CLIMATE CHANGE RISK AND VULNERABILITIES

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Country area –38,394 Km2

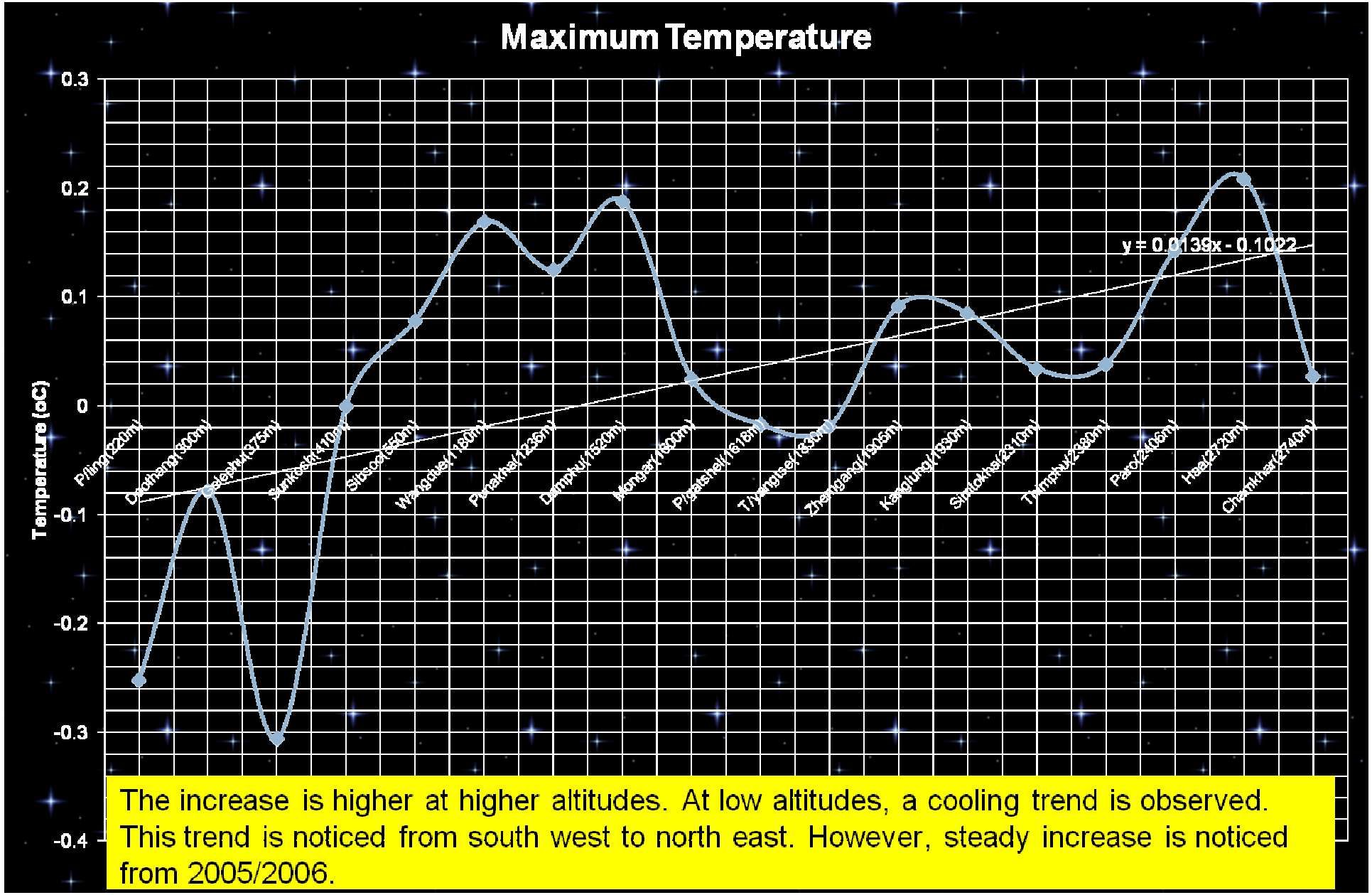
- Population –694,000 (projection for 2010
- Population density –18 persons/Km2
- Location: Bordered by Tibet Autonomous Region of China in the north, Indian state of Assam in the south and east and West Bengal in the west and east.

Country Profile

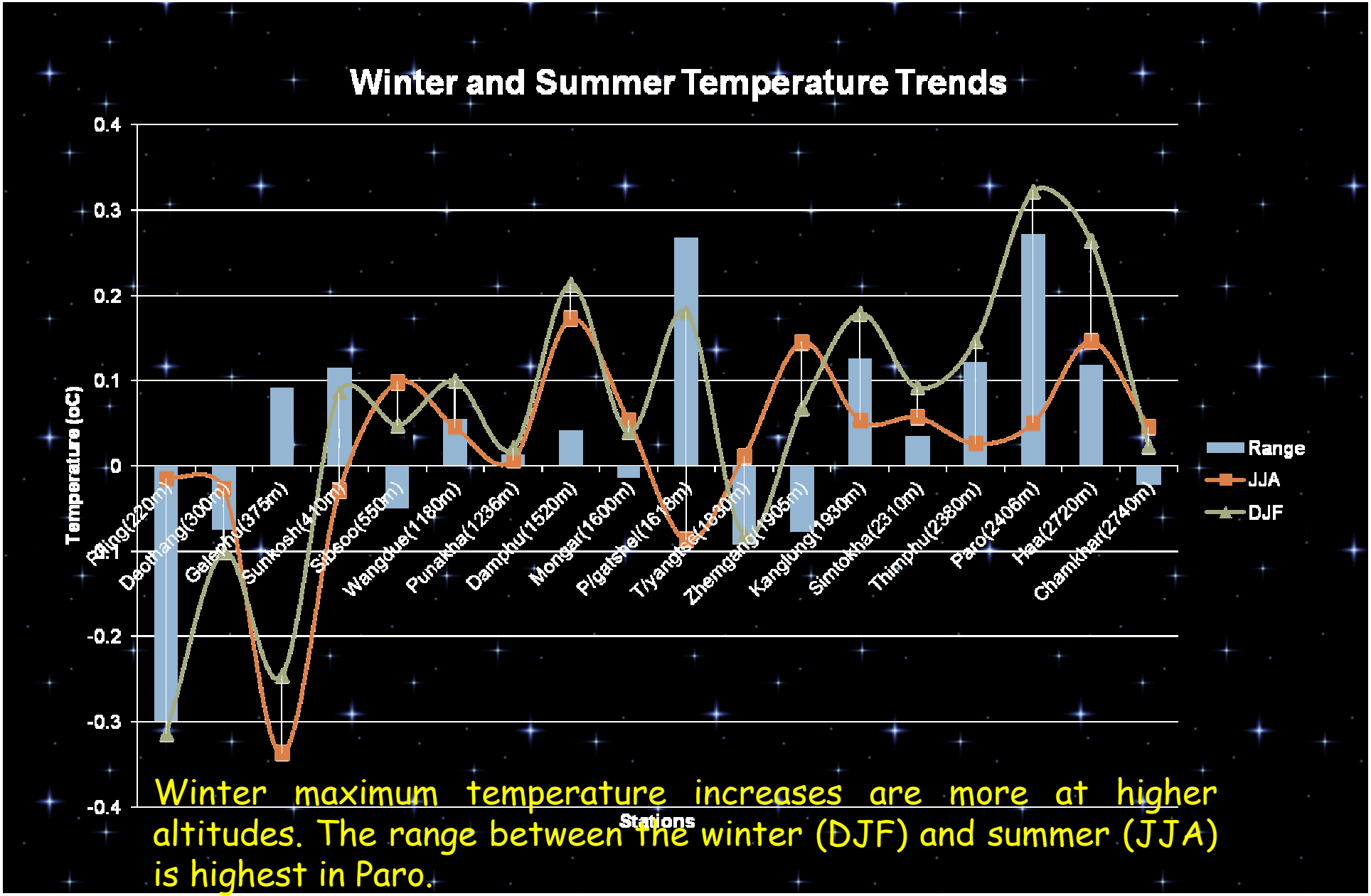
- Three broad geographic areas and corresponding climatic zones:
  - **Southern foothills**
    - Hot and humid, temperatures ranging from 15 to 30oC throughout the year and precipitation between 2,500 and 5,550 mm.
  - **Inner himalayas**
    - Rise to 3,000 m, has broad valleys, is the economic and cultural heartland. Characterised by a cool temperate climate with annual average precipitation of 1,000 mm.
  - **Higher himalayas**
    - Norternmost high mountain ranges with elevations up to 7,550 m, under perpetual snow, sparsely populated and have an alpine climate with average annual precipitation of 400 mm.

Climate Patterns & Variability

- Climate mainly determined by the the summer southwest monsoon from the Indian Ocean (late June through late September), and variations in topography and elevation.
- Monsoon accounts for 60% to 90% of the country's total precipitation.
- There are substantial disparities in temperatures and precipitations from one valley to another.
- The south-western and southern valleys are the warmest zones.
- Below freezing temperatures in the winter occur in the central, west-central and northern mountains.
- The southern valley of Bhutan receives the highest annual precipitation, while low precipitation occurs in central and northern Bhutan.
- The monsoon precipitation of Bhutan occurs more or less in opposite phase with that of India: when the monsoon is strong over Bhutan, it is weak over India and *vice-versa* (Quadir *et al.*, 2006).

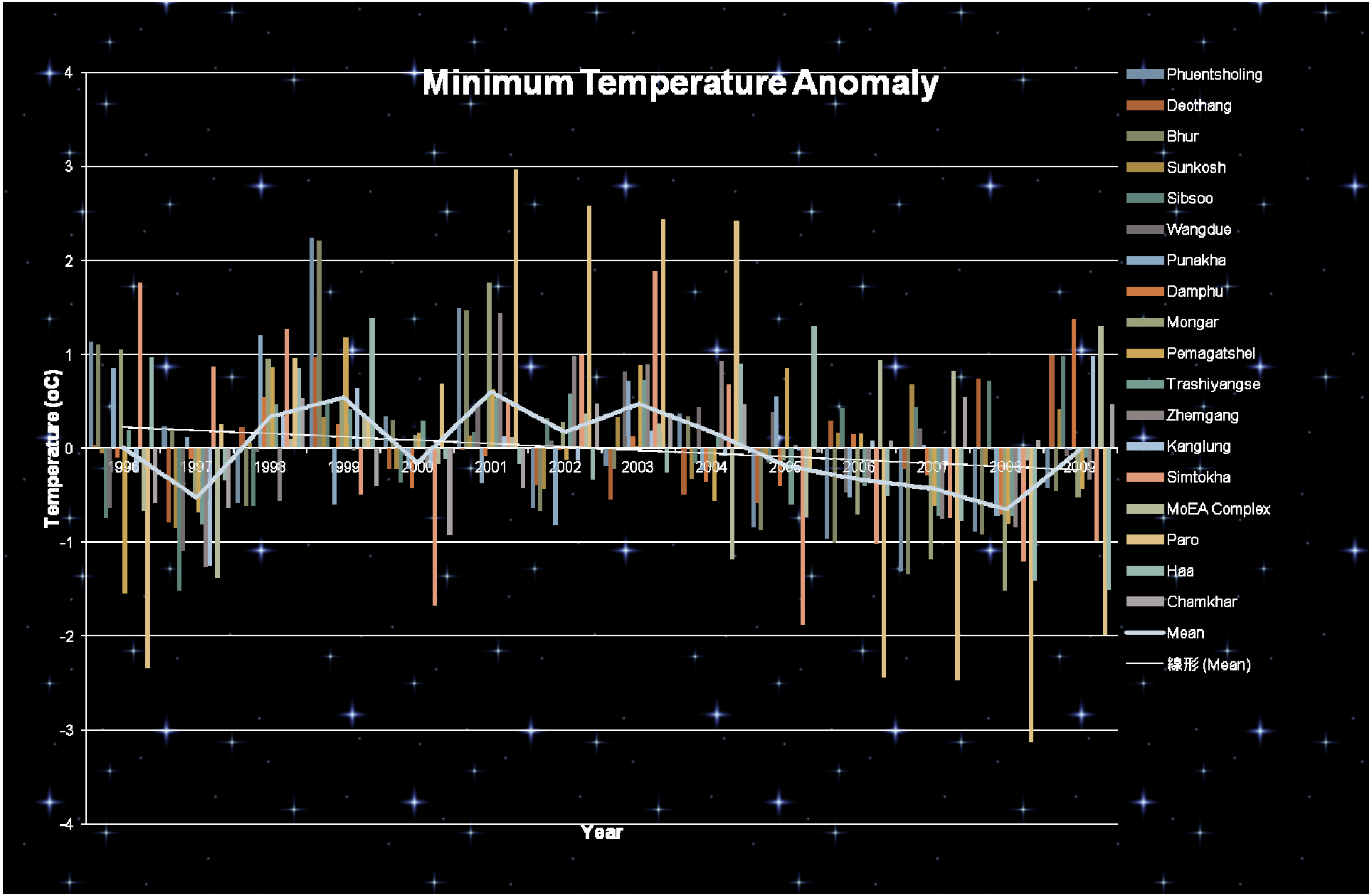


Observed Climatic Trends - Temperature



Winter maximum temperature increases are more at higher altitudes. The range between the winter (DJF) and summer (JJA) is highest in Paro.

Observed Climatic Trends - Temperature

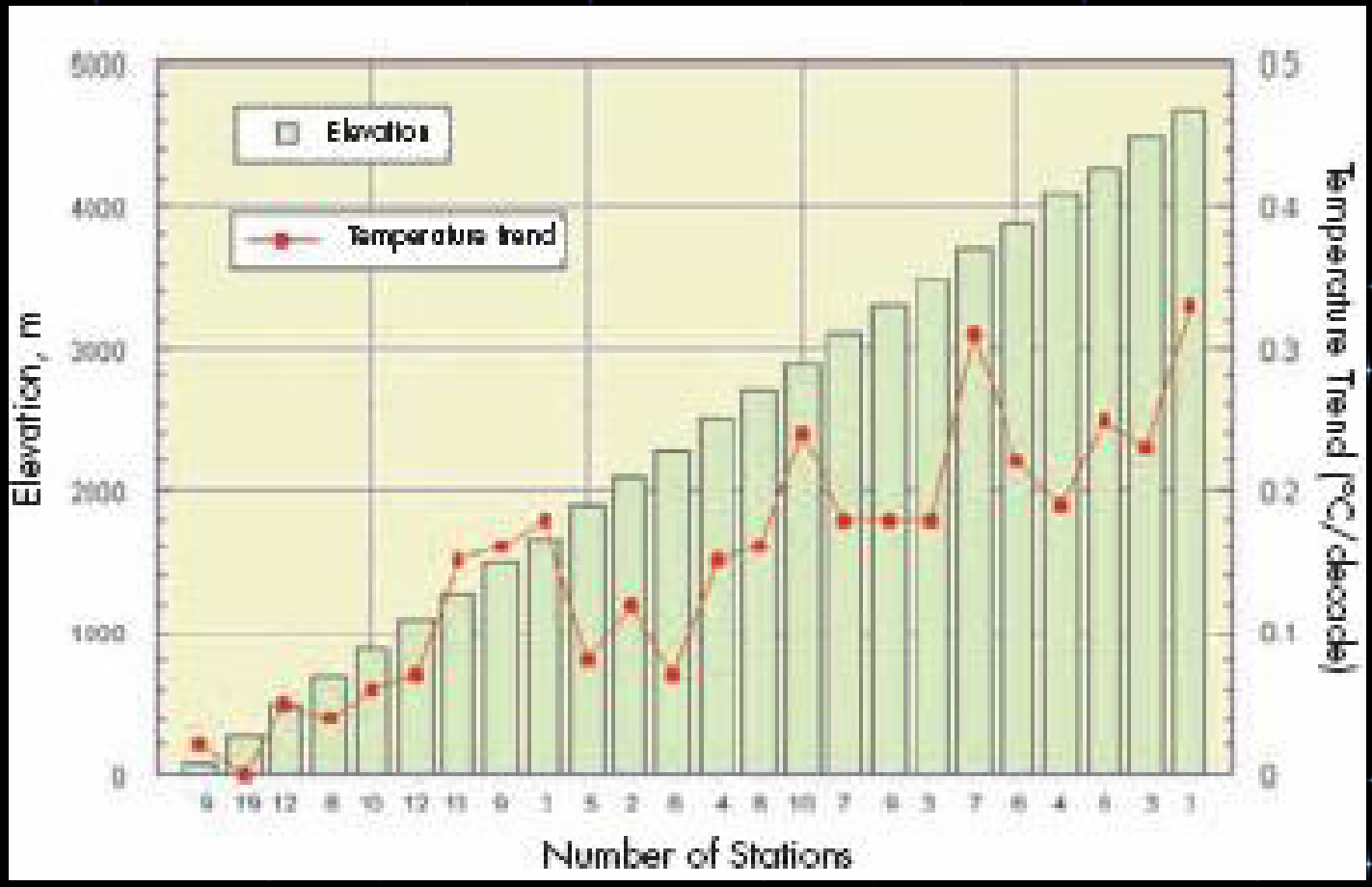


Observed Climatic Trends - Temperature

- Regional climate models indicate temperatures in the Indian sub-continent to rise between 3.5 and 5.5ºC by 2100, and on the Tibetan Plateau by 2.5ºC by 2050 and 5ºC by 2100 (Rupa Kumar et al. 2006).
- In early 2011, downscaling on Bhutan specifically performed with PRECIS by START / ADPC under an ADB consultancy predicts +3 ℃ by 2050 (less than 0.1/decade).
- Because of the extreme topography and complex reactions to the greenhouse effect, even high resolution climatic models cannot give reliable projections of climate change in the Himalayas.
- Various studies suggest that warming in the Himalayas has been much greater than the global average of 0.74 ℃ over the last 100 years (IPCC 2007a).
- Warming will be significant in arid regions of Asia and the Himalayan highlands, including the Tibetan Plateau (Gao et al. 2003; Yao et al. 2006)

Climate Modeling

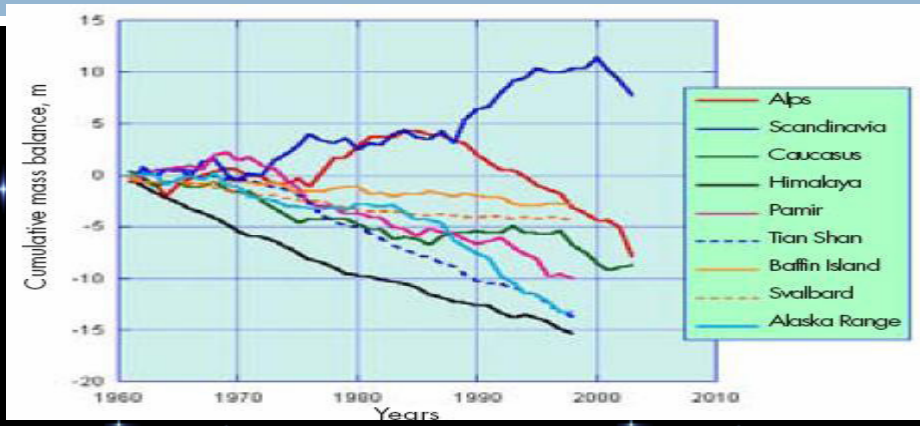
- Warming in Nepal and on the Tibetan Plateau has been progressively greater with elevation (Figure 1).



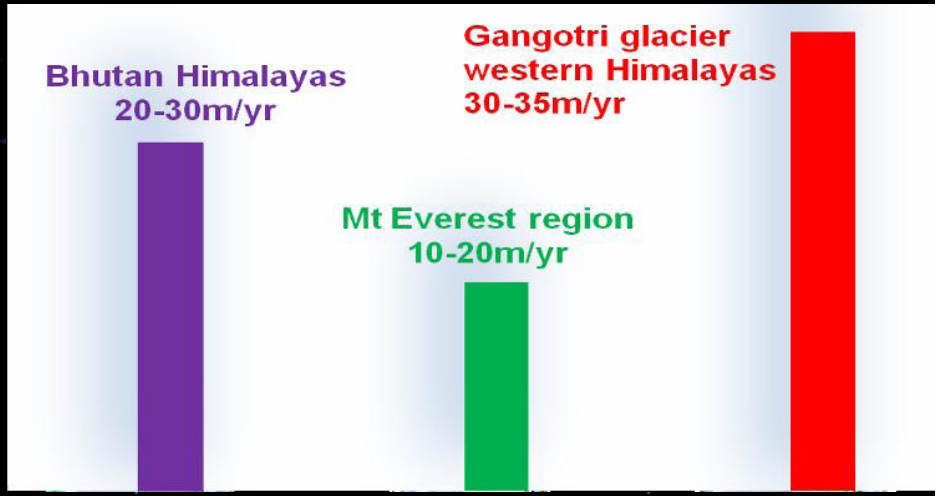
Climate Modeling

Issues – Glacier Retreat

- Tarina Glacier retreat rate was 35 m per year from 1967 to 1988 (Ageta et. al. 2000);
- Retreat rates as high as 26.6 m per year were reported for 103 debris free glaciers in the Bhutan Himalaya over a period of 30 years from 1963 to 1993 (Karma et; al., 2003);
- Jichu Dramo Glacier retreated by 12 from 1998 to 1999 (Naito et. al., 2000);
- The retreat rates are higher for glaciers in Bhutan Himalaya than in eastern Nepal (Karma et. al., 2003);
- 8% shrinkage estimated using 66 glaciers in 30 years from 1963 to 1993 (Karma et. al., 2003);
- Luggye Glacier retreated by 68.5 m per year from 1967 to 1994; and
- Raphstreng Glacier retreated on an average 35.5 m per year from 1957 to 1987, and rate increased to 60 m per year from 1998 to 1993.



Rapid retreat of greater himalayan glaciers compared to the global average.



Increased glacier retreat since early 1990's

Issues – Glacier retreat

- A serious concern for Bhutan whose economy is dependent on the glacial lakes which act as natural reservoirs and also help to regulate seasonal flows in the rivers.
- Bhutan‘s accelerated development of hydropower programme has set a target of 10,000 MW by 2020. Out of this, more than 6000 MW is planned in the Punatsangchhu Basin which is located downstream of major glacial lakes.

Issues – GLOF

- Formation of supra-glacial lakes due to the accelerated retreat of glaciers with increasing temperatures. The risk of Glacial Lakes Outburst Floods (GLOFs), which pose new threats to lives, livelihoods and development, is mounting as the water levels in several glacier lakes approach critical geostatic thresholds.
- Although current disaster management policies, risk reduction, and preparedness plans in Bhutan are able to address recurrent natural hazards in the country, they are not yet prepared to deal with the new GLOF apparently caused by the impacts of climate change.
- Rising mean temperatures, attributed to climate change, are the main cause of glacial retreat and are correlated with faster rates of glacier melt. This may be the reason for accelerated melting of glaciers receding at a rate of almost 20-30 meters per year. The melting ice from these receding glaciers is increasing the volume of water in glacial lakes, and the melting of ice-cored dams is

Issues – Runoff over Time and Space

- Most mountain people rely on glacier melt and seasonal flows for water supply.
- The current trends in glacial melt suggest that the low flow will become substantially reduced as a consequence of climate change (IPCC 2007a).
- Impact food production and slow down economic growth.
- Flooding may also arise as a major development issue. It is projected that more variable, and increasingly direct, rainfall runoff will also lead to more downstream flooding.

Issues – Hydropower Generation

- Increased risk of Glacial Lake Outburst Flooding (GLOF).
- Increased run-off variability‘s of glacier retreat, more intense precipitation during monsoon and potentially decreased precipitation in winter;
- Increased sediment loading as a result of landsides, GLOF as a result of intense rainfall events.
- Increased evaporation losses from reservoirs.
- Domestic water supply is presently met from the springs and small tributaries, but main rivers will have to be tapped into to meet increasing demand. Implications on hydropower projects during the lean flow period, will be there in the long run.

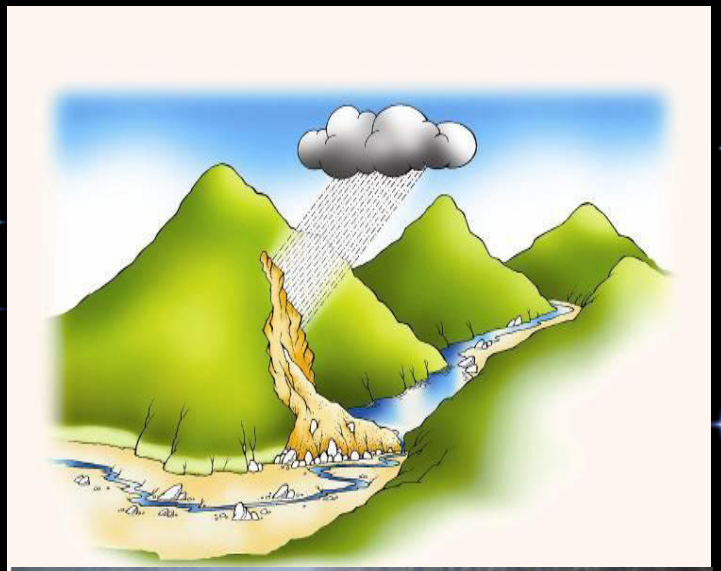
Issues – Sanitation & Hygiene

- Damage of water supply and sanitation infrastructures from increased flooding or landslide, debris flow, GLOF etc.
- - Increased O&M costs for water treatment due to degradation of water quality input.
- - Pollution induced by overwhelming capacity of low cost surface water protection system, including pathogen loading, water borne diseases propagation,
- - Water borne diseases Increased by dry spells / droughts and degradation of quality of shallow water, ponds and marshes,
- - Possible drying up of spring and stream sources in remote areas.

Issues – Landslide Dam Bursts

Landslides triggered by cloudbursts cause temporary dams blocking the path of the stream/river. Devastating floods result when the dam burst.

Change in rainfall patterns is expected to accelerate these earth movements in steep terrain.



Issues – Water Related Health Hazards

- The impact of climate change on human health may be classified into three categories:
  - direct impacts of for example, drought, heat waves, and flash floods
  - indirect effects due to climate-induced economic dislocation, decline, conflict, crop failure, and associated malnutrition and hunger,
  - indirect effects due to the spread and aggravated intensity of infectious diseases due to changing environmental conditions (WHO 2005).

Issues – Impact on Agricultural Productivity

- Due to climatic vulnerability and associated risks, agricultural production systems especially in marginal areas are prone to degradation of land resources through land and soil erosion, and over-extraction of groundwater (National Water Mission, Subsistence and smallholder farmers are particularly vulnerable to climate variability and socio-economic stresses that further complicate their livelihood systems (Bates et al. 2008). It is paradoxical that too much water (floods, land slips) and too little water (droughts) both adversely affect agriculture leading to food insecurity. Extremes in temperatures (high/low) and shifts in rainfall patterns (early/late) lead to adjustments in planting and harvesting times, often resulting in lower crop productivity and food production. Government of India, 2010).

Issues – National Action Plan

- The National Action Plan has 4 broad goals:
  - **To improve understanding and increase awareness of the impacts of climate change on water resources.**
  - **2. To increase resilience to respond to the impacts of climate change on water resources.**
  - **3. Water Resources Management through adoption and implementation of IWRM and eco-efficiency**
  - **4. Mainstream climate change and water resources in national plans and programmes.**

The Implementation Plan

- The National Action Plan has 4 broad goals, objectives and activities that constitute a road map for the next 10 years.
- The activities have been agreed upon through a multi-stakeholder discussion process.
- While the activities listed are numerous, the priority of implementation will depend on so many factors – alignment with implementation plan of others, prioritization based on priority of others, support form GEOSS/AWCI.
- The list has been presented so as to enable GEOSS/AWCI to identify which one could be supported.
- This road map has been adapted to the GEOSS implementation plan mainly to avoid the risk of duplication.

Goal 1: To improve understanding and increase awareness of the impacts of climate change on water resources

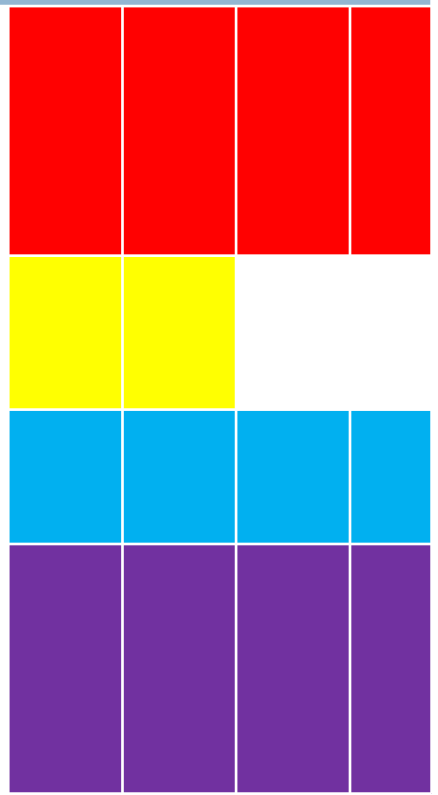
Log Framework	12	13	14	15	16
Objective 1.1 Conduct comprehensive water resources inventory					
1.1.1 Comprehensive water resources inventory; mapping, assessment of the quality and quantity of the major water sources for various uses.					
1.1.2 Development of database on the amount of water (rainfall, snowfall, reservoir storage, river discharges, groundwater levels, water quality) and water allocations (water intakes, water demand, and related seasonal changes).					
1.1.3 Monitoring of glacial and seasonal snow covers to assess the contribution of snow melt to water flow of Bhutanese rivers.					
1.1.4 Establishment of water quality and monitoring stations on all major rivers.					

Goal 1: To improve understanding and increase awareness of the impacts of climate change on water resources

	12	13	14	15	16
Objective 1.2 Build capacity at various levels to enhance understanding of the science behind climate change impacts on water resources					
1.2.1 Promote the networking of educational institutes, especially the higher education sector, to share research and data related to climate change and its impacts on water resources					
1.2.2 Identify the human resource gap and build technical and managerial capacity at all levels.					
1.2.3 Develop long-term monitoring and analysis of indicators of climate change on water resources.					
1.2.4 Strengthen technology transfer, sharing of best practices and researches within the institutions in the region on understanding the impacts of climate change on water resources					

Goal 2: To increase resilience to respond to the impacts of climate change on water resources.

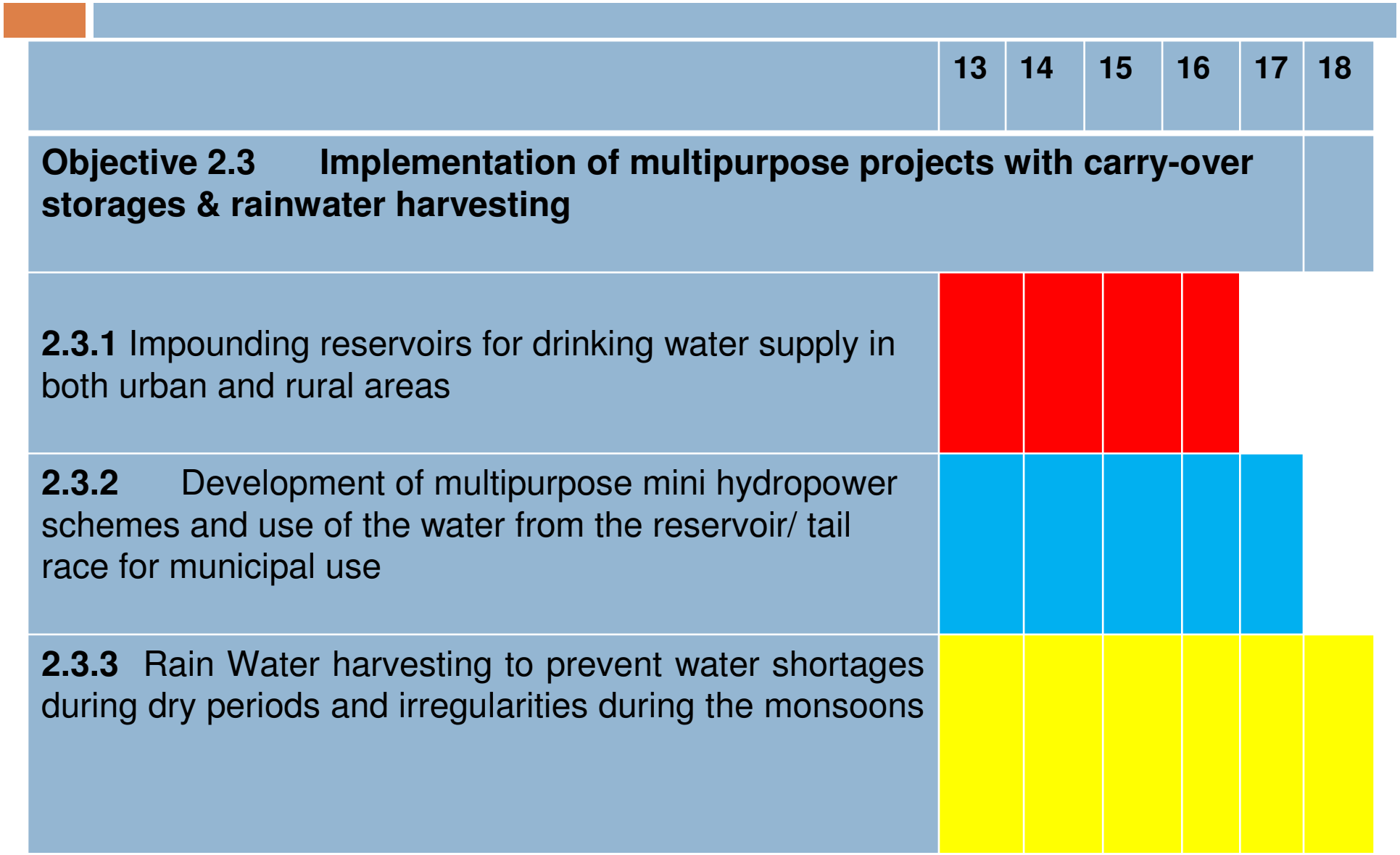
	12	13	14	15	16
Objective 2.1Improve preparedness to water related natural disasters and emergencies					
2.1.1 Develop and facilitate cost effective, socially acceptable, and sustainable disaster-preparedness and risk-minimisation through improved assessment and socio-economic vulnerability analysis					
2.1.2 Installation of GLOF technical early warning systems with associated awareness-raising					
2.1.3 Regular monitoring of lake levels, both manually and through the satellite.					
2.1.4 Strengthen trans-boundary collaboration on the exchange of flood forecasting and information					



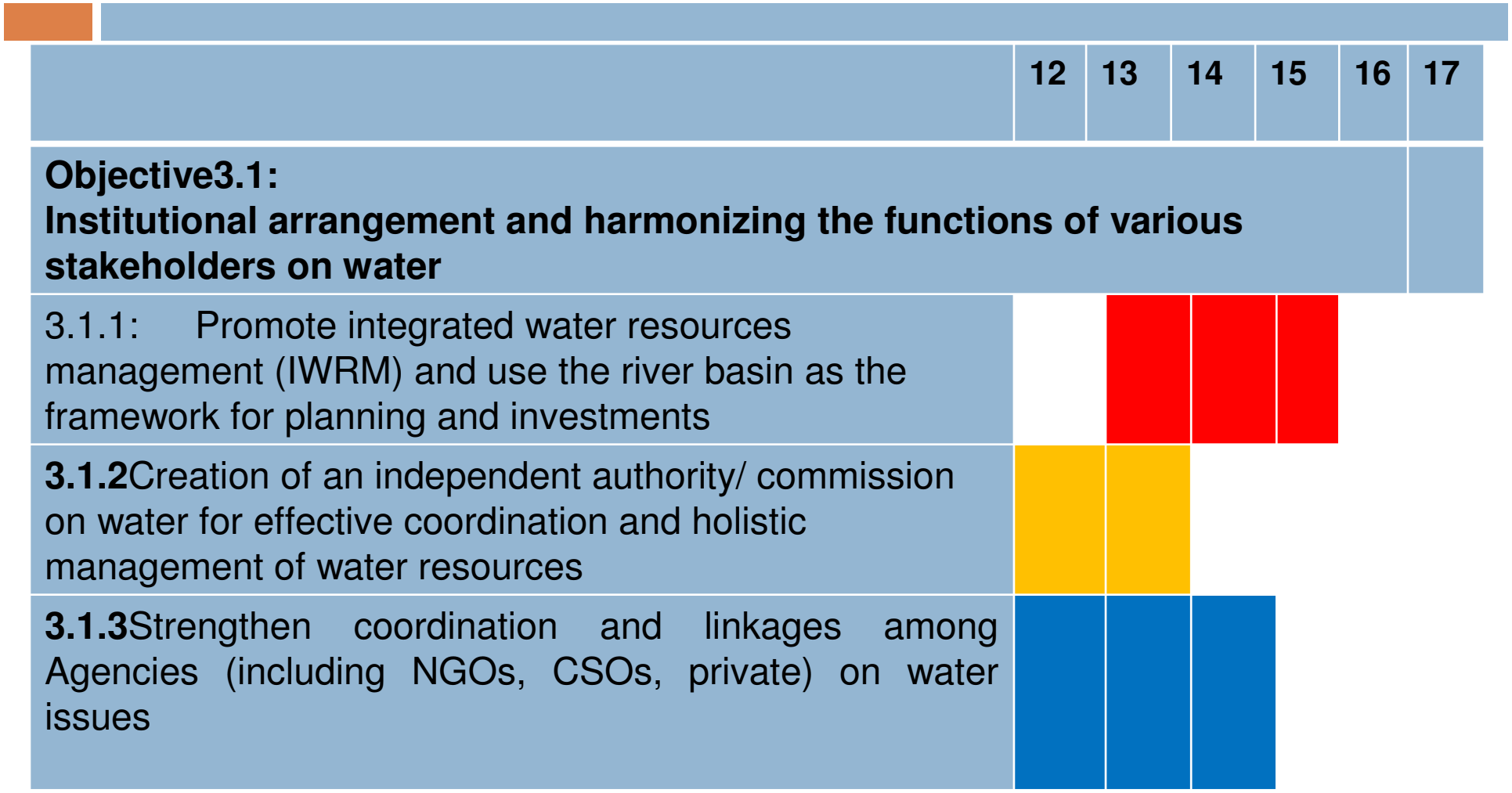
Goal 2: To increase resilience to respond to the impacts of climate change on water resources.

	12	13	14	15	16
Objective 2.2: Enhance knowledge & preparedness of the local community, schools and institutes on the impacts of climate change on water					
2.2.1 Promote community involvement in watershed/ catchment protection and in decision making processes					
2.2.2 Incorporate traditional knowledge and local perspectives in adapting to the changing climate					
2.2.3 Integrate into the school curriculum on the awareness and preparedness on water -induced natural disasters.					
2.2.4 Training local communities to respond to water-induced disasters.					

Goal 2: To increase resilience to respond to the impacts of climate change on water resources.



Goal 3:Water Resources Management through adoption and implementation of IWRM and eco-efficiency



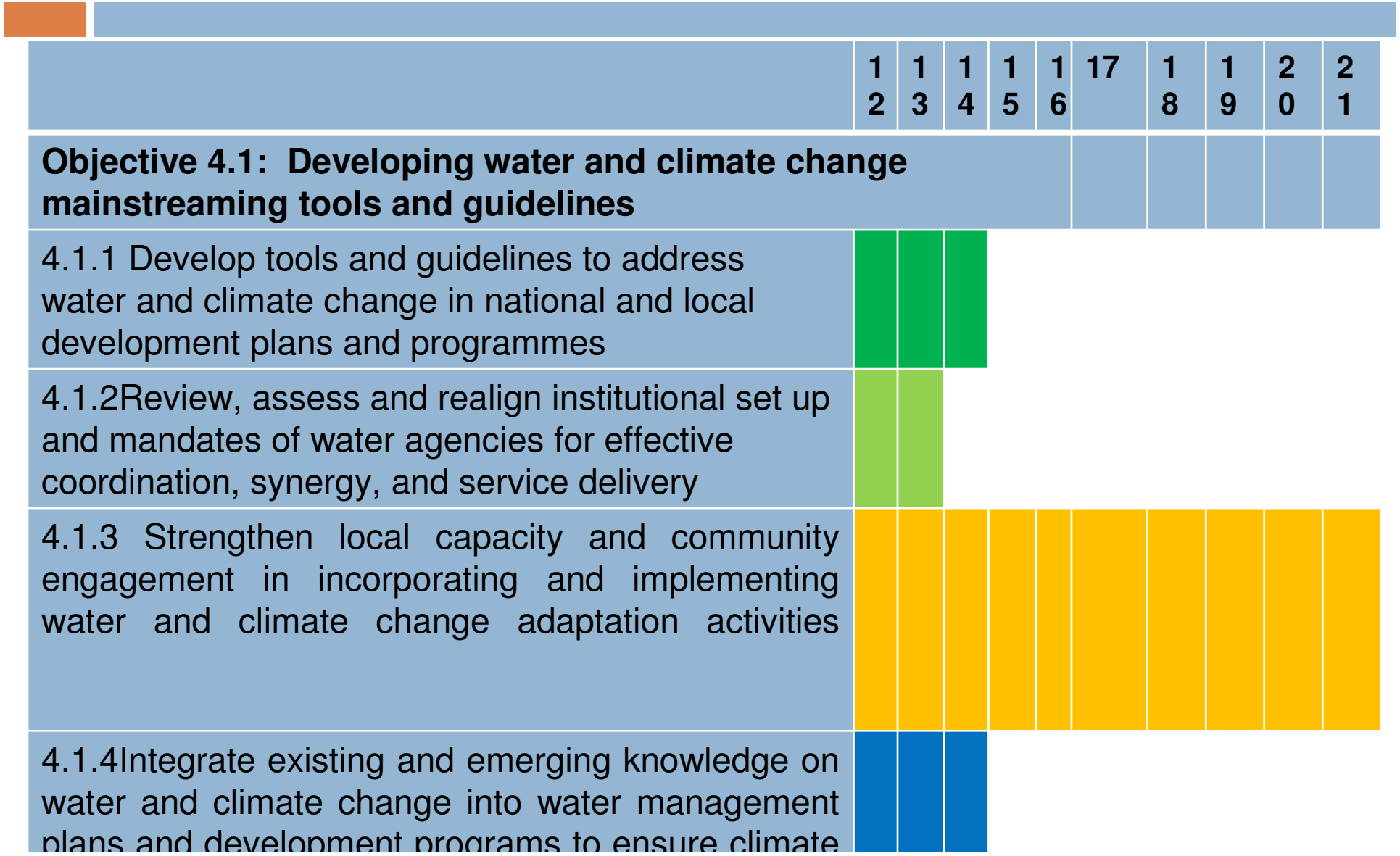
Goal 3:Water Resources Management through adoption and implementation of IWRM and eco-efficiency

	12	13	14	15	16	17	18	19	20	21
Objective3.2: Enhance ecological management practices										
3.2.1 Conserve wetlands in the headwater catchment areas as continual source of pure water, habitat for biodiversity, spiritual and cultural asset and for other ecosystem services										
3.2.2. Encourage the spread of green belt to increase local resilience to sediment-related disasters, recharging of groundwater and create aesthetic green landscapes in the urban environment										
3.2.3 Develop and implement stringent rules and regulations to protect water sheds and catchment areas										

Goal 3:Water Resources Management through adoption and implementation of IWRM and eco-efficiency

	12	13	14	15	16	17	18	19	20	21
Objective3.3:Implementation of Eco-efficiency for effective management of water resources										
3.3.1 Promotion of Water Safety Plan as a tool to consistently ensure the adequacy and safety of a drinking water supply through comprehensive risk assessment and management approach from catchment to consumers										
3.3.2. Prevention of water loss in the system due to breakage of old pipes, leakages and illegal tapping of water.										
3.3.3 Reconstruction of irrigation systems (lining, better maintenance) to reduce water loss (by as much as 50%) and apply advanced water-saving methods of irrigation										

Goal 4:Mainstream Climate Change and Water Resources into national plans and programmes



THANK YOU