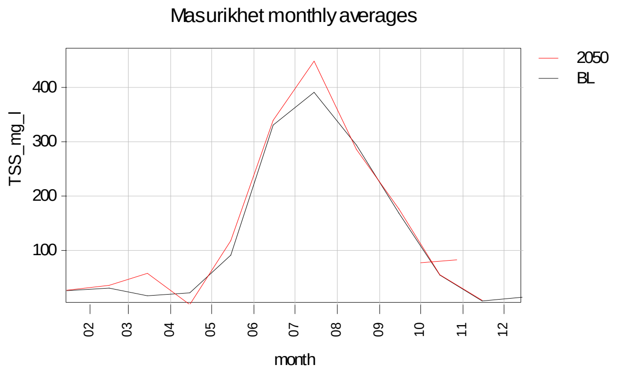


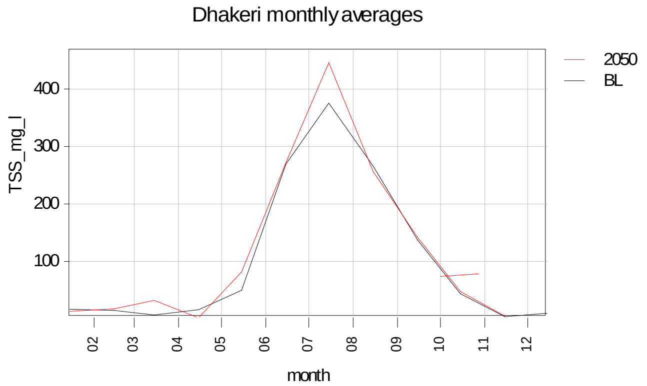




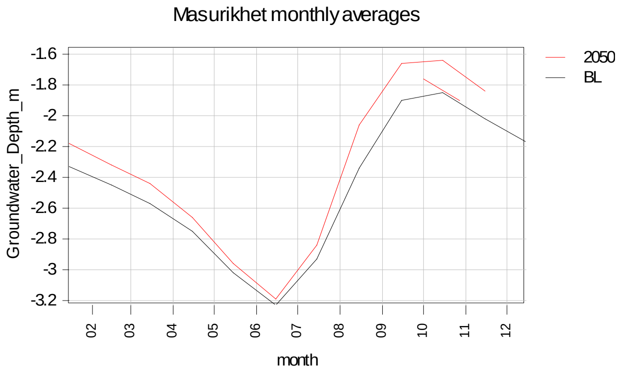
Total Suspended Solids in Rivers (mg/litre)

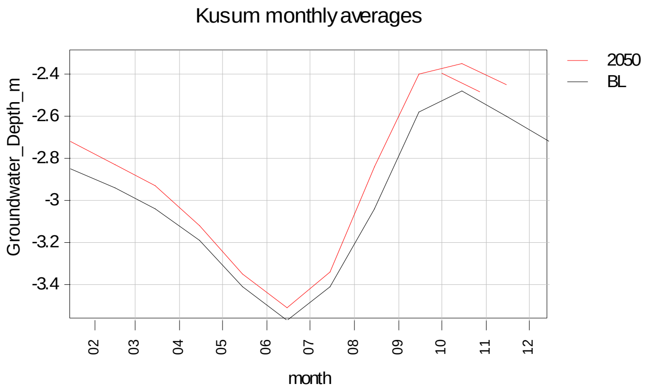


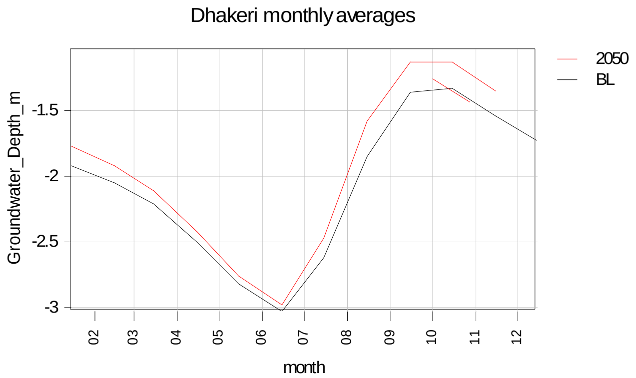




Ground Water Depth (m)







ANNEX B: VULNERABILITY ASSESMENT MATRICES

B.1 Chisapani Naibasta Irrigation Project

Asset – Chisapani Naubasta Irrigation scheme with 306 ha command area. Major elements are:

- **3m deep concrete core wall and downstream cutoff wall both 67m long across Man Khola form diversion weir,**
- **Gated scour sluice in front of single gated headwork structure. No sediment basin in main canal**
- **Lined main canal with capacity of 300l/sec for 770m thereafter 1.5km of idle unlined canal to command area**
- **1 hume pipe road crossing and 3 aqueducts**

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]L	L	L	• Could reduce water demand from Man Khola during the monsoon period	H	L
Increased River Flow (intake)	▪ Most significant increase during monsoon period	[5]M	H	M	• Irrigation water not able to enter main canal • Increased flows could further damage diversion weir and intake structure	VL[6]	H

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

[2] Average monthly ETo increases by 1mm 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 only sub-surface flows trapped by the core wall are available.

[6] Diversion weir at present has partially collapsed preventing water from the Man Khola entering the headworks

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 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
Storms	▪ Increased rainfall intensity over cropped area	H	[10]M	H	• Crops could be damaged and difficult to harvest • Level terraces will absorb increased rainfall	M	H
Drought	▪ Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops	[11]M	M	M	▪ Could affect yields for wheat, pulses and potato crops ▪ Alternative cropping pattern could be introduced	[12]M	M
Landslide	▪ Where main canal passes near sand hills	M	L	M	▪ Blockage of the canal will prevent irrigation of the command area	M	M

Linkages with other sectors

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

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[7] 100 year return period flood could increase in size by up to 50% Rainfall intensity will increase by 20%. Catchment area in the Churia mountains being mostly forested area but steep and liable to landslides

[8] Weir design requires better protection from larger boulders or stronger gabion baskets for the Khola bed downstream of the core wall

[9] Very expensive to rectify damage to diversion weir and beyond farmers' capability. Maybe a redesign required. Sediments collected in main canal can be manually shifted

[10] Wind and hail storm damage to winter wheat and vegetable crops the most significant

[11] Rainfall predicted to decrease from November to March.

[12] Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops

Chisapani Naubasta Irrigation vulnerability assessment summary

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
1. Increased Temperature (Command Area)	M	L	M	M	M
2. Increased Rainfall (Command Area)	L	L	L	H	L
3. Increased River Flows (Intake Structure)	M	H	M	VL	H
4. Flash Floods (Intake Structure}	H	VH	VH	L	VH
5. Storms (Command Area)	H	M	H	M	H
6. Drought (Command Area)	M	M	M	M	M
7. Landslides (Conveyance Structures)	M	L	M	M	M

Comment on VA methods

The poor condition of the diversion weir and intake shows its vulnerability to future increased flows and flooding in the Man Khola.

A.2. Chisapani Deep Tube Well No. 3

Asset – Chisapani No 3 Deep Tubewell Irrigation scheme with 40 ha command area. Major elements are:

- **160m deep boring steel cased with screen and submersible pump delivering discharges of up to 35l/sec**
- **30m^3 concrete storage tank above pump house containing electrical controls,**
- **Buried distribution pipes deliver irrigation water to outlet chambers containing alfalfa valves at 100m intervals,**
- **Distribution system incorporates an air safety valve outlet,**
- **Unlined canals from the outlet chambers deliver water to the fields**

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 ▪ No impact on infrastructure	[4] L	L	L	• Could reduce the pumped water demand at land preparation stage and during the monsoon period	H	L
Water Table Depth Rise	▪ Easier access to groundwater table	[5] L	[6] L	L	• More irrigation water for crop production • Less pumping head required	[7] H	L

[1] Average monthly maximum temperature increase by 2^{o}C throughout the year
[2] Average monthly ETo increases by 1mm 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] Groundwater table depths are likely to rise by some 10% at the end of the monsoon period in August and September
[6] Reduces pumping power requirement and opportunities for greater groundwater yields. Possibilities for expanding irrigation area and more cash crop production
[7] Pumping costs reduced and possibilities for further aquifer development

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Storms	▪ Increased rainfall intensity over cropped area	[8]H	[9]M	H	• Crops could be damaged and difficult to harvest • Level terraces will absorb increased rainfall	M	H
Drought	▪ Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops	[10]M	M	M	▪ Could affect yields for wheat, pulses and potato crops ▪ Alternative cropping pattern could be introduced ▪ More pumping of water required increasing costs	[11][12]M	M

Linkages with other sectors

- Nepal Electricity Authority provides the electricity to power the pumps. Unreliable supply affects pump operation
- DADO not active in the area to provide farmers with extension services

Chisapani No 3 Deep Tubewell Irrigation vulnerability assessment summary

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
1. Increased Temperature (Command Area)	M	L	M	M	M
2. Increased Rainfall (Command Area)	L	L	L	H	L
3. Water Table Levels Rise (Tubewell)	L	L	L	H	L
4. Storms (Command Area)	H	M	H	M	H
5. Drought (Command Area)	M	M	M	M	M

Comment on VA methods Command area least vulnerable to increased rainfall, at the same time being beneficial in reducing irrigation demand.

[8] Greater chance of lightning strikes hitting the transformers disturbing the electricity supply to the pump
[9] Wind and hail storm damage to winter wheat and vegetable crops the most significant
[10] Rainfall predicted to decrease from November to March. Additional pumping from groundwater should meet the additional irrigation demand
[11] Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops
[12] Active water user group and farmers willing to pay additional water costs if required

A.3. Binauna Shallow Tube Well Cluster (10*2.5 ha)

Asset – Binauna Shallow Tubewell Cluster. Each tubewell commanding 2.5 ha. Major elements of one tubewell are:

- **25m deep steel cased boring with 10m long screen and submersible pump delivering discharges up to 20l/sec,**
- **4.5 HP portable Chinese made diesel pump,**
- **6" diameter flexible plastic hosepipe to deliver irrigation water to the fields.**
- **10 No shallow tubewells make up cluster with spacing between individual wells some 500m**

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 ▪ No impact on infrastructure	[4] L	L	L	• Could reduce the pumped water demand at land preparation stage and during the monsoon period	H	L
Water Table Depths Rise	▪ Easier access to groundwater table	[5] L	[6] L	L	• More irrigation water for crop production • Less pumping head required	[7] H	L

[1] Average monthly maximum temperature increase by 2°C throughout the year
[2] Average monthly ETo increases by 1mm 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] Groundwater table depths are likely to rise by some 10% at the end of the monsoon period in August and September
[6] Reduces pumping power requirement and opportunities for greater groundwater yields. Possibilities for expanding irrigation area and more cash crop production
[7] Pumping costs reduced and possibilities for further aquifer development

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Storms	▪ Increased rainfall intensity over cropped area	H	[8]M	H	• Crops could be damaged and difficult to harvest • Level terraces will absorb increased rainfall	M	H
Drought	▪ Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops	[9]M	M	M	▪ Could affect yields for wheat, pulses and potato crops ▪ Alternative cropping pattern could be introduced ▪ More pumping of water required increasing costs	[10][11]L	M

Linkages with other sectors

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

Binauna Shallow Tubewell Irrigation Cluster vulnerability assessment summary

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
1. Increased Temperature (Command Area)	M	L	M	M	M
2. Increased Rainfall (Command Area)	L	L	L	H	L
3. Water Table Levels Rise (Tubewell)	L	L	L	H	L
4. Storms (Command Area)	H	M	H	M	H
5. Drought (Command Area)	M	M	M	L	M

Comment on VA methods Most vulnerable is the command area to storm damage of the crop

[8] Wind and hail storm damage to winter wheat and vegetable crops the most significant
[9] Rainfall predicted to decrease from November to March. Additional pumping from groundwater should meet the additional irrigation demand
[10] Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops
[11] Cheap Chinese diesel pumps are used which are unreliable and in the long run generate higher maintenance costs if extra pumping is required

A.4. Kiran Nala (Lift) Irrigation Project

Asset – Kiran Nala Irrigation scheme with 205 ha command area. Major elements are:

- **Concrete weir across Nala with scouring sluice,**
- **Gated offtake to sediment basin and pump sump,**
- **5 electric pumps within a pump station house, total capacity of 200l/sec, lift water into main canal**
- **1.3km lined main canal with 3km of unlined branch canals.**
- **4 division boxes to assist distribution of water. 3 culverts under road crossings**

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increase in Max. temperature and evapotranspiration	▪ Increased crop water demand	[36][37][38]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 ▪ No impact on infrastructure	[39]L	L	L	• Could reduce water demand from the Nala during the monsoon period	H	L
Increased River Flow (intake)	▪ Spring flows contribute to increased discharges	[40]M	M	M	• Little impact on crop production • Less pumping head required	H	M

[36] Average monthly maximum temperature increase by 2°C throughout the year

[37] Average monthly ETo increases by 1mm during January to March and July to August

[38] 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

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

[40] Average monthly river flows to increases over the period from July to Septembers. The rest of the year little change

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	[41]H	[42]L	M	• Blockage of intake, leading to temporary restriction of irrigation water • Sediment entering intake could damage pumps	[43]L	M
Storms	▪ Increased rainfall intensity over cropped area	[44]H	[45]M	H	• Crops could be damaged and difficult to harvest • Level terraces will absorb increased rainfall	M	H
Drought	▪ Reduced rainfall in winter period creates a higher water demand for wheat and vegetable crops	[46]M	M	M	▪ Could affect yields for wheat, pulses and potato crops ▪ Alternative cropping pattern could be introduced	[47]M	M

Linkages with other sectors

- Nepal Electricity Authority provides the electricity to power the pumps. Unreliable supply affects pump operation
- DADO not active in the area to provide farmers with extension services

[41] 100 year return period flood could increase in size by up to 50% Rainfall intensity will increase by 20%. Catchment area relatively flat cultivated lands

[42] Well-designed weir across Nala with scouring sluice and intake infrastructure well maintained

[43] Sediments collected in main canal can be manually shifted, but damage to pumps expensive to repair and beyond capacity of farmers

[44] Greater chance of lightning strikes hitting the transformers disturbing the electricity supply to the pumps

[45] Wind and hail storm damage to winter wheat and vegetable crops the most significant

[46] Rainfall predicted to decrease from November to March. However flows in the Nala are not significantly reduced as fed by spring flows from a quite high groundwater table

[47] Farmers are not interested in changing their cropping pattern at present to introduce higher value cash crops

Kiran Nala Irrigation vulnerability assessment summary

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
1. Increased Temperature (Command Area)	M	L	M	M	M
2. Increased Rainfall (Command Area)	L	L	L	H	L
3. Increased River Flows (Intake Structure)	M	M	M	H	M
4. Flash Floods (Intake Structure}	H	L	M	L	M
5. Storms (Command Area)	H	M	H	M	H
6. Drought (Command Area)	M	M	M	M	M

Comment on VA methods

Command area least vulnerable to increased rainfall, at the same time being beneficial in reducing irrigation demand. Most vulnerable is the command area to storm damage of the crops

Linkages with other sectors

1. Nepal Electricity Authority provides the electricity to power the pumps. Unreliable supply affects pump operation
2. DADO not active in the area to provide farmers with extension services