Climate change adaptation for sustainable industrial development

A strategy outline for the implementation of the "Climate Change Adaptation Project (CCA)" in industrial areas of Andhra Pradesh and Telangana, India

November 2015

Executive Summary

Sustainable development is defined as ***"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*** (Brundtland Commission (1987), Chapter 2.IV, Conclusion, paragraph 1).

Over the past decades, industrialisation in India has increased rapidly and has been a driver of its economic growth. Nowadays, industry and industrial estates are ***entangled in a range of pressures*** coming from market, supply chain, finance and insurance on one side. On the other side, policy and regulation, deficiencies in infrastructures, environmental adversities and pressures from communities in their immediate surroundings influence industry and industrial estates. Significant effects due to a wide range of climatic changes like cyclones/storms heavy rainfalls and floods, heat waves and droughts are likely to exacerbate these pressures. These changes could be observed in both Andhra Pradesh and Telangana through already existing evidences such as changes in frequency and intensity of cyclones, shifts in monsoon periods, changing rainfall patterns, increasing maximum temperatures and duration thereof during heat waves. Future climate projections include a further rise in mean and maximum temperatures, continuing changes in rainfall patterns, alterations in cyclone intensity and rising sea levels.

The resulting ***climate change impacts*** on industries and industrial estates can be direct or indirect; i.e. caused through other systems. Impact areas can be related to buildings, infrastructures, production and stock on site, employees and management amongst others. Collateral climate change effects on the supply chain, wider market as well as finance and insurance can also affect industrial estates and their industries.

Potential climate change impacts are generally determined by a combination of the ***exposure to the climatic drivers*** based on location and the ***specific characteristics of the industry or estate that make it susceptible or fragile***. It is oftentimes the latter, ***non-climatic aspects*** of the system, which contribute strongly to the overall vulnerability; e.g. insufficient and badly managed drainage and sewage systems at an industrial estate that are already unable to handle heavy rainfalls, will be very unlikely to cope with further increases in flood events.

Since prevailing risks and their expected increase ***call for a policy shift to provide a regulatory and governance framework promoting and actively supporting climate change adaptation,*** this report provides input and guidance for the integration of adaptation of climate change into strategies for sustainable industrial development, and for the development of rules, regulations and processes for climate resilient industrial development in Andhra Pradesh and Telangana.

The proposed policy shift entails a joint commitment of all parties towards sustainable industrial development and understanding climate change adaptation as an integral part and mandatory task of good governance to avoid serious, long-term losses and damage to industry and to harness the rising potential opportunities.

Next to properly identifying the risks for each industrial site, awareness and capacities, policy mainstreaming and implementation through appropriate planning processes are key for that shift. Specifically for APIIC and TSIIC, integrating climate change adaptation into the overall mandate and mainstreaming it into the institutional setting are required. This should be accompanied by external communication and advocacy.

The report also outlines the overall strategy of the Projects for APIIC & TSIIC on climate change adaptation in industrial areas in India to achieve the above goals. In addition, a detailed description of each work package is included in chapter 5.

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List of Abbreviations

ADB	Asian Development Bank
AG	Stock Corporation (*German*: Aktiengesellschaft)
ALEAP	Association of Lady Entrepreneurs of India
AP	Andhra Pradesh
APIIC	Andhra Pradesh Industrial Infrastructure Corporation
APPCB	Andhra Pradesh Pollution Control Board
BAU	Business as Usual
BIS	Bureau of Indian Standards
CPCB	Central Pollution Control Board
CCA	Climate Change Adaptation
CRZ	Coastal Regulation Zone
CO_2	Carbon dioxide
DRM	Disaster Risk Management
e.g.	For example
EIA	Environmental Impact Assessment
EPTRI	Environment Protection Training and Research Institute
EMF	Environmental Management Fund
EPA	Environmental Protection Agency
EURAC	European Academy of Bozen/Bolzano (research centre)
FICCI	Federation of Indian Chambers of Commerce and Industry
GDP	Gross Domestic Product
GHG	Green House Gas(es)
GIDC	Gujarat Industrial Development Corporation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GoI	Government of India

IALA	Industrial Area Local Authority
Ibid.	In the same place (as the preceding reference)
ICRM	Integrated Climate Risk Assessment
ICT	Information & Communications Technology
i.e.	That is to say
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
INCCA	Indian Network on Climate Change Assessment
IPCC	Intergovernmental Panel on Climate Change
IRDA	Insurance Regulatory and Development Authority
IT	Information Technology
m, mm	Metre, Millimetre (for precipitation 1mm ~ 1 litre per m^2)
N/A	Not applicable, not available or no answer
NAPCC	National Action Plan on Climate Change
NDMA	National Disaster Management Authority
NDTV	New Delhi Television
MoEF&CC	Ministry of the Environment, Forests & Climate Change
OECD	Organization for Economic Co-operation and Development
p. /pp.	Page / pages
PIK	Potsdam Institute for Climate Impact Research
PRECIS	Providing Regional climates for Impact Studies(Regional Climate Modelling System)
RDF	Refuse Derived Fuel
RCM	Regional Climate Model
RCP	Representative Concentration Pathway (SRES),
Rs	Rupee (s) (₹)
SAPCC AP	State Action Plan on Climate Change for Andhra Pradesh
SEA	Strategic Environmental Assessment

SIA	Social Impact Assessment
SIDBI	Small Industries Development Bank of India
SRES	Special Report on Emission Scenarios, published by the IPCC
TSIIC	Telangana State Industrial Infrastructure Corporation
TERI	The Energy and Resources Institute
TG	Telangana
UBA	Umweltbundesamt (German Environmental Protection Agency)
USD	U.S. Dollar ($)
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	The United Nations Office for Disaster Risk Reduction

1.Introduction

In numerous industrial parks all over India a situation like the following can be found[1]:

An industrial area or significant parts of it, as well as surrounding areas, e.g. housing quarters, are often flooded after heavy rainfalls and signs of erosion can be observed in elevated or inclined areas of the park. Flooding during excessive rainfalls is often increased through disturbances to the natural drains caused by construction of roads and buildings, and the lack of or an inadequate, badly constructed or poorly managed storm water drainage system. Flooding may damage or destroy infrastructure like roads, buildings, electricity, and water supply, jeopardize storage facilities of raw materials, hazardous substances / hazardous waste, and finally contaminate surface waters, soil or even groundwater resources, in addition to risks for human beings.

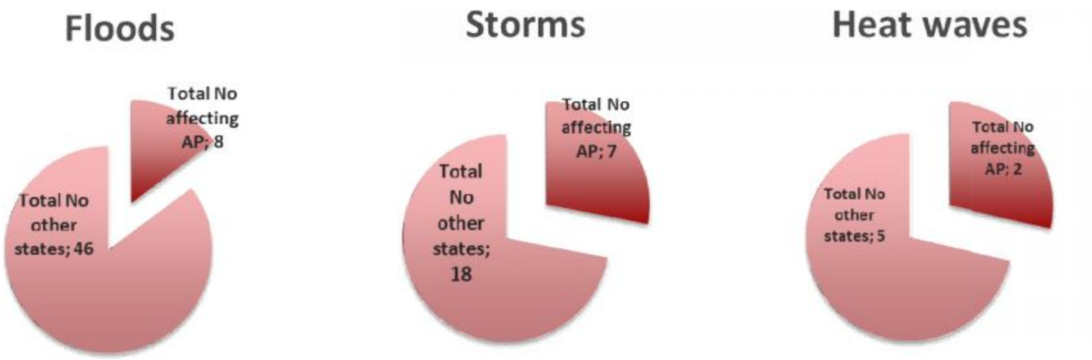
However, when analysing such cases, it can often be found, that areas prone to erosion could be easily tected through simple measures like plantation and smart layout of the industrial parks. Through proper planning, development, refurbishment, proper tions and maintenance, not only the risk of flooding minimized and surface waters, soil and ground water better protected, but also ground water recharge could be fostered, heat islands minimized, biodiversity and landscape aesthetics could be increased.

Source pics: GIZ/FICCI (2012)

In addition to hydro-meteorological events below the threshold to a disaster, severe events can hit Indian trial cities and parks at any time: On October 12, 2014 cyclone “Hudhud” made landfall near the port city of Visakhapatnam with peak winds of up to 200 km/h and a storm surge of up to 3m in some areas. With a population of 2 million, Visakhapatnam is the third largest city on India’s east coast. The total losses were estimated at USD 7 billion, the largest of all natural catastrophes in the world in 2014. However, only approx. 9% of these losses were insured. Thanks to efficient and effective early warning and evacuation of up to 400,000 people ahead of the storm executed by the responsible authorities and organizations, death toll could be limited to 68 lives (SWISS RE (2015)).According to IRDA, production processes of many industries were hampered or were at a standstill for more than 10 days. In addition, major damages to infrastructure affected industries indirectly, e.g. around 40,000 broken electricity poles or more than 3,700km of damaged roads (Disaster Management (2015)).When assessing the SWISS RE Sigma reports of the past 10 years, Andhra Pradesh and Telangana can be viewed as strongly affected by certain climatic hazards in comparison to other Indian States (see Annex 4 for analysis) as depicted by below figure.

[1]The following paragraphs are based on a case study from an Industrial Area in Gujarat (Source: GIZ/FICCI (2012), p. 64), but can be found in AP and Telangana as well.

Figure 1: Climatic hazards in Andhra Pradesh and Telangana in national comparison



Source: Own analysis based on SWISS RE Sigma Reports 2005-2015

All these factors need to be thoroughly considered when striving for ***sustainable development and operations of industrial areas***, otherwise they will become even more severe and threatening under the projected conditions of climate change.

Generally, as experience shows from discussions and workshops, many individual industries would immediately accept measures tackling:

- either own inconvenient experiences, such as changes in design of the Indus trial building to provide better ventilation and lighting, or
- focussing on topics the public is well aware of, or
- that would result in cost reductions, like energy and water conservation,
- that are easily visible, such as improving vegetation inside and outside the industry premises.

People and industries might already be aware of existing hazards, as well as of non-compliance of specific matters with environmental standards, or the concept of Green Industrial Parks. However, they are not yet aware that climate change might even worsen these hazards or environmental impacts, e.g. increasing droughts imposing additional pressures on already stressed ground water resources, or increasing frequency and magnitude of heavy rains causing growing flood risks in IPs with poorly dimensioned, constructed, or maintained storm water drainages. Nevertheless, many individual industries would be willing to take up adaptive measures, if awareness is raised and short/ mid/long term advantages are made visible, comprehensive strategies are developed and communicated, jointly translated into plans, and capacities are built.

Sustainable development is defined as ***"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*** (Brundtland Commission (1987), Chapter 2.IV, Conclusion, paragraph 1).**Sustainable industrial development has to consider the economic, social, and environmental dimensions under the perspective of the future, which inevitably requires to duly integrating climate change, both in terms of mitigation, as well as adaptation.**

Andhra Pradesh Industrial Infrastructure Corporation (APIIC), Central Pollution Control Board (CPCB), Andhra Pradesh Pollution Control Board (APPCB) and the German agency for technical co-operation (then GTZ) entered into a Memorandum of Understanding in 2004 to collaborate in a project for developing "Eco-Industrial Parks" in Andhra Pradesh. To commemorate the 34th Formation Day of APIIC, in 2006, the Honourable Chief Minister of Andhra Pradesh announced creation of an Environment Management Fund (EMF) with an annual outlay of Rs. 50.00 Crores (equivalent to approx. € 6.75 mill.) with the aim to address and implement modern environmental management systems in industrial parks in the State of Andhra Pradesh. The Government of Andhra Pradesh has decided upon its vision and objectives to transform the existing industrial parks into "Eco-Industrial Parks" and to ensure sustainable model(s) for industrial growth in the State. Today, APIIC administrates 236, and Telangana Industrial Infrastructure Corporation (TSIIC) 150 existing and new industrial areas. In addition to the former eco-industrial development approach, visible and projected impacts of climate change brought additional urgency and challenge to work for adaptation and mitigation, and to integrate both aspects in all sustainable development policies.

Several aspects addressing adaptation to climate change in industries and industrial areas are already in place; however, considering the imminent costs and losses of continuing business as usual a consistent approach and policy is urgently needed to address the following pending topics:

- Adaptation to Climate Change in the industrial and manufacturing sector is not yet directly addressed in ***India's National Action Plan on Climate Change (NAPCC)***. However, the National Mission on Strategic Knowledge for Climate Change encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds. Currently four new National Missions under the NAPCC are under discussion (The Indian Express (2015)). One of these is a 'Mission' on India's Coastal Areas to map vulnerability along India's shore line and prepare Integrated Coastal Resource Management (ICRM) plans in addition to the Coastal Regulation Zone (CRZ) Instrument. As and when the Mission is endorsed it will also promote adaptation of Industrial Areas and Development Zones in coastal areas.
- The ***State Action Plan on Climate Change*** for Andhra Pradesh (SAPCC AP), which was endorsed by the then State Government in 2012, identified industries as one of the important sectors to be addressed. There are several matters related to climate change adaptation in industries mentioned in the plan. However, the following aspects are not yet discussed in detail or not provided in a budget/plan:
    - Proper zoning and setting of industries was a matter of concern according to feedback received from stakeholders (Chapter 5.5.6, page 67)
    - Assessment of vulnerability of major industrial hubs to climate risks is seen as priority intervention area, and
    - Protection and disaster mitigation works to minimise risks to industrial hubs (Chapter 6.5.3, page 82).

  With the bifurcation of former Andhra Pradesh into residuary Andhra Pradesh and Telangana State in 2014, both States are developing their own SAPCC documents.

- According to ADB, ***annual average adaptation costs*** for India in 2100 under a Business as Usual (BAU) Scenario (temperature increase 6.9^{o}C; sea level rise 1.1m) would be USD 110.9 Billion, corresponding to 1.32% of GDP (ADB (2014), p. 81). In contrast, annual average adaptation costs for India in 2100 under the so-called Copenhagen-Cancun (C-C) Scenario (temperature increase 1.9^{o}C; sea level rise 0.3m) would be reduced to USD 31.0 Billion ,corresponding 0.36% of the then GDP. Compared to this, total economic costs of climate change for the year 2100 are assessed as equal to 8.7% of GDP under the BAU Scenario, and 1.9% under the C-C Scenario (ADB (2014), p. 77 ff.).

- Adaptation to climate change also plays an important role not only for sustainable development, but also for ***Disaster Risk Reduction***. A consistent and integrated policy for adaptation of industries and industrial areas to climate change will, therefore, also contribute to achieve all the following 4 priorities of the UN Sendai Framework (2015-2030) for Disaster Risk Reduction:

    - Priority 1: Understanding disaster risk,
    - Priority 2: Strengthening disaster risk governance to manage disaster risks,
    - Priority 3: Investing in disaster risk reduction and resilience, and
    - Priority 4: Enhancing disaster preparedness for effective response to "Build Back Better" in recovery, rehabilitation and reconstruction.

This above priorities offer opportunities for linking the work of the disaster management authorities of Central and State Governments and building on the cooperation established through previous projects (e.g. GIZ Adapt Cap project in Andhra Pradesh established cooperation with NIDM on climate change adaptation (see GIZ/NIDM (2014)).

Considering the above aspects, the Ministry of Commerce and Industry (GoI), the Departments of Industries and Commerce of the then Govt. of Andhra Pradesh and APIIC along with GIZ took a decision in the year 2013 to take up the ***project of "Adaptation to Climate Change in Industrial Areas in India"*** *to* address these challenges.

The strategy of the "Policy Document on Climate Change Adaptation for Sustainable Industrial Development" this project and discusses the following four key questions:

(1) Why is adaptation to climate change in industrial areas required?
(2) How can risks of on-going climate change for industrial areas be minimized?
(3) What strategies and measures apply best to minimize the risks, and
(4) How can the project make use of it?

In line with the above, the strategy of the Policy Document will provide input and guidances on

a) the integration of adaptation to climate change into strategies for sustainable industrial development, and
b) the development of rules, regulations and processes for climate resilient industrial development.

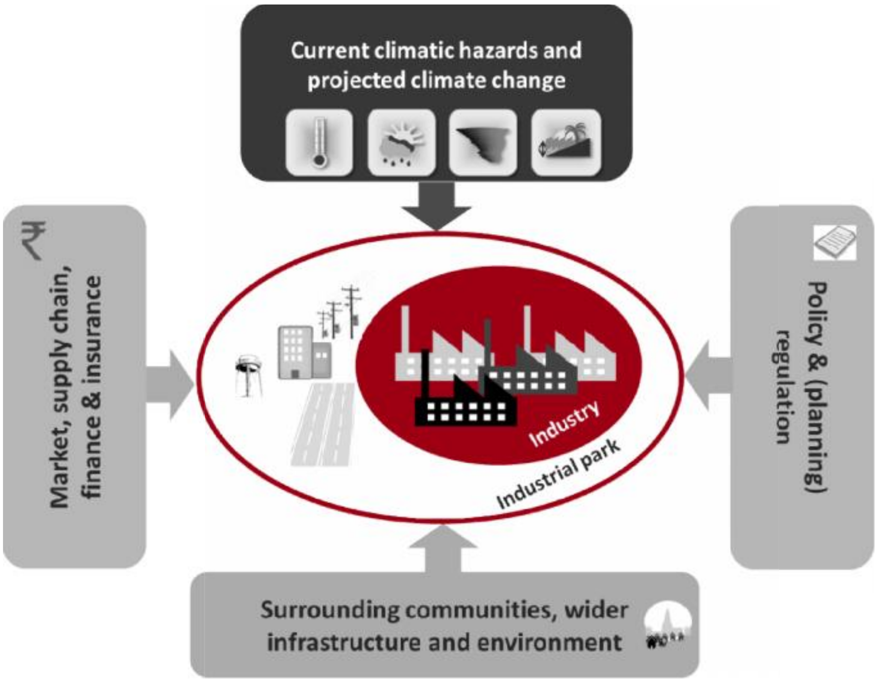
This guidance is provided through five Working Groups (WG) under the project, i.e. WG 1A "Guidelines", WG 1B "Engineering and planning", WG 2 "Capacity Development", WG 3 "Policy" and "Up-Scaling" and WG 4 "Implementation Support". For WG 3 the report will be used as zero draft for the policy paper "Climate Change Adaptation for Sustainable Industrial Development" envisaged by the project.

Accordingly, the target audience of the report is as follows:

- APIIC and TSIIC, including their sub divisions and concerned officials are, responsible actors assigned to the above working groups,
- Departments of Industries and Commerce of both the states,
- Private sector organizations from industry having adopted Sustainable Industrial Development into their agenda, such as FICCI, CII at national level ,and/ or industrial associations at State level such as ALEAP or private IE developers, and
- Training providers supporting the stakeholder capacity development modules according to the overall policy strategy.

The following chapters provide a recommendation for such a policy approach considering industries and industrial areas connected with surrounding communities, infrastructure and environment, as well as supply chains and markets, guided by the regulatory framework and exposed to current and projected climatic hazards as shown in the Figure 2.

Figure 2: Industry in context including climatic hazards and climate change



2. Why is adaptation to climate change needed?

2.1 Climatic hazards

Andhra Pradesh and Telangana are generally exposed to a range of climatic hazards resulting in severe effects on the local communities and economies. These hazards include cyclones, heavy rainfalls, droughts and heat waves.

Figure 3: General climatic hazards in Andhra Pradesh and Telangana

Sources pics (from left to right and top to bottom): Chiru.in, Agence France-Presse, GIZ/FICCI, Zee news India

Cyclones are a serious climatic hazard to India. The east coast of India is considered to be one of the most cyclone prone areas of the world. An analysis of cyclone frequency on the east and west coasts of India between 1891 and 1990 indicates that about 262 cyclones (92 severe cyclones) occurred in a 50 km wide strip on the east coast (EPTRI (2012), p. 23 ff). Andhra Pradesh's coastal districts are particularly exposed to cyclones formed over the Bay of Bengal, the Andaman Sea or the South China Sea. In the past century, more than 103 cyclones (of which 31 were severe) hit the coast of Andhra Pradesh and thousands of people lost their lives or were rendered homeless (EPTRI (2012), p. 75). According to numbers from the State Department Disaster Plan in 2010, the annual cyclone frequency along Andhra Pradesh's coast was four in the period between 1981 and 1990. On average, one out of the annual four cyclones has been severe. At the coastline of Andhra Pradesh, the section between Nizampatnam and Machilipatnam is most susceptible to cyclones (Revenue (Disaster Management II) Department AP (2010)[2], p. C3-2). About 44% of the State is vulnerable to tropical storms and related hazards and approximately 2.9 million of the more than 31 million inhabitants of Andhra Pradesh are living in these vulnerable areas (EPTRI (2012), p. 75). In 2013, two strong cyclones, "Phailin" and "Helen", hit the coast of Andhra Pradesh within a period of only two months. This frequency was extraordinarily high; the impacts were tremendous (TERI (2014), p. 5).

The city of Visakhapatnam appeared in the OECD list of port cities of high risk and vulnerability to climate extremes (Nicholls et al. (2008), p. 55).The latest very severe cyclone hitting

[2] The Department has now been renamed to "Revenue (Disaster Management) Department". Its website including several maps can be accessed at: http://www.disastermanagement.ap.gov.in/

Andhra Pradesh was “Hudhud” in October 2014. It made landfall near Visakhapatnam, where various industrial sectors are located. However, Vizianagaram and Srikakulam districts were also heavily affected (Babu et al. (2014), p. 63). The number of fatalities was 41 and the economic losses summed up to US$ 11 billion (UN ESCAP (2015), p. 5). Cyclone Hudhud is also a striking example for the threats tropical storms impose to the industrial sector. Hudhud caused a blackout of the electricity grid in Visakhapatnam and it took around two weeks for the power supply to be restored (NDTV (2014)). Storms also have been observed to be an issue for Telangana (e.g. recently in April 2015) but, to the knowledge of the authors, there are no separate long-term recordings available.

The ***rainfall*** scheme in Andhra Pradesh and Telangana is mostly dominated by the ***South-West and North-East Monsoon***. The distribution of precipitation is variable which leads to remarkable regional differences: the coastal area receives the highest annual rainfall rates (750 to 1500 mm) whereas the western part of the Rayalaseema region is the driest area with average annual rainfall rates of 300 to 500 mm only. Not only the quantity of rainfall but also its variability differs within the regions: While the ***rainfall variability*** in ***Telangana and the northern coastal regions ranges between 20 and 25%, it is even higher in the southern coastal regions and in Rayalaseema*** (25 to 30%). The higher the rainfall variability, the higher is the risk of related extreme climatic events like droughts and heavy rainfalls (EPTRI (2012), p. 22). Also Krishnamurthy and Shukla (2000) analysed rainfall variability over India as a whole based on data from 1901 to 1970. During the summer monsoon period (June to September), they calculated a standard deviation from the seasonal mean rainfall of about 10 %. Years that exceeded 10% of the seasonal mean were referred to as flood years and those falling more than 10% below it were denoted “drought” years. This example shows that the 20 to 30% rainfall variability in Andhra Pradesh and Telangana ranges higher compared to the national values which indicates an elevated risk for extreme climatic events like droughts and heavy rainfalls.

Heavy rainfalls generally occur in regions with high rainfall variability and in cyclone prone areas. According to numbers from the Revenue (Disaster Management) Department AP, between 2000 and 2010, there were 14 incidents of heavy rainfalls in the former State of Andhra Pradesh, each of them affected on average 12 districts causing severe damages to humans and their livelihoods (EPTRI (2012), pp. 24-25). One consequence of heavy rainfalls are ***flood events*** as natural and technical drainage systems are often not capable to transport the large water masses accruing in a relatively short time span. The delta areas of the Krishna and Godavari rivers are especially prone to floods due to the accumulated discharge from upstream areas of rivers. ***The situation in the delta flood plains is even more critical when cyclones cause heavy rains and storm surges occur at the coast simultaneously.*** Also, heartland regions close to rivers, are exposed to flood events caused by heavy rainfalls (Disaster Management II of Revenue Department of GoAP (2010), pp. C3-6 – C3-14)e.g. 2005 in Khammam (Telangana),.***Urban floods*** are another serious issue for industrial estates as they are often located within or nearby a city.

Droughts are a frequent hazard in the former State of Andhra Pradesh. According to the World Bank, it is the third highest drought prone State (12.5 million ha of drought prone land area) of India after Rajasthan (21.9 million ha) and Karnataka (15.2 million ha).[3]. The drought hazard varies strongly within the regions: The entire Rayalaseema region, where rainfall quantities are low and variability is high, parts of Telangana and coastal Andhra region where rainfall can vary a lot are considered to be the most vulnerable (World Bank (2005), p. 20).

Exceptionally high temperatures compared to the normal mean temperatures are characteristics of ***heat waves***, a climate hazard that has been affecting Andhra Pradesh and Telan-

[3]For these numbers, the Central Water Commission’s definition of drought was used: Drought is a situation occurring in an area when the annual rainfall is less than 75% of the normal (defined as 30 y ears average) in 20% of the years examined and where less than 30% of the cultivated area is irrigated (World Bank (2005), p. 20).

gana considerably. Heat waves occur mostly between April and June and a maximum temperature of 48.8 °C has been recorded in Gannavaram, Krishna District in 2002. Apart from claiming thousands of lives, heat waves severely affect different sectors of local economies, especially agriculture (Disaster Management II of Revenue Department of GoAP (2010) p. C3-30).

Table 1summarizes the main climatic hazards for the two States.

Table 1: Climatic hazards in Andhra Pradesh and Telangana

Hazard	**Features** *(incl. frequency)*	**Geographic areas affected**	**Sectors at risk-** more details in Annnex5 (longlist of risks for industry)
Cyclones & storms	At an average of 4 cyclones per year out of which 1 is severe.	Coastal regions of Andhra Pradesh, especially shoreline between Nizampatnam and Machilipatnam.	All sectors in the affected areas, damage of buildings, infrastructure and electric grid.
Heavy rainfall / floods	Inundations, 14 heavy rain and flood events in former Andhra Pradesh between 2000 and 2010.	Mostly floodplains and delta regions of rivers (e.g. Godavari and Krishna river): According to NDMA[4], there has been an increasing trend of urban flood ters in India over the past several years, whereby major cities have been verely affected. The same features being relevant for cities are also prevailing in industrial areas, such as high degree of sealed faces, insufficient dimension and encroachment of drainage systems etc.	Threat to agricultural land and flood damage of production facilities: Pollution of drinking water.
Droughts	Water scarcity due to reduced rainfall and runoff.	Areas with low annual rainfall and high rainfall variability (e.g. Rayalaseema region).	Scarcity of water for drinking and industrial parks, threat to harvests.
Heat waves	Periods of extraordinarily high temperatures.	Possible all over the States, but often in urban and industrial areas and inland regions.	Heat stress affects employees and increases the energy demand for cooling facilities.

Sources: Summary of data from chapter 2.1

Till date, the mid- and long-term predictability of frequency and intensity of these hazards is limited.

Also, the number, severity, frequency and complexity of these climate-induced hazards are influenced by climate change as described in the following paragraphs.

[4]http://www.ndma.gov.in/en/guidelines-urban.html

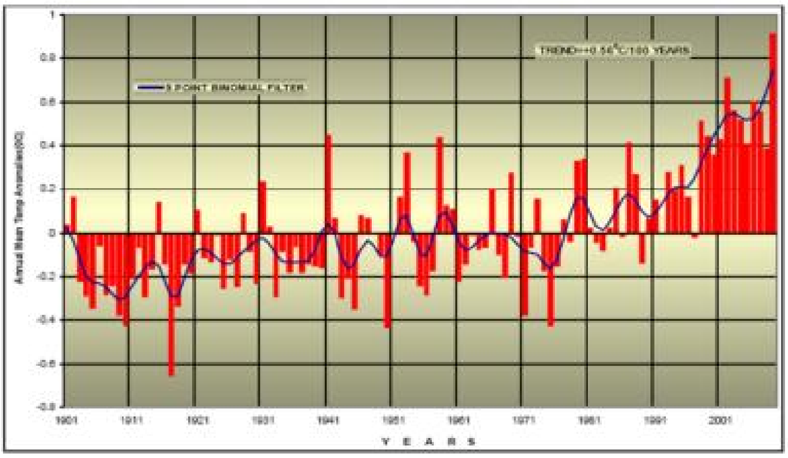
2.2 Observed and potential future climate change

Past and current climatic changes

On a ***global*** scale, surface temperatures have risen during the last century at an average of about 0.74 °C. The global warming of air temperature is associated with other environmental changes caused to a large extent by anthropocentric ***greenhouse gas emissions and depletion of ozone layer.*** Alterations of precipitation patterns have been observed, not only in terms of total annual amount but also due to the intensity and frequency of rainfall. . Other consequences of the ongoing climatic changes include the increased occurrence of extreme weather events such as droughts and severe cyclones. Finally, sea levels are rising due to thermal expansion of the oceans which is further aggravated by water input from reservoirs like ice caps and glaciers (IPCC (2007a), pp. 103 - 108). Observed effects of these climatic changes globally include altered hydrological systems, water resources being affected in terms of quantity and quality, a shift of species, impacts on crop yields, alterations of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, and impacts on human health and well-being (IPCC (2014a), pp. 4-8).

At national level, the average surface air ***temperature*** in ***India*** has increased by about 0.4 °C during the last century and even if the observed monsoon rainfall did not show significant trends on a nationwide level, regional decreasing/increasing variations in seasonal ***rainfall*** have been recorded (MoEF (2004), p. 6).

Figure 4: Observed temperature rise in India since 1901



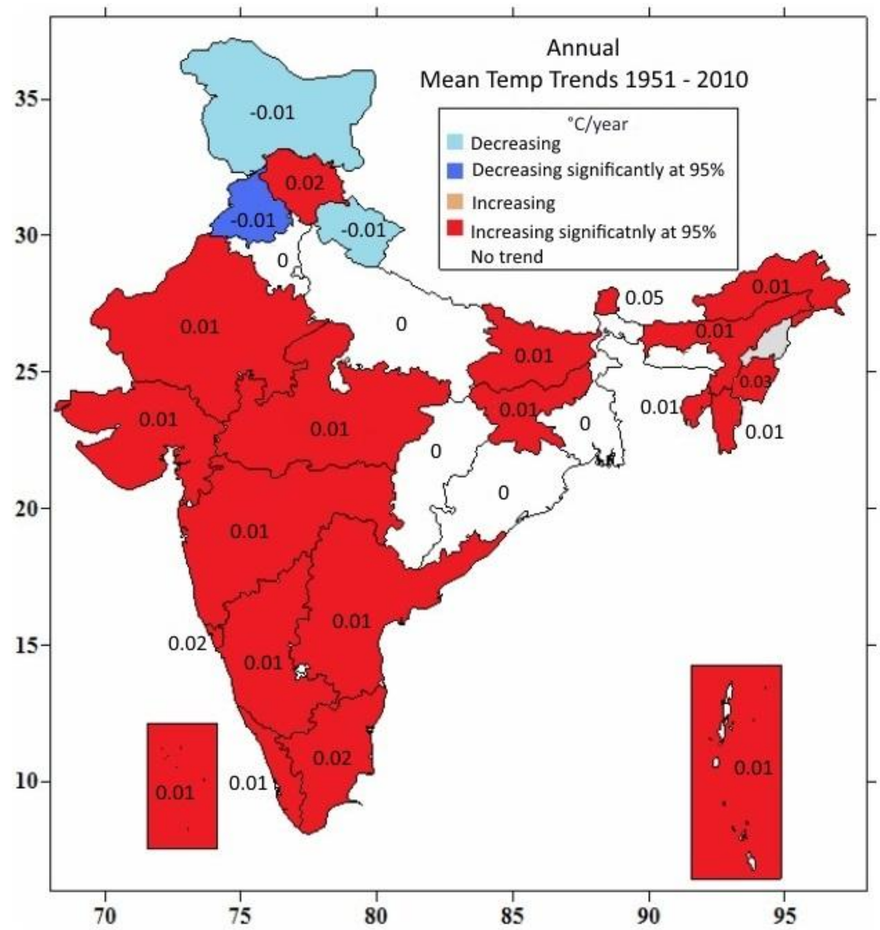
Source: IMD (2009), p. 1

Also the 130 years of observation of ***extreme weather events*** that are one side-effect of climatic changes, did not reveal long-term trends in frequency at national level, but only for certain regions there are considerable trends for storm, drought and heavy rain events (ibid.).

As observations at the national level are too broad to make statements on past and current climate changes in the States of ***Andhra Pradesh and Telangana***, regionally specific data needs to be considered.

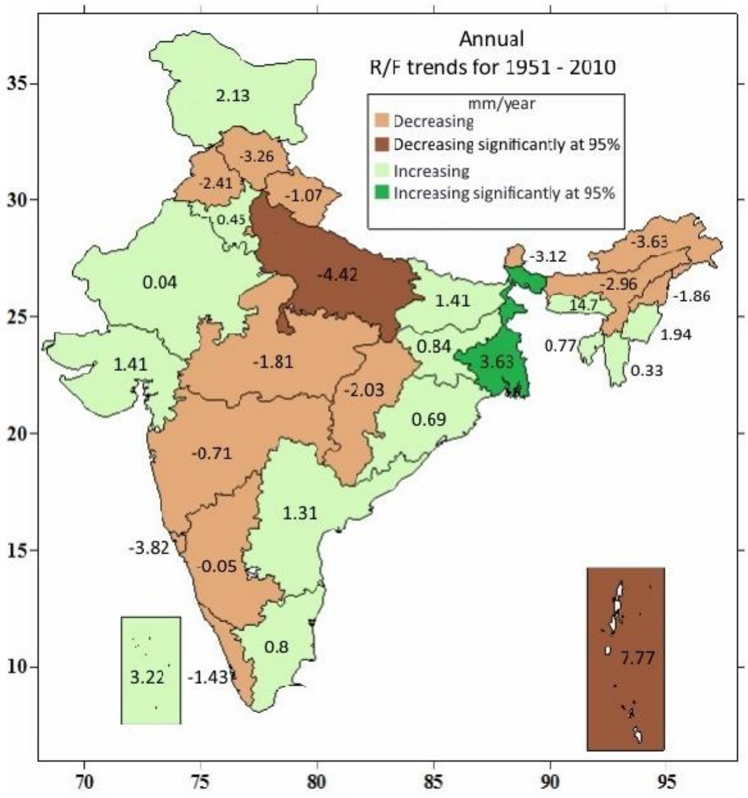
The Indian Meteorological Department (IMD) has been analysing climate data collected through a 60 years observation period (1951-2010) in order to quantify state level climatic changes in India. During the past 60 years a cumulative increase in the annual mean surface ***temperature*** of 0.6 °C has been recorded compared to a warming on a national scale by 0.4 °C in the last century. For the former State of Andhra Pradesh including Telangana, the annual ***rainfall*** trend showed an increase of 1.31 mm/year (IMD (2013), pp. 140 - 142). When comparing these trends with other States one can see that the increase in the mean annual temperature in Andhra Pradesh is similar to that of other states in Southern India (see Figure 5).

Figure 5: State level annual mean temperature trends (1951-2010):



Source: IMD (2013), p. 54

Figure 6: State level annual rainfall trends (1951-2010):



It is worth noting that the trends shown in the map (Figure 6) were assessed for the entire former State of Andhra Pradesh and thus need not be the same/similar for Andhra Pradesh and Telangana, separately (e.g. see IMD (2010), p. 29f., with several maps on rainfall data for Andhra Pradesh, Telangana and Rayalaseema region in different seasons).

Source: IMD (2013), p. 56

Monsoon periods are decisive for the annual precipitation regime and changes in the monsoon characteristics have been observed during the last few decades. As per the ***southwest monsoon***, there was a shift towards a later onset and also the period of main withdrawal was later. This is also reflected by the monthly rainfall trends: rainfall in June decreased in the central and eastern and July rainfall in most parts of India. In Telangana, this is indicated by a decreasing rainfall trend observed in June and July whereas rainfalls significantly increased in August during 60 years of observation (1941 – 2000). The duration of the southwest monsoon was reported to have increased during this time span, especially for the coastal regions of southeast India (and thus also parts of Andhra Pradesh). ***The northeast monsoon*** from October to December contributes considerably to the total annual precipitation. In the past, a high inter-annual variability has been observed for the northeast monsoon which caused both floods and drought years (IMD (2010), p. 33ff.).

Extreme temperatures are already occurring in Andhra Pradesh and Telangana due to ***heat waves***. However, changes in the characteristics of this climatic hazard have been observed. In the past, such periods were less frequent, shorter and less intense: between 1986 and 1993 the maximum duration was 7 days and the maximum temperature recorded was 47 °C. But from 1994 on an increase in the duration of heat waves was monitored (up to 19 days) and also a new maximum temperature of 48.8 °C was measured in 2002(Disaster Management II of Revenue Department of GoAP (2010) p. C3-30). Despite not reaching the record temperatures of 2002, the latest severe heat wave of May/June 2015 also entailed around 2500 deaths in India (The Telegraph (2015)).

Spread over all of India's coasts and for different seasons, the frequency of ***tropical cyclones*** generally shows a decreasing trend. But in the typical cyclone months (May and November) an increasing trend in the frequency of tropical cyclones over the Bay of Bengal is observed. Also their intensity appears to have increased (IMD (2010), pp. 65-66).

More detailed data recorded by IMD is provided in **Annex 4.**

Future projections

Climate projections are “what if” prognoses of the climate, which are based on different greenhouse gas emission scenarios (GIZ/PIK (2009), p. 12). These scenarios (now called “Representative Concentration Pathways (RCPs)”) are different ways in which the future of the world might turn out. The emission scenarios then feed various global climate models (i.e. computer models). For local assessments with better resolution and to take local climate features into account, Regional Climate Change Models (RCM) can be produced (ibid.).

It is worth noting that future climate projections include a degree of ***uncertainty*** due to various reasons such as predictions of greenhouse gas emissions, uncertainties within individual climate models or downscaling aspects (ibid., pp. 28-30). However, assuming uncertainty does not mean that there will be no change.

Generally, the IPCC has identified the following ***Climate Change Drivers (CCDs)*** for impact projections. Globally - marked in red are those which have relevance for Asia (IPCC (2014), p. 22):

Figure 7: Climate-related drivers of impacts globally

Source: IPCC (2014), pp. 21-22

Regarding climate change projections for ***India***, the Indian Network on Climate Change Assessment (INCCA) describes India as a whole and five regions (Himalayan, North-Eastern, West-Ghats and Coastal (subdivided into eastern and western coast) region). Andhra Pradesh and Telangana are situated in the ***eastern coastal region***, to which also the indicated changes projected by the RCM (refer to MoEF (2010), pp. 6-8)[5]. These are summarized in the Table 2. As precise regional projections of future sea level changes are not yet available, global projections are used (MoEF (2012), p. 152; IPCC (2007a)).

[5] Regional climate model (PRECIS) projections for India are based on the second generation Hadley Centre Regional Climate Model (HadRM2) as a global climate model. The emission scenario used for it is the IPCC Special Report on Emission Scenarios (SRES) A1B scenario which assumes significant innovations in energy technologies and improvements in energy efficiency (MoEF (GoI) (2012), pp. 99 - 101).

Table 2: Future climate projections for the eastern coastal region in India, sea level rise global – past recordings are provided for comparison (in grey)

Climate signal	When?	Projected changes
Air temperature 	1951 - 2010	• Observed rise for past 60 years has been 0.6 °C
	2030	• The rise in temperature with respect to the 1970s is around 1.6°C to 2.1°C; i.e. rise from 28.7 (+/- 0.6°C) to 29.3 (+/- 0.7°C).
Extreme temperatures	2002	• Maximum temperature measured so far was 48.8 °C
	2030	• Maximum temperature rises between 1 and 3.5 °C
Precipitation 	1951 - 2010	• Average mean annual Precipitation in Coastal Andhra (1018 mm/year), Rayalaseema (698 mm/year) and Telangana (930 mm/year)
	2030	• The increase in the 2030s with respect to the 1970s is estimated to range between 0.2% to 4.4%; i.e. total between 858 mm/year (+/- 10%) and 1280 mm/year (+/- 16%) in 2030. • Summer monsoon precipitation increases in the North (Telangana and northern coastal districts of AP) and decreases in the southern districts of Andhra Pradesh)
Cyclones 	1981 - 1990	• On average 4 cyclones (of which one has been severe) per year at the coast of Andhra Pradesh
	2030	• Decreasing number of cyclones but higher intensity projected
Sea level 	20^{th} century	• Estimated sea level rise of about 0.17 m
	2090s	• Sea level rise of 0.22 – 0.44 m globally relative to 1990s levels

Source: MoEF (2010), IMD (2013), IPCC (2007b), Revenue Disaster Management Department (2010) – past data is mostly based on recordings from IMD, past extreme temperatures based on Revenue Disaster Management Department, past sea level rise from IPCC; future projections are mostly based on PRECIS (A1B scenario), future sea level rise based on IPCC SRES (A1B scenario)

There has been an attempt to regionalize Global Climate Models (GCM) with different input scenarios for ***Hyderabad, Telangana***, as depicted in Table 3[6].

It provides two future scenario types: (1) B1 represents moderate global emission scenarios with a globally coherent approach towards a more sustainable development; (2) A2 presents scenarios that depict a more pessimistic development with lower trade flows, a slower technological progress and a subdivision of the world into distinct economic regions with less emphasis on economic, social and cultural interactions (IPCC (2000)). Also, two future time spans are given for the regionalized climate models: climate change projections for a near future for the time period 2046-2055 and for a more distant future for the time period 2081 to 2100.

Table 3: Downscaled future projections for Hyderabad (for two different scenarios and two different time scales)

Climate signal	Present	Future scenario	Projected future changes	
			(2046 – 2055)	(2081 – 2100)
Mean annual temperature	26.9 °C	B1	28.4 °C	29.1 °C
		A2	28.8 °C	30.7 °C
Annual precipitation sum	809 mm	B1	852 mm	890 mm
		A2	853 mm	888 mm
Change in heavy rain days (>80 mm/day)	0.49 days/year	B1	57 %	76 %
		A2	60 %	172 %
Heat wave days	1.2 days/year	B1	8.0 days	12.8 days
		A2	18.9 days	41.0 days

Source: Luedecke et al. (2010), pp. 12-18, see also there for standard deviation of projections

In summary, ***mean annual temperatures*** are projected to rise for both scenarios in Hyderabad. ***Annual precipitation*** is projected to rise in both scenarios (but slightly more under the B1 scenario). A change in ***heavy rain days*** is projected for both scenarios, but with a much higher increase under the A2 scenario. ***Heat waves*** are expected to increase as per both scenarios, also with a much higher increase under the A1 scenario.

[6] Locally recorded climate data were used as reference data and the projections listed in the table "Hyderabad Downscaled" – Model are weighted averaged values of the 17 global climate models, which were scaled down to the Hyderabad region.

2.3 Risks for industry and industrial parks

Possible impacts for industry and industrial parks

As shown above, climate change and its effects can trigger serious impacts on the national industry system, industrial estates, individual industries and specific production sites.

It has to be emphasized in this context, that the same climatic hazard hitting a well-planned and operated industrial area and one badly planned and/or managed, will most probably cause more severe impacts in the second case:

- badly planned and maintained storm water drainages will not be sufficient to bring increasing volumes of rain water away in appropriate time,
- badly maintained roads or other infrastructures are more severely damaged than well maintained ones,
- appropriate zoning of an industrial area can help to protect more sensitive elements and support their protection from being flooded,
- or a storm hitting well-designed and appropriately constructed buildings will cause less damages, as when hitting unstable and inappropriately maintained ones.

Furthermore, secondary effects caused by inadequate planning outside the industrial areas may also affect these. For example, if planning of the electricity sector failed to duly consider heavy droughts, these might cause shortages in electricity generation from hydropower plants running out of their driving force and thermal power plants running out of cooling water, and thus negatively affect industrial areas and industrial production or, if food processing companies exclusively rely on a small region for their primary products, such companies are more probably hit by adverse local weather events than the ones having diversified either their regional origin of primary products, or their production depending on various agricultural goods.

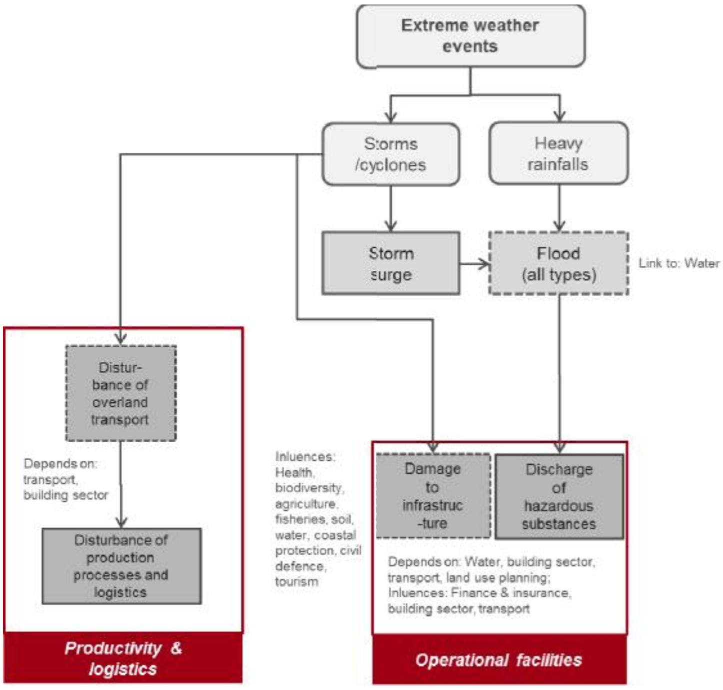
In Figure 10 below, the design and management of an industrial area are represented in the boxes “Susceptibility / Fragility” and “Resilience”.

Generally, there are various methods and tools available to analyse the effect that climate change can have on these entities. Examples include impact chains, vulnerability analyses or site specific risk assessments. Impact chains and vulnerability analyses are oftentimes used at national level, whereas risk assessments mostly apply to individual companies and sites.

Overleaf is an excerpt from a climate change impact chain for industry and commerce (see Figure 8) which was derived through a long dialogue process between science and industry in Germany. The impact chain depicts how climatic drivers (e.g. here extreme weather events) affect the single industries and their links. It not only shows that climate change propagates through the whole system and causes various direct and indirect impacts along the impact chain but also highlights that climate change is a cross-sectoral issue – it is affecting not only the industrial sector, but through impacts on this sector also has links to water, health, energy, building sector, biodiversity, agriculture, fisheries, coastal protection, civil defence, finance & insurance. It therefore requires dialogue of policy makers from various departments.

Considering the above, it becomes evident, that **inappropriately planned, unorganized and poorly managed systems like many industries and industrial areas in India are more vulnerable and at risk to impacts of climate change, than well-planned, organized and managed ones**.

Figure 8: Excerpt from a climate change impact chain for industry and commerce (for climatic driver extreme weather events only – other drivers are: precipitation changes, temperature changes and global climate change & other drivers)



Source: Translated from EURAC (2013) and slightly adapted to the Indian context

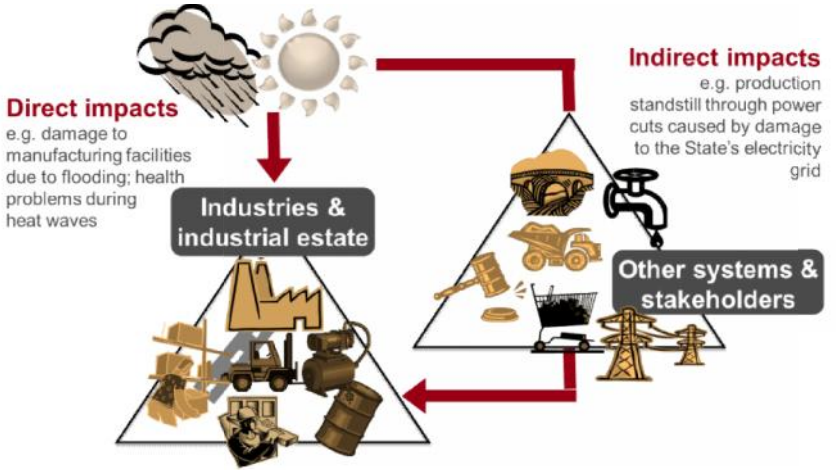
Industries and industrial parks do not operate in isolation but are, amongst others, embedded in the surrounding communities and influenced by market and regulation (see Figure 1 in chapter 1). When analysing the effects of climate change, one therefore needs to take a wider perspective. In that way, the direct and indirect effects of climate change on industries in the context of local conditions can be identified.

Direct impacts cause physical risks as they have the potential to usually entail physical damage within the production sites or industrial parks. Examples include damage to manufacturing facilities due to flooding, health problems during heat waves, contamination of waters and soils due to flooding of storage sites of hazardous materials or wastes.

In contrast, impacts on other systems outside a company's or industrial estate's control cause indirect risks, e.g. production standstill through power cuts caused by damage to the State's electricity grid.

This is illustrated by the figure overleaf.

Figure 9: Direct and indirect impacts on industries and industrial estates



Source:adelphi/GIZ (2014) Climate Expert, training slide 25

Deriving risks for industry and industrial parks

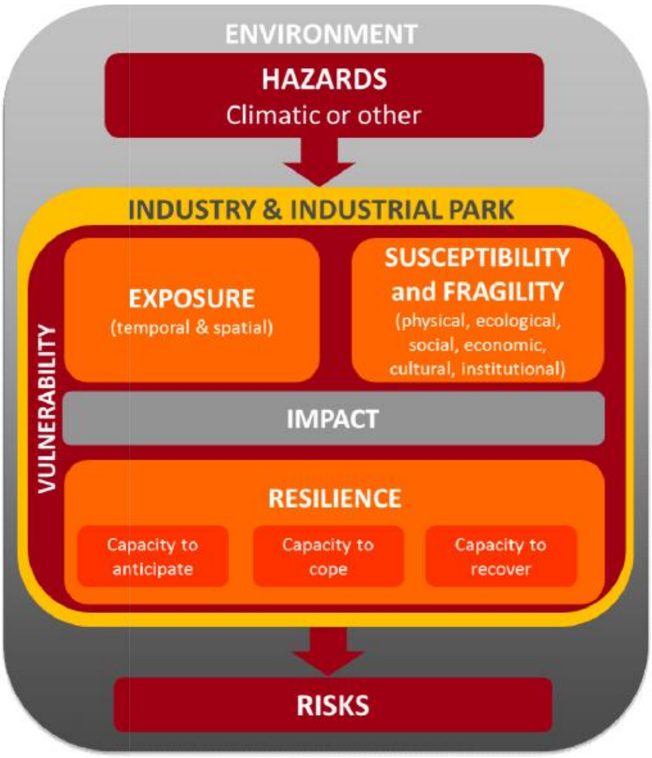
Generally, the proper identification of risks is a long process - checklists can support this process but cannot represent a final list of risks. Also, for a full risk assessment, each site would need to identify the relevant risk types, quantify the expected impact, analyse its resilience and assess the likelihood that the risk will occur. A ranking of risks could then be developed. As hazard protection is a public task, the corresponding exposure analysis at all levels should also be performed by a public institution (e.g. APIIC/TSIIC; IALAs). An individual company can then use the public data available for their location to combine it with its own susceptibility/fragility and resilience in order to derive vulnerability – and, where possible, derive the individual risks.

Figure 10 overleaf shows how hazards interact with the system of interest ultimately resulting in potential risks. The logic of the figure can be understood as follows:

The system of interest, e.g. an industrial area, is exposed to a specific hazard, e.g. a cyclone. The risk for the industrial park to be negatively affected by the said hazard is determined by three major parameters:

(1) The temporal and spatial ***exposure*** to events caused by the hazard, i.e. number and strength of cyclones hitting the IE;
(2) The industrial areas ***susceptibility and fragility***(also sensitivity) against cyclones, e.g. solidity of buildings / roofs, and infrastructures, design and maintenance of storm water drainage etc.;
(3) Its ***resilience***, e.g. efficiency and effectiveness of early warning, capacity of response teams, efficiency of disaster management etc.

Figure 10: Hazards, vulnerability and risks



Source: Amended from Welle (2011), slide 5

For analysing the risks for a system, e.g. an industrial area, the following approach is recommended:

1. As a starting point for a specific risk analysis, it is recommended to ***define and describe the system of interest*** for the analysis. E.g. to map an existing or planned industrial estate with its sub-entities, processes and system borders and to describe to what other entities (e.g. government through regulation, suppliers of water/energy/raw materials, transport systems etc.) it has important links.
2. ***Collect data on exposure*** from relevant climatic hazards and potential future climate change for the specific location. A maps-based approach can be helpful for this step.
3. ***Determine susceptibility and fragility*** for the particular system, e.g. building structures, drainage systems, condition of the work force, current status of greenery and water bodies, etc. – some examples were already presented above.
4. ***Describe the potential impact*** resulting from the exposure to climate change drivers combined with the susceptibility and fragility, e.g. by poor planning, management and maintenance. In many cases it can be helpful to distinguish between impacts under current conditions (without climate change), and the ones to be expected under climate change conditions. In both cases, high susceptibility is determined by e.g. poor planning and maintenance. But the expected impacts under climate change conditions might be even worse than without.
5. ***Determine the resilience*** of the system of interest.
6. Ultimately, ***derive potential risks*** by quantifying the potential vulnerability and the likelihood of occurrence.

Case study: Exposure and susceptibility to flooding of industrial estates in Aachen

The German City of Aachen published a guidebook for its industrial estates on climate change adaptation. Next to identifying climate change impacts and risks, it also encourages stakeholders to check criteria related to the exposure and susceptibility/fragility regarding climatic hazards and climate change. E.g. With respect to flooding these include the following parameters:

Parameters defining possible exposure to flooding:

- Location nearby a surface water body
- Location at a slope, sink or lowland in the vicinity of a water body (= flood plain)
- High groundwater levels

Parameters defining susceptibility / fragility of the site against flooding:

- High % of tarmacked, paved or built-up areas on site and in the immediate environment
- At-ground accesses and sensitive or high value items or usages at ground floor or basement level (e.g. ICT, building services technical equipment, heating, machinery, electric facilities, storage of moisture sensitive or hazardous materials, car pool)
- Mobile / uplift-prone assets (e.g. tanks) on site
- Low retention capacity of the existing sewage and draining system
- High dependency on supply chains and site visitors (i.e. high frequency of outside entities having to enter the site)
- High density of people (employees, clients) in the area (e.g. large number of people that would need to be evacuated)
- Dependency on boat transport (i.e. that would be unable to transport during flood events)
- In addition, structural safety and stability of buildings, age and current condition of buildings

As can be seen from the above list, susceptibility and fragility issues play an important role in determining the potential impacts of climate change on industrial estates. It is oftentimes the characteristics of the system of interest (such as improper sewage or drainage systems) that highly contribute to its overall vulnerability to climate change. This particularly holds true for industrial areas in India.

Source: Städte Region Aachen (2012), p. 23 and own elaborations

The following table shows general impact areas for industry and industrial estates, provides suggestions on who is primarily affected and of exemplary risk types.

Table 4: General climate change impact areas for industry and its context

Impact area	Primarily affected	Resulting risk types and examples
Industry park and industries		
Location	Industrial park	The location of an industrial park determines its overall exposure to climate change. E.g. a low-lying site close to the sea is more prone to sea level rise or a site situated in the flood plain of a river more flood-prone. *For example: damage to coastal industrial areas and buildings from sea level rise (which could, in extreme cases, require relocation).*
Site layout	Industrial park	With regards to site layout, closely situated buildings without green spaces can increase heat island effects. Also, depending on the sensitivity of specific industries to flooding, these might need to be placed on elevated areas within a park; similarly for storage facilities of hazardous materials or critical infrastructure. *For example: buildings are situated too close to each other without green/blue spaces in between and cause heat island effect leading to higher temperatures in outdoor and indoor work spaces (ultimately, causing lower productivity of employees).*
Infrastructure	Industrial park, (State)	Storms and floods may cause damage to the wider infrastructure. The overall physical infrastructure of an industrial park and its input/output routes, which could be affected, must be taken into account. This also includes revising the operations and maintenance. *For example: damage to roads from floods (e.g. subsurface erosion); damage to water or power supply; clogging of drainage and sewer system during heavy floods which causes sewer overflows, damage to transmission and distribution grids causing power cuts and stop of production, as well as of all other services*
Buildings	Industry, Industrial park	Storms and floods may damage buildings within an industrial park and other physical assets that belong to the industries or the industrial park. *For example: damage to buildings from strong winds, in particular to roofs and facades.*
Industrial processes	Industry, (Industrial parks,) State	Access to inputs, including water and energy, can become increasingly unreliable. **For example, during summer already many clusters in India face electricity cuts, sometimes of 8 hour and longer. As the number of hot days increases, so does the number of blackouts.** *For example: increasing frequency of power-cuts from the grid (which then can lead to production stops or to an increasing need of diesel-generators at higher costs); shortage of cooling water for electricity production*

Impact area	Primarily affected	Resulting risk types and examples
		causes controlled load-shedding
Stock (on site)	Industry	Storage on site can be affected both by gradually changing climate, as well as by extreme weather events. *For example: raw material may get moist and unusable in case of heavy rainfalls.*
Employees (& Management)	Industry	The working conditions of employees are expected to deteriorate due to climate change impacts. Climate impacts may then result in losses in productivity; companies may see increased absenteeism of workforce and decreased productivity due to the impact of more severe weather events and declining health. *For example: physical stress due to increased indoor and outdoor temperatures, deteriorating air quality and increased UV radiation (causing lower productivity).*
Market, supply chain, finance and insurance		
Logistics	Industry, State	Supply chains are affected because both the suppliers and buyers face impacts of climate change and because of transport risks. *For example: a flood in China may drive prices for cotton up in the long-term, while also stalling the production of yarn at a supplier there and delaying a truck already on the road to a textile company in North India.*
Market	Industry, Industrial Park	In the face of climate change, certain products and services can become less relevant or ineffective. The regional impacts of climate change may lead to changing consumer behaviour; or in terms of industrial parks to lower demand for plots that are at risk (e.g. flood-prone). *For example: sales price variations and default risks due to changed consumer patters.*
Finance & insurance	Industry, Industrial Park	Climate change may affect the financial situation of an industrial company or industrial park, including higher interest rates or even financing difficulties in particular affected areas. Damages due to more frequent and/or more intense weather events may lead to rising insurance costs. Furthermore, **an industrial company or industry park could become liable and face damages** claims from surrounding communities, in case it has not adequately prepared for foreseeable events; for example, a company may need to pay reparations in case a flood caused toxic outflow. *Exemplary risk type: higher insurance costs and less insurances willing to cover risks.*
Surrounding communities, wider infrastructure, and environment		
Community	Industrial park, State	The relationship between an industrial park and its surrounding community may suffer due to climate change impacts. *For example: both may be competing for water resources; or increased pumping activity by the company may lead to a falling water table.*

Impact area	Primarily affected	Resulting risk types and examples
Policy and regulation		
Policy & regulation	State (regulate), Industrial park, Industry (implement)	Restrictive policies in response to climate change challenges as well as supporting programmes to encourage companies in implementing adaptation may influence industrial businesses and industry parks; further, business opportunities may arise due to adaptation efforts at national, state and communal levels. *For example: higher compliance costs for industry and industrial parks.*

Source: Based on GIZ/SIDBI/ Adelphi's (2013) Climate Expert adopted for industry and industrial estates

In ***Annex 5***, an initial long-list of different types of risks that have been derived through literature research is provided. Also, a list of risks for different types of industries is given in ***Annex 6***.

Case study: Major climate risks for an industrial estate in Gujarat

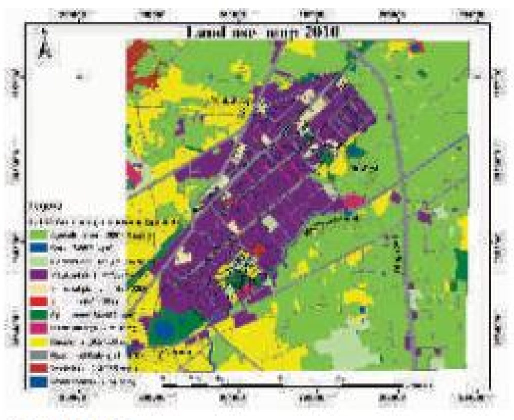
The Naroda Industrial Estate was established in 1964 and is located in the north-eastern part of Ahmedabad. Today is accommodates more than 1,200 industries.

The two major climatic concerns identified for the Naroda Industrial Estate are:

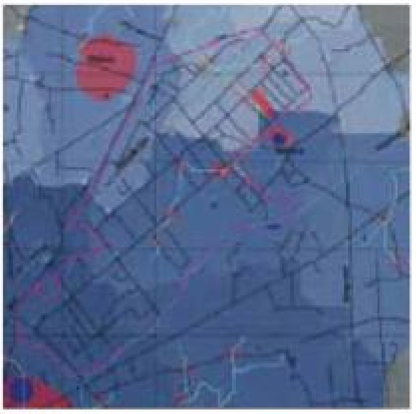
1) Floods from increased precipitation and
2) Rise in temperature leading to heat/radiation stress.

The flood hazard analysis shows that at present more than 50 industries may face the risk to shut down in a flood event; in the case of severe floods this number could increase to 300.

It is worth noting that the vulnerability to flooding usually entails several factors: the exposure to heavy rainfalls / flooding based on geographical location can be a result of bad planning and the susceptibility of the estate to flooding is partly rooted in insufficient infrastructure (e.g. lack of proper drainage system or maintenance management) and environmental issues (e.g. no absorption capacity of ground and vegetation).



Pic: Land use


Pic: Flood prone areas

Source pics: GIZ/FICCI (2012), p. 61

Next to the flood hazard, areas with heat island effect have been identified in the estate, where the risk of increased energy demand of the industries to maintain the required temperature levels pertains. Workers productivity could also be affected due to higher temperatures.

Source: GIZ/FICCI (2012), pp. 59, 61-63 and own elaboration

3.How to deal with the risks?

3.1 Introduction to adaptation to climate change

What is adaptation to climate change?

As depicted in chapter 2, the States of Andhra Pradesh and Telangana are facing a range of climatic hazards and the climate is changing. It is mostly the extreme weather events such as cyclones that bring the issue to our minds, but it is also the slower changes such as rising temperatures, changing rainfall patterns or sea-level rise that will continue to alter peoples' lives globally. Even with climate change mitigation efforts (e.g. Copenhagen-Cancun scenario described in chapter 1), the greenhouse gases that are already in our atmosphere will remain there for decades or centuries to come and will influence our climate (UBA (2013a)).

Good news is that we can deal with the already observable consequences of climate change and effectively prepare for those to come. This is where climate change adaptation comes in which refers to ***"the process of adjustment to actual or expected climate and its effects"*** (IPCC (2014), p. 5).

Timely and active adaptation to climate change may reduce or even prevent damage and can also open up opportunities arising from climate change.

Some of the questions arising in this context for policy makers and planners, industrial parks and individual industries are - for example:

- **For policy makers, planners and suppliers:** How can we guarantee that electricity supply is continued during extreme weather events and with changing rainfall patterns? Will it be necessary to adapt energy systems? How can we ensure that industrial sites are safe despite changing climatic hazards? Do we need to change planning requirements for industrial site selection and development?

- **For industrial parks:** How will floods continue to affect the infrastructure and buildings of our site, e.g. electricity, water, sewers, lights, waste, roads, warehouses and storage facilities, ICT. What belongs to the critical infrastructure and do we need to adjust or relocate it? Do we need to revise the maintenance of drainage channels and sewer systems? How can we work with the individual industries to ensure that best suitable plots are allocated (e.g. industry with hazardous materials not in flood-prone area)?

- **For individual industrial businesses:** Do we need to adapt our products, processes and strategy in the light of climate change to avoid increases in costs or losses in revenue? Do we need additional back-up systems or reserves to improve our resilience? Can we create new products or services that exploit opportunities arising from climate change?

Climate change, both mitigation and adaptation, disaster risk management and sustainable development are often discussed and considered by separate communities and understood as separate goals and processes. However, we strongly suggest to pursue an integrated approach understanding adaptation to and mitigation of climate change, disaster risk management and sustainable (industrial) development as interlinked and closely connected processes all striving to improve and ensure livelihood conditions of existing and future generations (please refer to I. Kelman et al. (2015)).

A policy perspective to climate change adaptation

In India, climate change adaptation is on the political agenda; however, up to now it is only partly reflected in national and state action plans, which are more focusing on climate change mitigation than on adaptation. Policy action is required to set up the framework for successful adaptation through e.g. mainstreaming climate change issues into the relevant policy fields, setting the framework of responsibilities, approaches and procedures to identify, plan and execute the required actions, cater for the necessary financing, but also to sensitize stakeholders and promote political discussion. As climate change impacts are oftentimes local issues, district authorities and local planners also play a crucial role in developing, financing and implementing local adaptation measures. After all, policy and planning provide the framework in which industrial parks and individual industries operate.

This includes, for example:

- Planning regulations for industrial sites taking up matters of sustainable industrial development, comprehensive disaster risk management and adaptation to climate change,
- Environmental impact assessments duly considering and addressing threats caused by climate change,
- Disaster risk management plans and structures including relief and recovery programmes comprehensively and consistently considering future climate risks,
- Public funding schemes or public (private) insurance initiatives, which so far do not include increased risks and damages from climate change.

An (eco-) industrial park's perspective to climate change adaptation

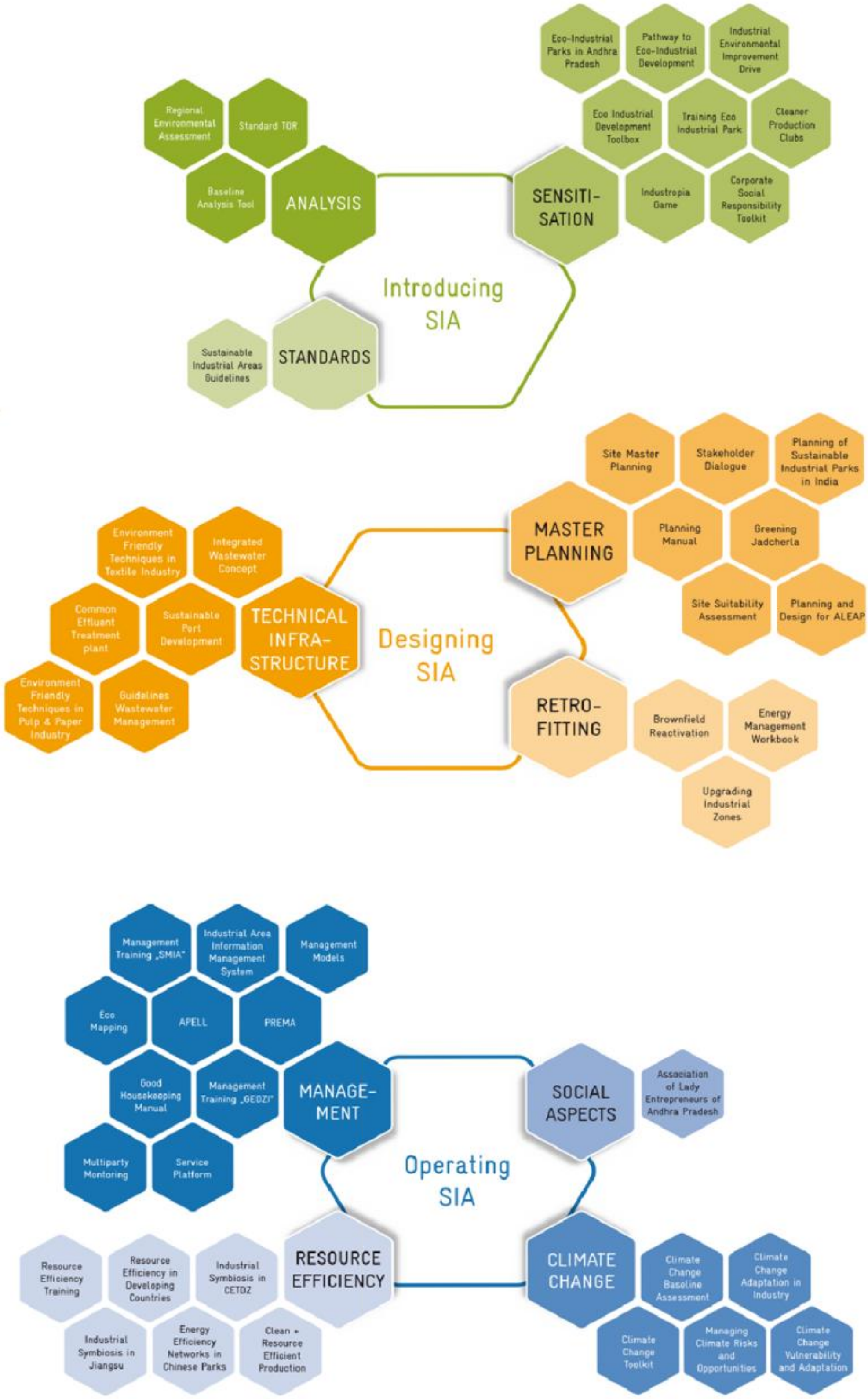
It is the main objective of an industrial park to provide the relevant infrastructure, buildings and support services that are needed by their clients, i.e. the individual industries on site.

Eco-industrial parks (such as the APIIC initiative) aim to promote sustainable industrial development, to improve the industries' environmental performance regarding management of materials, energy and waste, and to address social and health issues related to both the workers as well as the surrounding communities.

Figure 11overleaf depicts potential interventions for industrial parks as developed under the GIZ approach for Sustainable Industrial Development (or) Areas (SIA).

Several of these have potential synergies with climate change adaptation. For example, resource conservation could help in dealing with reliability issues for inputs for industrial processes despite a changing climate and increase in resource efficiency can also improve the competitive advantage of an industrial park and its industries, etc.

Figure 11: Interventions for sustainable industrial developmentin industrial parks



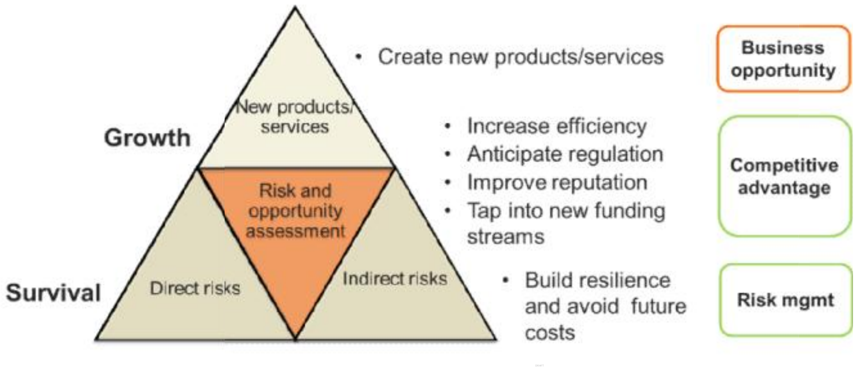
Source: GIZ SIA (2015), p. 5

However, so far these interventions have only been implemented from case to case. Overall mainstreaming of the approach and interventions into policies and procedures is still pending. In this respect adoption of a CCA policy for planning, development and management of industrial states would also be an important step to further strengthen and establish the eco-industrial development approach.

A business and economics perspective to climate change adaptation

In order to achieve climate change adaptation in industrial estates, it is very important to get the individual businesses on site on board. From a business perspective, adaptation assures survival and enables growth of industrial businesses in times of changing climate as depicted by below graphic. As a basis, risks from climate change are reduced which can involve spending financial resources. However, on the other hand, the competitive advantage can be increased (e.g. by reducing costs and increasing efficiency) and ultimately, even new business opportunities could arise through adaptation (e.g. new products such as efficient water pumps for flood events).

Figure 12: A business approach to adaptation



Source: adelphi/GIZ (2014) Climate Expert, training slide 33

In order to build resilience and avoid future costs, climate change adaptation aspects should be integrated into the risk management process of an industrial company or an industrial estate.

In terms of opportunities, climate change adaptation provides links for business in five areas (adapted from adelphi/GIZ (2014), training slide 45):

1. **Opportunities for cost reduction in operations** (e.g. improved water or energy management in companies reduces costs and at the same time vulnerability to climate change; rainwater harvesting and storage can unload water supply during dry seasons, recycling of water can reduce consumption);
2. **Opportunities for improving an industry's or industrial park's reputation among key stakeholders** (e.g. joint water project with a neighbouring community like recharging of ground water body with recycled water or harvested rainwater to strengthen local water resources and reduce pressures on these);
3. **Opportunities for developing the skill-base for the future** (e.g. training programmes for industrial park staff and industries on energy efficiency, water resource management and efficient use of water);
4. **Opportunities for anticipating regulation and becoming a first-mover** which can result in a competitive advantage to other companies not following the respective development (e.g. staying informed about regulatory developments through participation in industry fora, dialogue processes, etc.);
5. **Business opportunities in new markets for adaptation products and services or from tapping into climate finance opportunities** (e.g. energy efficient water pumps; new insulation materials for industrial buildings; consulting services on industrial site

layout taking into account climatic hazards; securing financial resources through climate change adaptation finance to upgrade industrial parks and individual industries).

It is worth noting, that a great number of opportunities only stem from actual adaptation to climate change. However, there might also be some advantages arising as a direct result of climatic changes themselves, e.g. wherever there is a relation to temperature (e.g. air/water heating requirements) this could be turned into an advantage (e.g. improved energy balance). Or other options for the use of renewable energies (e.g. solar, wind) could arise from changing weather patterns (Städte Region Aachen 2012, p. 15).

3.2 Adaptation strategies and options

General adaptation strategies

There is a whole range of approaches towards adaptation from technical solutions like building sea walls to "soft" measures like awareness raising and knowledge sharing. Many technologies appropriate for adapting to climate change are also appropriate to meeting sustainable industrial development objectives. Below table illustrates some general adaptation strategies.

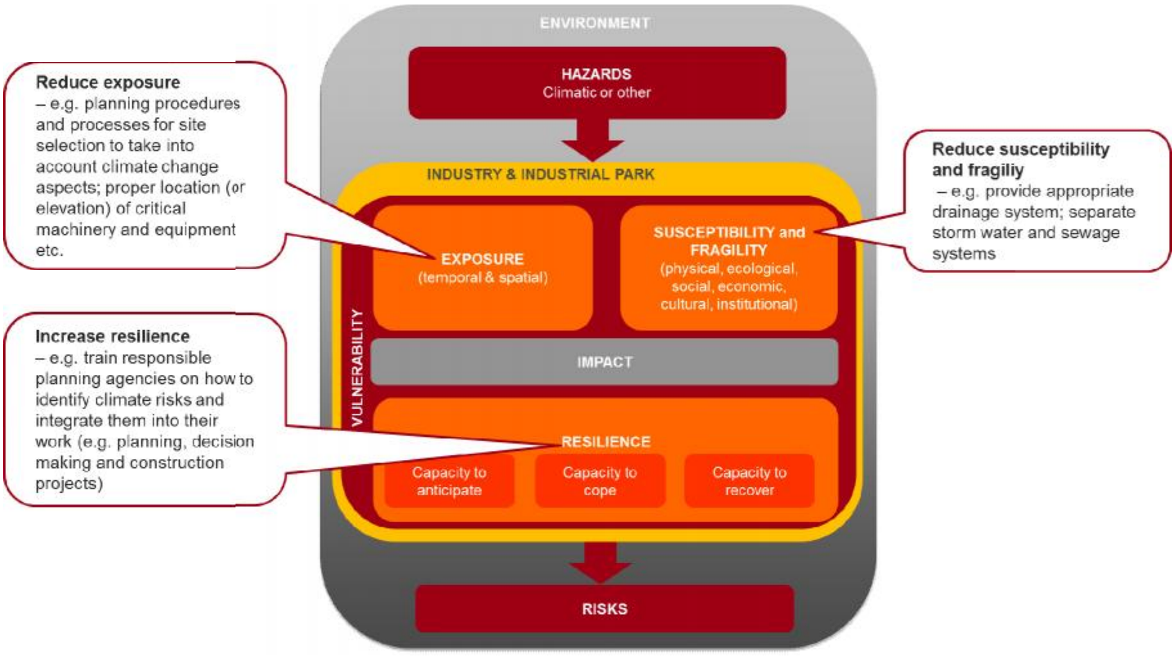
Table 5: General adaptation strategies

Strategy	Example
Share losses	Cover potential losses through a) financial support (relief) from State in case of major damages caused by disasters and b) promotion of specific insurance products
Modify threat	Change the maintenance of drainage channels, improve drainage capacity and reduce extent of frequency of flooding
Prevent impacts	Redistribute water or start rain water harvesting and storage to avoid scarcity; refurbish buildings to better protect against heat, plant trees to improve micro climate and reduce heat islands
Change (resource) utilisation	Change suppliers or supply chain management towards less exposed suppliers and routes
Change location	Relocate industrial site or plots on site e.g. to reduce flood risk for sensitive industries or infrastructures
Research	Improved research on water usage in industrial processes – and implementation of the findings
Change behaviour and rules	Rainwater harvesting; water conservation, establish regulations for maintenance and operation of infrastructures, e.g. storm water drainage

Source: Based on GIZ/OECD Adaptation ToT slides draft; based on OECD policy guidance adapted for industry

Ultimately, the aim of adaptation is to reduce the risks from climatic hazards and climate change. In relation to the approach suggested in this report (see Figure 10), adaptation could aim at reducing exposure, at reducing susceptibility / fragility and / or at increasing resilience. Below figure provides examples in that respect.

Figure 13: Adaptation examples with respect to exposure, susceptibility / fragility and resilience



When developing adaptation measures, it is important to take into account the ***uncertainties*** in projecting and quantifying future climate change and the probability of occurrence of specific hazards/events. This includes considering ***"no-regret", "low-regret", "win-win" and "flexible / adaptive" adaptation options*** as described overleaf.

"No-regrets" options: Adaptive measures that are worthwhile (i.e. they deliver net benefits) whatever the extent of future climate change will be. These types of measures include those justified (cost-effective) now under current climate conditions and are further justified when their introduction is consistent with addressing risks associated with projected climate changes. These options are particularly appropriate for the near term as they are more likely to be implemented (due to obvious and immediate benefits).
Example: Investments into leaky water supply systems or in damaged storm water drains.

"Low-regrets" options: Adaptive measures for which the associated costs are relatively low and for which the benefits (although primarily realised under projected future climate change) may be relatively large.
Example: Sharing development and operations of additional water storage facilities (e.g. water groups building and operating a joint water reservoir).

"Win-win" options: Adaptation measures that have the desired result in terms of minimising the climate risks or exploiting potential opportunities but also have other social, environmental or economic benefits (e.g. contribution to climate change mitigation or other social and environmental objectives).
Example: Green roofs and green walls which have multiple benefits in terms of reducing building temperature and rainfall runoff from buildings, and increased green spaces within urban areas, but also reduces energy use for both heating and cooling.

Flexible/adaptive management options: Refer to incremental adaptation options, rather than undertaking large-scale adaptation in one stage only. This approach reduces the risks associate with being wrong, since it allows for incremental adaptation. Often such a decision to delay introducing a specific action is taken when the climate risks are below defined thresholds or when the required adaptive capacity (e.g. Institutional circumstances) is insufficient to allow effective action.
Example: Delay implementing specific adaptation measures while exploring options and working with appropriate levels of government or industry associations to build the necessary standards and regulatory environment.

Source. GIZ/FICCI (2012), p. 38f.

Exemplary adaptation options for industry and industrial parks

With respect to adaptation to climate change for industry and industrial parks, it is worth distinguishing between existing sites (i.e. retrofitting) and new sites (i.e. planning).

Below list provides ideas for adaptation options for the ***retrofitting of existing industries and industrial estates as well as for newly planned estates***. An additional row highlights options that are relevant to all industrial estates irrespective of their stage (i.e. planned and implemented).

Colour-code for adaptation options for below table is as follows:

Retrofit of existing industrial parks	Newly planned industrial parks	For both (existing and newly planned industrial parks)

The options are, as in the previous chapter on risks, related to the different climate change impact areas within industry and industrial sites. In addition, responsible initiators for each option are suggested (in implementing the measures, other entities might then be required to support).It has to be emphasized, that planning and implementation of most of the measures in existing parks requires prior sensitization of and consent amongst the stakeholders.

Generally, the developer in this context is the Industrial Development Corporations such as APIIC/TSIIC or a private developer. The operator is the industry park or, in this case, the IALA together with the Service Society or a private operator.

Table 6: Examples of adaptation options for existing / newly planned industry and industrial estates

Impact area	Adaptation options [and responsible initiators]
Industry park and industries	
Location	• Planning procedures and processes for site selection to take into account climate change aspects [Government (planning) / Developer] • Train responsible planning agencies / departments on how to identify climate risks and integrate them into their work (e.g. planning, decision making and construction projects) [Government (planning)/ Developer]
Site layout	• Development and implementation of rehabilitation plans for already affected sites / areas within a site (incl. incentives or compensation for resettlement for the industries) [Operator of the site with help from the Government] • Retrofit green and blue spaces on site to avoid or mitigate heat islands [Operator of the site] • Reduction of sealed surfaces; intermediate storage of water in open landscape [Operator of the site]
	• Plot allotment guidelines taking into account proper zoning and climate change [Developer] • Site planning to avoid heat islands by including green and blue spaces and enough space between buildings [Developer] • Site planning to include sufficient drainage and run-off areas for rainwater, minimize sealed surfaces; intermediate storage of water in open landscape Developer]
	• Avoid erosion of slopes (e.g. through planting of scrubs and trees; terracing) [Operator / Developer] • Plantations and walls against strong winds [Operator / Developer]
Infrastructure	• Retrofit drainage systems to cope with flooding [Operator / industries] • Exposure reduction through relocation (or elevation) of critical infrastructure (retrofit) [Operator of the site or individual industries in their premises]
	• Provide appropriate drainage system; separate storm water and sewage systems [Developer] • Ensure non-exposed location of critical infrastructure Developer]

	• Assess the vulnerability of major industrial hubs to climate related risks [Government (agencies on industry, planning, environment & climate change) and industrial stakeholders] • Allocate budgetary funds to upgrade of industrial park infrastructure [Government/Developer] • Installation of decentralised / renewable energy supply; ensure sustainable electricity backup Developer / industries] • Provide sufficient cooling for ICT facilities and production processes [Developer for public buildings during planning, Operator of the site for public buildings, individual industries in their premises] • Install measures to protect infrastructure from flooding [Developer / Operator] • Establish grey and rainwater harvesting, set up own water storage facilities (rainwater harvesting, reuse of treated water),set up alternative irrigation schemes for green spaces (e.g. drip-irrigation, rainwater harvesting, recycling of treated water) Developer /Operator] • Proper maintenance and cleaning of draining channels regularly to allow water to discharge [Operator] • Maintain roads to avoid subsurface erosion [Operator] • Create emergency plans (e.g. also for occurrence of multiple risks at same time) [Government to establish requirement and guidelines/Operators to implement]
Buildings	• Improve the disaster preparedness of storage facilities for hazardous materials [Government (National Government / NDMA providing / amending / updating respective guidelines and standards, state factory inspectorates executing inspection)/Operator /Industries] • Improve insulation of buildings (retrofit), retrofit green roofs [Operator/ Industries]
	• Exposure reduction via structural measures (e.g. elevate buildings) [Developer / Industries] • Climate resilient design standards / building codes [Government], specifications for industry buildings on site [Developer] • Proper insulation of buildings; build green roofs; optimise number and size of windows; high thermal mass of walls (best for inside walls to use temperature time delay for heating/cooling); use reflecting or absorbing window glass [Industries / Developer] • Optimise building orientation (i.e. to avoid sun radiation on walls – East/West walls receive most of the low-lying sunshine) [Industries / Developer] • Install roofs that can cope with storms (e.g. 30° roof pitch or appropriate fixation of materials) [Industries/Developer] • Avoid superstructures that are susceptible to vibration from winds (e.g. tall masts) or ensure appropriate fixations [Industries/Developer]
	• Shading, ventilation and cooling of buildings to reduce indoor temperatures [Industries / Developer / Operator]
Industrial processes	• Exposure reduction through relocation of critical machinery and equipment [Industries] • Adapting cooling capacities for processes and facilities for production processes to expected exposure in time [Industries]
	• Exposure reduction through proper location (or elevation) of critical machinery and equipment [Industries]

	• Increase water efficiency in production processes; increase re-use quota of water to avoid lack of resources stemming from water shortages [Industries] • Use renewable energy as decentralised power supply (to reduce dependency on pot. damaged grid) and increase energy efficiency in production processes to reduce energy load in order to install decentralised energy supply [Industries] • Increase resource efficiency in production processes to be less dependent on suppliers that might default during climatic events [Industries] • Include flexibility in production steps [Industries]
Market, supply chain, finance and insurance	
Logistics	• Integrate climate change aspects into the risk and innovation management processes of the company (e.g. supply risks) and identify critical components [Industries] • Communicate identified climate risks to suppliers [Industries] • Diversify suppliers to reduce dependency (multi sourcing) [Industries] • Increase storage of critical supplies (to be less dependent on just-in-time deliveries) [Industries]
Stock (on site)	• Shade and cool storage facilities [Industries / Developer / Operator] • Provide shelter roofs for external storage areas [Industries/Developer/Operator]
Management &OHS of employees	• Establish sound and resilient overall management practices for the industry park that allow for implementation of climate change adaptation aspects and supervision thereof [Operator] • New work practices to avoid heat stress among outdoor workers [Industries / Operator] • Supply of drinking water to staff [Industries / Operator] • Provision of shelter and resilient assembly places for staff [Industries / Operator] •
Market	• Diversify products and selling markets to be less dependent on one market that might be affected by climatic hazards [Industries] • Investigate in potential business opportunities through changes in customer preferences (e.g. cooling technologies) [Industries] • Development of climate friendly and resilient products [Industries] • Promote diversified and dispersed industries, including small/medium scale agro processing, to stabilise agricultural livelihoods [Industries]
Finance & insurance	• Promote public-private risk reduction initiatives [Government] • Insurance of companies and sites against natural disasters [Industries / Operator • Communicate good risk management regarding climate change risks to potential investors [Industries/Developer/Operator]
Surrounding communities, wider infrastructure, and environment	
Community	• Establish dialogue with the communities on climate related matters (e.g. water usage) [Operator / Developer] • Set up joint early warning systems [Operator / Government]
Policy and regulation	
Policy &	• Mandatory environment impact assessments to include climate change aspects (“climate proofing”) [Government]

regulation	• Review of current standards and regulations to take into account climate change aspects [Government] • Review of current funding schemes to include sources of funding for climate change adaptation [Government] • Establish provisions regarding minimum width of buffer zones / no settlement zones around industrial areas [Government] • Ensure compliance with relevant legislation [Industries / Developer / Operator]

Source: Compilation of various sources (e.g. IPCC (2014), Prognos/adelphi (2014), EPTRI (2012), Städte region

Case study: Exemplary adaptation options for an industrial estate in Gujarat

Based on the baseline and vulnerability analysis and the subsequent stakeholder discussions at Naroda Industrial Estate in Gujarat, the following adaptation options were suggested. The concept has been recently approved by GIDC and implementation is under tendering process:

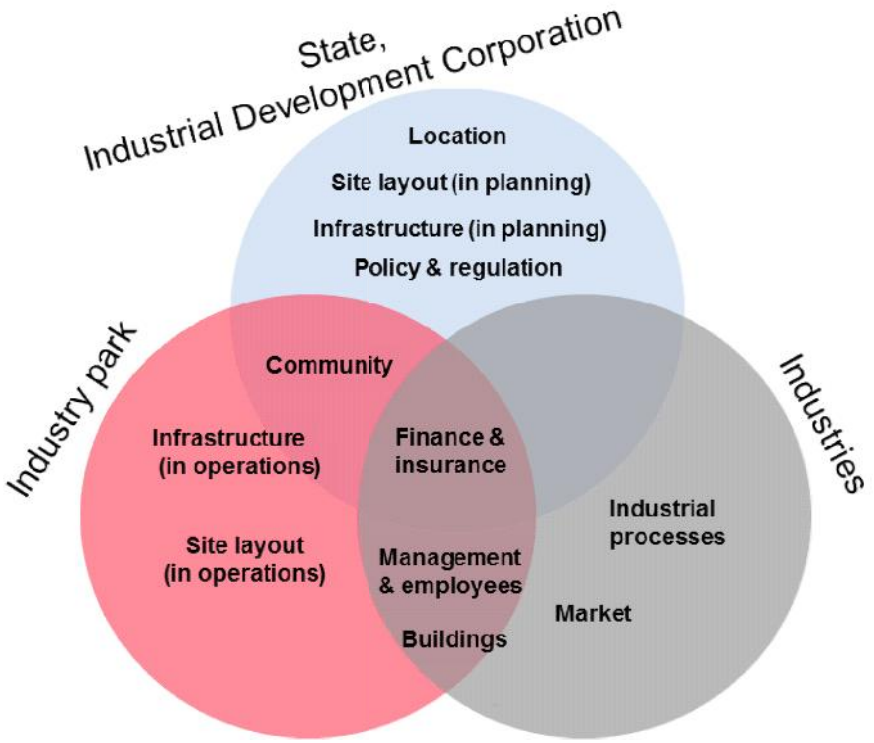
Climate hazard	Adaptation option
Floods	• Storm water drainage plan for vulnerable, low-lying areas that are susceptible to water logging • Increasing the water storage capacity and integrating it into the landscape of the industrial estate • Reduction in run-off through increased green cover • Special species of trees are suggested to be planted in all flood prone and erosion areas
Heat waves & increasing temperatures	• Increased green belts, particularly in the heat island areas identified • Special species of trees are suggested to be planted in all heat islands • Adjustments for ventilation, lighting, building material etc. for industrial buildings
General	• For handling social vulnerability aspects, suggestions have been made for improvement of basic amenities (drinking water, toilet facilities, solid waste management and separate storm water and sewage lines; also provision of transportation for workers and health facilities for workers and their families • Creation of safe shelter and assembly places in case of climate or industrial disasters

Source: Based on GIZ/FICCI (2012), p. 64

Aachen (2012)), Dierks et al. (2002)) and own elaborations

Regarding the responsible initiators for adaptation measures in industries and industrial parks in India, the following graphic summarises the key responsible initiators per impact area:

Figure 14: Key initiators for adaptation options per impact area



The next chapter will explore in more detail how climate change adaptation can be anchored sustainably within the industries and industrial estates.

4. What strategy and measures apply best to minimize risk?

The risks that are already prevailing for industries and industrial estates and that will most probably be increased by the impacts of climate change call for a policy shift.

This shift entails ***as a first and fundamental step a joint commitment of all parties towards sustainable industrial development including climate change adaptation***. Only then the required adaptation efforts can be implemented in a sustainable manner to avoid serious, long-term losses and damages to industrial development and to harness the opportunities arising. Although, such a commitment was already a key element of the eco-industrial park concept, it needs to be reinforced and amended, acknowledging the new challenges and opportunities.

There will be conflicting interests regarding strategies and details of actions to achieve and ensure sustainable industrial development. However, such conflicts are neither necessarily preventing a joint commitment to the overarching goal of sustainable development nor making it dispensable. In fact, conflicting interests are an essential and inevitable part of such a process. The prominent task is to jointly come to an agreement on both, the process to find the best possible consent, as well as the rules and framework to take and accept overruling decisions.

To promote, foster, and bring to practice such a joint commitment, key actors, such as industrial infrastructure corporations, need to take the stake and to first commit themselves through a policy, to mainstream climate change adaptation into their overall mandate, corporate identity, and institutional setting, and to thoroughly adapt their planning and management procedures for industrial infrastructure development.

In doing so, and through consequent translation of the cornerstones of their policy into reality, and in dialogue with other key actors, industrial infrastructure corporations can take leadership in advocacy for, and realization of climate change adaptation and sustainable industrial development.

Next to ***policy mainstreaming***, ***awareness building, communication, capacity development, proper identification of risks*** for each industrial site and its vicinity, and ***realization of appropriate measures*** through appropriate planning processes and financing instruments are key for that shift. All these fields will be addressed by the Joint Project for adaptation to climate change in industrial parks. The project's strategy to achieve this will be further detailed and discussed in the following chapters of this report.

Below table illustrates the key elements to be addressed by a policy for climate change adaptation in industrial areas for industrial infrastructure corporations and their possible sequence.

Table 7: Toeholds for APIIC/TSIIC Policy on Climate Change Adaption

Field of action	Toeholds
Integrate climate change adaptation in the ***overall mandate*** of APIIC/TSIIC	• TSIIC / APIIC substantiate their previous commitment to the development of eco-industrial parks and sustainable industrial development; • TSIIC / APIIC acknowledge and emphasize adaptation to climate change and disaster risk management as key elements of both eco-industrial parks and sustainable industrial development; • The objective to promote and advocate for effective and consistent adaptation to climate change is integrated into the corporations' identity, vision and mission; • APIIC / TSIIC understand climate change adaptation as

<table>
<tr><td></td><td>a key element of good governance in general, and for sustainable industrial development in particular;
APIIC / TSIIC establish a standard for eco-industrial estates and climate change adaptation; e.g. considering the “GIZ Guidelines on Sustainable Industrial Areas”.</td></tr>
<tr><td>⬇</td><td></td></tr>
<tr><td>Mainstreaming of climate change adaptation into the institutional setting of APIIC/TSIIC</td><td>
Anchor climate change adaptation in the organisational framework of TSIIC /APIIC to make it fit for efficient promotion and realization of climate change adaptation:

Establish a CCA cell or department being responsible for steering, guiding and supervising CCA in all relevant processes and departments, and for promoting and further developing the CCA policy and framework;
Equip the organizational entity or line positions with a mandate to operationalize CCA;
Establish clear decision making structures;
Allocate resources, staff and budget;
Mainstream CCA into the line departments.

Mainstream climate change adaptation into the organisation’s procedures:

Establish CCA as key element of a comprehensive planning procedure for sustainable industrial development
Integrate CCA in the comprehensive planning procedures for new IAs and retrofitting of IAs; this includes e.g.:

Climate Risk Analysis as a key instrument
Stakeholder participation
Procedures for decision making

Integrate CCA into technical provisions and standards, e.g. for industrial buildings, infrastructures, operations as well as park infrastructures and operations;
Allocate, respectively mobilize financial resources for implementation of CCA, considering CCA as key element of good governance:

Consider CCA for planning of new industrial areas in the standard budget planning;
Mobilize additional financial resources for retrofitting and increasing resilience of existing industrial areas;
The last two could be promoted through establishment of funding opportunities for adaptation projects at IP or industry level similar to the EU SWITCH Asia or the German IKI funds.

Provide internal Capacity Development for CCA and related to sustainable industrial development for IIC staff and IALAs.
Promote Capacity Development for CCA and related to sustainable industrial development for external stakeholders like industries, planners, etc.
</td></tr>
</table>

⬇	
External communication of and advocacy for climate change adaptation and sustainable industrial development	• Promote discussion and exchange on CCA with other strategic sectors, stakeholders, partners, and government departments, such as spatial and land use planning, urban development, State Pollution Control Board, Ministries / Departments of Industry, industrial associations and chambers, training and research institutions, academia, DRM authorities and institutions, insurances, financial institutions and service providers, international donors. • Promote regulatory mainstreaming of CCA into relevant planning and approval processes, such as regional, district, municipal and state development plans, and respective monitoring and control procedures; • Advocate for formal adoption of integrated planning processes including CCA through competent government bodies; • Advocate for inclusion of CCA as key element in SEA, EIA, and SIA; • Promote policy discussion and decisions on integrated and sustainable approaches for financing of CCA; • Promote availability of up-to-date information and data on climate change and CCA for industries and industrial sites; • Communicate and promote understanding of relevance of CCA beyond the focal areas of APIIC's and TSIIC's mandate.

5. Implementation of the findings through the project working groups

The project “Climate Change Adaptation in Industrial Areas” (CCA project) is based on the five success factors of Capacity WORKS, the GIZ management model for sustainable development. Capacity WORKS is a management model to support contract and cooperation management. The model comprises of a management toolbox for flexible application in the context of extended networks with cooperation partners and operates with five success factors which are central to the structured approach and serve as a methodological guide for contract and cooperation management. These five success factors are (GIZ (2009)):

1. **Strategy:** Strategic action always involves careful consideration of the relationship between means and ends and its orientation is the result of a process of negotiation and selection from various options.
2. **Cooperation:** A clear definition of who the project/programme will be cooperating with and how. This includes the identification of “Key” stakeholders (in some cases veto players), “Primary” and “Secondary” stakeholders.
3. **Steering structure:** The primary functions of the steering structure include resource management (personnel, funds, time, knowledge and expertise), strategy, decision-making, planning, coordination, conflict and risk management, supervision and results-based monitoring. An effective steering structure enables the project to go into right direction.
4. **Processes:** Successful projects/programmes support the key strategic processes through measures that optimise the quality, stability and speed of those processes.
5. **Learning and innovation:** Technical Cooperation projects and programmes aim to support capacity development at four levels, policy frameworks, organisational networks, organisations and individuals. Capacity development aims to develop capacities to help facilitate changes within the organisations and organisational networks themselves, leading to innovations.

Whilst the two success factors “Strategy” and “Steering structure” are described separately as overarching factors below, the remaining success factors are taken into account for each work package of the project individually.

5.1 Strategy

The main strategic elements of the CCA project are:

- The core of the strategy: **Training and professional qualification**
- Creation of **4 work packages and 5 working groups**:
  - Work package 1 on “Guidelines” is divided into two parts: one is more process and planning oriented one, and the second one is more technically oriented providing best practice examples. These tasks are assigned to two working groups (1A and 1B).
  - Work package 2 (and working group 2) on “Capacity development”.
  - Work package 3 (and working group 3) on “Policy & up-scaling”.
  - Work package 4 (and working group 4) on “Implementation and support”.
- Clearly defined **output processes** based on the 4 work packages.
- Defined **cooperation processes** (based on the cooperation landscape) based on key stakeholders.
- Organising **three learning and innovation processes in the form of modules**.
- Build **steering and auxiliary processes** to keep the project on track.

Figure 15: The strategic orientation and approach of the project

- **Top-down:**
  1. Focus on development of institutional policies and settings to incorporate Climate-resilient Industrial Development
  2. Provide guidelines and instruments for planning and retrofitting
- **Bottom-up:**
  1. Support the implementation by IALAs and IIC;
  2. Use practical examples and practices to support the institutionalisation of guidelines and regulations

Source: Integration (2015)

5.2 Steering structure

The project has established five working groups that are related to the main work packages of the project. A **Working Group** involves subject-matter experts working together to achieve specified objectives and outcomes. Each working group comprises of officials of APIIC, TSIIC and the INTEGRATION Team (the groups can then co-opt external experts from organisations such as the Pollution Control Boards, Institutions, Private companies, etc.). Working Groups are responsible to execute their tasks under the guidance and with support from the project team.

The specific tasks of the working groups are further elaborated under the description of the 4 work packages.

The **Steering Committee** has been established as an overarching entity with the key objective to support, guide and monitor the progress of the project and suggest appropriate measures for successful implementation and its replication. The specific tasks of this committee include:

- Approval of the annually updated operational plans of the project.
- Review the progress of the project activities and make suggestions as may be relevant for the successful achievement of the project objective and indicators.
- Suggest measures for any troubleshooting affecting the progress of the project during the course of the project.
- Suggest measures for enhancing implementation of the identified solutions in the project and their application/replication.
- The Steering Committee shall meet at least once in 6 months.

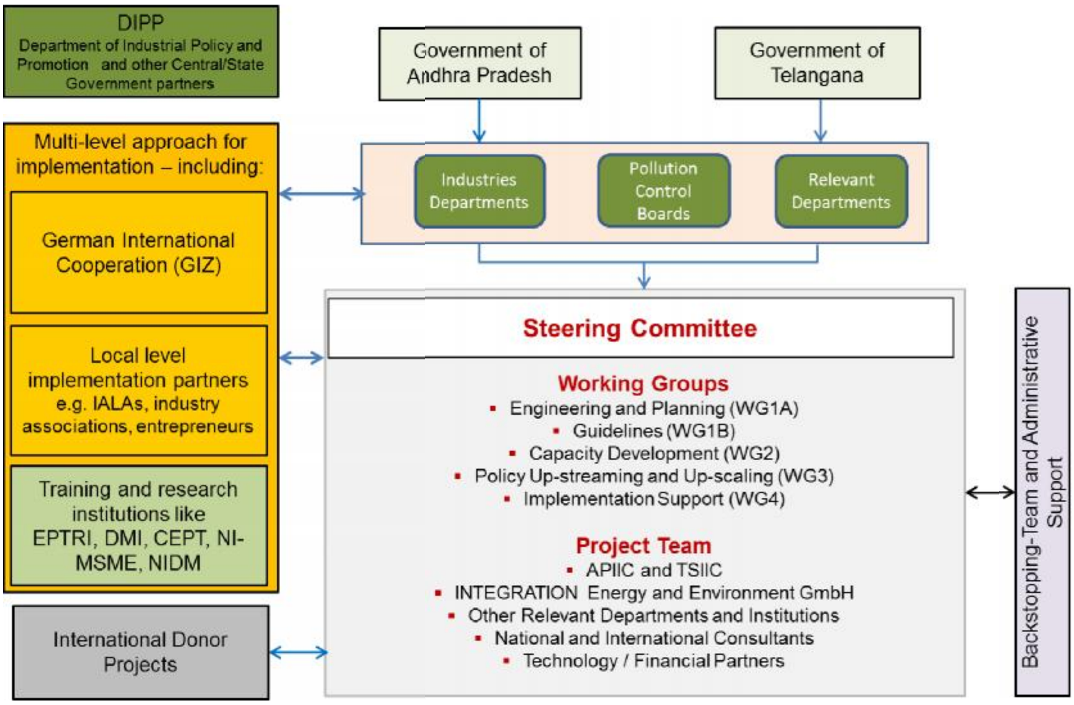
The following organisations are members of this Steering Committee:

- Secretary, Industries and Commerce, Government of Andhra Pradesh
- Secretary, Industries and Commerce, Government of Telangana
- Vice Chairman & Managing Director, Andhra Pradesh Industrial Infrastructure Corporation
- Vice Chairman & Managing Director, Telangana State Industrial Infrastructure Corporation
- Member Secretary, Andhra Pradesh Pollution Control Board
- Member Secretary, Telangana State Pollution Control Board
- Director of the CCA for Industrial Parks Project, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Director and Head, Climate Change Adaptation Project (CCA), INTEGRATION Energy and Environment, GmbH

- Nominee of the Confederation of Indian Industries(CII), Andhra Pradesh Chapter
- Nominee of the Federation of Indian Chamber of Commerce and Industries (FICCI), Andhra Pradesh Chapter
- Nominee of the Federation of Telangana and Andhra Pradesh Chamber of Commerce & Industries (FTAPCCI), AP Chapter
- Nominee of Bulk Drugs Manufactures Association(I) (BDMAI)
- Representative of the Ministry of Commerce & Industry, Govt. of India.

Below graphic illustrates the overall steering structure including the Steering Committee and the Working Groups in relation to other key stakeholders. This structure and, in particular the working groups therein, are based on discussions with TSIIC and APIIC as well as a stakeholder workshop conducted in August, 2015. The two Managing Directors of APIIC/TSIIC had assigned members to the five working groups. These members then came together for the mentioned workshop in August 2015, during which also the success factors of Capacity WORKS were introduced to them. The working groups will have to define their individual processes along the outlined work packages. Each working group also has to define their own main stakeholder landscape to work with. In addition, they have to approve or revise their individual strategy and learning processes to achieve their milestones and the overall indicators of the project. For all these aspects, this chapter 5 aims to provide them with guidance. The overall "working team" comprised the consultant team plus the assigned people of both APIIC and TSIIC.

Figure 16: Overall steering structure of the project



Source: Integration (2015)

5.3 Work Package 1A: Guidelines (WG 1A)

5.3.1 Objectives

The objective of Work Package 1A (and thus Working Group 1B) is to lay the theoretical and methodological foundation for the development of climate resilient industrial areas – as such it provides the basis for the technical and managerial aspects to be considered in the other Work Packages, in particular, Work Package 1B and Work Package 4.

5.3.2 Outcomes

The main outcomes of this work package are ***"Modular guidelines on climate resilient industrial development"*** and the ***respective training modules*** for the capacity development work package. The intended target groups are officials of APIIC / TSIIC head office, planning departments, zonal offices, IALAs and selected industries.

It is suggested that these guidelines and training modules shall initially cover the following main topics:

1. Principles of sustainable industrial development;
2. Background on climate change and principles of climate change adaptation in industrial areas (linked to existing approaches for disaster risk management and general risk management);
3. Methodology for climate risk management;
4. Integration of climate resilience in the planning and management process of industrial estates.

<u>1. Principles of sustainable industrial development</u>

Various brochures and draft documents of GIZ, such as "Planning of Sustainable Industrial Parks (GIZ 2015), or the **"Guidelines for Sustainable Industrial Areas (SIA)"**developed by the SIA Working Group provide a sound basis to understand sustainable industrial development. The main features of the guidelines can be aggregated into four different groups (SIA Working Group (2015), p. 3 ff.):

- **Organisational Features:** comprise i.e. holistic and participatory planning approaches, service orientation, the promotion of internal networks and disaster risk management
- **Economic and Infrastructure Features:** deal i.e. with economic viability of management and site marketing, infrastructure provision and logistics
- **Environmental Features**: include i.e. the promotion of resource and land use efficiency, aspects of groundwater and soil protection as well as ***climate change mitigation and adaptation***
- **Social Features:** comprise i.e. security concepts, the promotion of working and occupational health standards, gender equality and the encouragement of trade unions and NGOs.

Linkages to the existing eco-industrial park concept and building on the recommendations from it in India are highly recommended.

<u>2. Background on climate change and principles of climate change adaptation in industrial areas</u>

This main topic can generally follow the approach of chapters 2 and 3 of this report.

As detailed in chapter 2, the current climatic hazards for the industrial parks should be a starting point. Then the topic of climatic changes could be brought in (also underlying uncertainties). The background on climate change including greenhouse gas emissions and the greenhouse effect should also be provided. This can be linked to a general discussion on climate change terminology (see Annex 3 of this report).

The methodological approach in chapter 3 outlines the overall approach to climate change adaptation. i.e. taking into account different vulnerability elements is essential as next to exposure, susceptibility/fragility (or sensitivity) aspects can be key drivers of impacts. Decision making under uncertainty is also vital – i.e. no-regret, low-regret, win-win and flexible /adaptive management options. We strongly suggest pursuing an integrated approach that includes understanding adaptation to and mitigation of climate change, disaster risk management and sustainable (industrial) development as interlinked and closely connected processes. In particular, the linkages to Disaster Risk Management (DRM) and general risk management in industrial areas shall be explored:

- ***Linkages to IDRM***: On- and off-site disaster management plans as well as district disaster management plans are mandatory; however, up to now only few such plans are in place. As adaptation to climate change is generally focusing on minimizing risks of future hazards and the related impacts, there is a clear connection between the two matters. Formulation of the guidelines should make use of previous activities implemented in this context: 1) two projects implemented between 2008 and 2013: Advisory Service and Training on industrial Disaster Risk Management (2008-2010) and Advisory Service and Training environmental knowledge, Civil Defence and Disaster Risk Management (2011-2013); 2) From the perspective of climate change adaptation in the then Andhra Pradesh, close linkages were established with NIDM through the GIZ AdaptCap project and initial foundations were laid to strengthen climate resilience through a combination of CCA (Climate Change Adaptation) and DRR (Disaster Risk Reduction) (GIZ/NIDM (2014)).

- ***Linkages to existing risk management approaches***: It shall be covered how to harmonise climate resilience aspects with existing regulations for on and off-site risk management plans. Also, other National and State level action plans and guidance shall be flagged.

3. Methodology for climate risk assessment

This chapter in the guidelines and the respective training module will detail the climate risk assessment methodology that has been developed for this project (see figure no. 9 of the policy report and a specific sub-activity already contracted) and will be tested in selected industrial parks in Andhra Pradesh and Telangana. Examples, best practice and lessons learned from the testing phase will be included.

4. Integration of climate resilience in the planning and management process of industrial areas

This chapter shall cover how climate resilience aspects can be mainstreamed into the planning process for new industrial areas and the retrofitting of existing industrial parks. Also, the integration of climate change adaptation into the organisational and management structures as well as procedures of APIIC and TSIIC shall be covered (at APIIC/TSIIC headquarters, zones, and IALA level). Aspects such as decision making and stakeholder participation shall be considered as part of the integration and mainstreaming also (e.g. stakeholder mapping, MCA matrix and potential criteria for selection of adaptation measures etc.).

5.3.3 Steps (Processes)

The steps suggested to reach the proposed outcomes are:

Table 8: Steps for WP1A

Step	Output indicator	Status of implementation
1. Analyse relevant national and state laws (also state action plans), develop an inventory and highlight the relevance of each law for this project per traffic light system, summarise the main findings of the relevant laws as part of the inventory	Inventory of relevant laws (and plans)	Initial materials available
2. Develop risk analysis and assessment methodology (sub-contract CarbonX)	Methodological outline (process description and tools)	On-going (has been sub-contracted)
3. Develop guidelines for climate risk assessment (sub-contract CarbonX)	Detailed guidelines	On-going (has been sub-contracted)
4. (a) Develop and compile overall guidelines for climate resilient industrial areas (b) Develop respective training modules → both as per the above 4 outcomes	(a) Guidelines (b) Training modules	Open
5. Exchange outputs with other working groups	Relevant information exchanges via Email; meeting held with members other WGs once (4a) + (4b) are finalised	Open

5.3.4 Cooperation

Key stakeholders are the project partners (APIIC/TSIIC, GIZ, Integration, sub-contractors) and, in particular, Working Group 1B and Working Group 2 (for feedback on the modules and the implementation thereof). ***Primary stakeholders*** include, next to the industrial parks of the CCA project, officers / departments responsible for other sustainable industrial development, climate change adaptation and disaster risk management initiatives nationally and internationally. ***Secondary stakeholders*** should be reached through the Capacity Development process in Work Package 2.

5.3.5 Learning & Innovation

For this Work Package as well as the other Work Packages, the following general aspects regarding learning and innovation apply:

(1) Development of appropriate structures is achieved through the set-up of the Working Groups,

(2) Optimized processes shall be established for each Working Group and

(3) Organizational rules and network qualities need to be established that support continuous and adaptive learning.

For the entire project, the following learning processes have been identified:

- Learning process 1: Understanding of climate change adaptation needs in industrial parks;
- Learning process 2: Being able to mainstream the needs into strategies, policies, planning and retrofitting processes;
- Learning process 3: Being able to translate climate change adaptation needs into actual infrastructure, management and cooperation measures on the ground.

Generally, learning and innovation from a project can take place at the following four levels (see GIZ Capacity WORKS):

- The policy field,
- Network and project,
- Organisations,
- The individual.

In addition, interplay should be encouraged between learning interventions at these four levels.

Within this Work Package 1A, learning and innovation is primarily taking place at the ***project, organisational and individual level*** through research on the content for the guidelines and training modules and the feedback received on the drafts prepared. Then, the key innovations also are the guidelines and respective training modules. In that sense, Work Package 1A mainly contributes to learning process 1.

5.4 Work Package 1B: Engineering & Planning (WG 1B)

5.4.1 Objectives

The objective of Work Package 1B (and thus Working Group 1B) is to collect best practice examples and to develop measures and approaches for establishing climate resilient infrastructures and processes in IPs. Work Package 1B should consider the general methodological approach developed in Working Package 1A.

5.4.2 Outcomes

The outcomes of Work Package 1B are a ***"Best practice handbook and toolbox for climate resilient industrial areas"*** and the ***respective training modules***.

It is initially suggested that the handbook / toolbox and training modules shall cover the following main topics:

1. Overview on potential climate change impact areas for industrial estates and industry
2. Overview on general adaptation options for industrial estates and industry
3. Specific best practice (technical and management) examples
4. Overarching planning, engineering and operational approaches, instructions and standards

1. Overview on potential climate change impact areas for industrial estates and industry

As an introduction, those areas within an industrial estate and its industries that have been impacted by climatic hazards and could be subject to future climate change will be impacted.

Examples will be provided for each impact area (wherever possible from industrial parks in Andhra Pradesh and Telangana based on the findings from the baseline assessment).

Potential climate change impact areas that have been initially identified for industrial estates and industries include: Location, site layout, infrastructure, buildings, industrial processes, stock (on site), employees (and management), logistics, market, finance and insurance, community, policy and regulation. Those impact areas that are most relevant for the industrial park level and thus for APIIC/TSIIC (as opposed to individual industries) will be highlighted.

2. Overview on general adaptation strategies and options for industrial estates and industry

This chapter / module will focus on general adaptation strategies for industrial estates and their industries. It will also include aspects on decision making under uncertainty (e.g. no-regret, low regret, win-win and flexible/adaptive management options). In addition, exemplary adaptation options are provided for each of the above climate change impact areas, differentiated for newly planned versus retrofitted industrial parks.

3. Specific best practice (technical and management) examples

A large part of the handbook and respective training modules will focus on best practice examples that can serve as detailed adaptation options.

Examples should include the following aspects: Site selection, approaches to planning a new IP or retro-fitting an existing IP, general site layout, buildings and general infrastructure, water supply and waste water, waste management, energy supply and management, stock and hazardous materials management, Operational Health and Safety (OHS), logistics, general park management, financing and insurance and community aspects.

Next to specific technical examples, management aspects such as Operations and Maintenance (O&M) shall also be considered.

4. Overarching planning, engineering and operational approaches, instructions and standards

This chapter/module will describe overarching planning, engineering and operational approaches that are relevant for climate resilient industrial development. The standards will also be incorporated in the plot allotment guidelines for new industries, which will be then required to be followed by industries.

GIZ's "Climate Proofing for Development" approach could be considered in that respect as appropriate requirements need to be integrated into infrastructure planning to make it "climate proof" (GIZ (2011), pp. 4 ff.).

In addition, the chapter/module should highlight available instructions (e.g. for health & safety) and standards that are of relevance. This can include, amongst others, reference to international and national standards, national laws and State-level requirements, e.g.:

International standards (examples):

- Requirements for Environmental Management Systems (EMS) are specified in the international standard **ISO 14001**, which was updated recently in September 2015. It requires organisations to commit to proactive initiatives in order to protect the environment from harm and degradation. 'Protect the environment' is not clearly defined but according to the revised text it can include prevention of pollution, sustainable resource use, protection of biodiversity and ecosystems as well as mitigation and adaptation to climate change (ISO (2015)).
- **ISO 31000** on risk management is another international standard that can be applied for climate change adaptation and disaster risk management. In the U.S. ISO 31000 was used for the preparation of a vulnerability assessment and a risk-based action plan for climate change adaptation (EPA (2014), p. 7).

- In order to assess and certify sustainable industrial areas, the rating system for industrial districts provided by the **German Sustainable Building Council (DGNB)** could also be used. There is a comprehensive set of indicators that can be grouped into five main categories (GIZ (2014), p. 35): (1) <u>Economic quality:</u> e.g. employment, tax revenues and investments, (2) <u>Technical quality:</u> e.g. use of renewable energies and efficiency of transportation, (3) <u>Environmental quality</u>: e.g. resource efficiency, climate change and disaster risks, (4) <u>Social quality</u>: e.g. aspects of gender equality and occupational health, (5) <u>Process quality:</u> e.g. management structures, service delivery, public private partnerships (PPP). Depending on the total score of a project calculated from the five quality categories a rating of gold, silver and bronze can be achieved which can then be used in product packaging and for marketing purposes of industrial parks (GIZ (2015), p. 29). Buero Happold has already developed a training for GIZ IGEP in that respect and have provided training to APIIC and TSIIC.

<u>National plans, codes and standards (examples):</u>

- **Intended Nationally Determined Contribution (INDC):** At the 2015 UN convention**,** India' has announced its Intended Nationally Determined Contribution (INDC) to combat climate change. With respect to adaptation the INDCs include the following (MoEFCC (2015)):

  - To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.

  - To mobilize domestic and new & additional funds from developed countries to implement the above (mitigation and) adaptation actions in view of the resource required and the resource gap.

- The eleventh five-year plan of the Gvt. oI (2007-2012) emphasised that "the process of adaptation to climate change must have priority" (GoI (2008a), p. 205) as one of the key challenges of sustainable development. Climate change also needs to be integrated into planning instruments such as **Environmental Impact Assessment (EIA)**. As per the (EIA) Notification issued in 2006 by MoEF, 39 types of industrial activities require Environmental Clearance. So far, aspects of vulnerability to natural disasters and susceptibility to natural hazards are only reflected in the requirements for obtaining Environmental Clearance as per the EIA notification and the amendments thereof, pp. 25-27).

- The five-year plan (2012-2017) of (Govt. of India (2013), p. 210) recognized the importance of EIA and stressed for a "cumulative and strategic EIA", but remains unspecific about how climate change adaptation and disaster risk management could be integrated into EIA regulations.

- On January 1st, 2015, the newly formed Government of India disbanded the Planning Commission and dispensed the Five Year Plans and announced the formation of a **National Institution for Transforming India Aayog** (NITI Aayog) – i.e. the "NITI Aayog is the successor in interest to the Planning Commission" (GoI (2015)). The bottom-up mechanism of NITI Aayog of integrating the States could of interest for the up-scaling aspects of the CCA project and NITI Aayog should therefore be included in the respective stakeholder analysis.

- In terms of Disaster Risk Reduction (DRR), the **National Building Code (NBC**) of India issued in 2005 by the Bureau of Indian Standards (BIS) is considering natural hazards and risks of various regions in the country with respect to siting, design and construction of buildings (GoI (2008a), p. 210). Requirements of climate change adaptation and disaster risk management could, therefore, be integrated into already existing provisions. Keeping future developments in the techno-legal and techno-financial regimes and changing requirements of cityscapes and life styles in view, BIS has decided to take up a **comprehensive revision of the NBC** in the month of

July 2013 and bring out a state-of-the-art and most contemporary version of futuristic developments by 2015 (BIS (2014), p. 1). The revision includes, amongst others, “detailed provisions relating to sustainability”, “mechanism for safety including certification of buildings against natural disasters”, “periodic renewal certification for other vulnerable buildings” and “norms for coastal areas” (ibid.).

- **Guidelines for Energy Conservation in Special Economic Zones** (**SEZs**) (GoI (2009)): Although the name indicates energy conservation, the Ministry of Commerce and Industries (MoC&I) along with Indian Green Building Council, has come up with guidelines on SEZs which include energy conservation, power utilisation, water efficiency, waste management, plantations, site preservation and restoration, local internal transportation, air quality and information technology which leads to Green Rating Certification for SEZ. In particular, the elements for “Site Preservation and Restoration” and “Indoor Air Quality in Individual Buildings” directly relate to climate change adaptation (ibid., p. 5f.).

- For the chemical industry, the existing **national disaster management guideline for chemical disasters** should be considered. It aims at reducing risks by identifying the existing gaps and providing guidance for industrial chemical installations, storages and transport accidents (NDMA (2007), pp. 13 – 60). This relates to adaptation in terms of addressing, for example, the storage of hazardous substances taking into account potential power cuts (e.g. failing of hydropower), floods or heat waves.

- A cornerstone of climate change adaptation in India was the **National Action Plan on Climate Change (NAPCC)** launched in 2008. It endorses the need for adaptation alongside with mitigation, sustainable development and disaster risk management. The national missions on sustainable habitat, sustainable agriculture and on strategic knowledge for climate change include adaptation into their agendas (GoI (2008b), pp. 3-6). As areas of concern for climate change adaptation agriculture, water resources, health and sanitation, forests coastal zone infrastructures and extreme weather events are listed in the NAPCC. Industrial areas are not explicitly named but indirectly included in the areas of concern (GoI (2008b), p. 17 f.).

- Seeking to broaden India’s response to climate change, Government of India proposed to add at least **four new ‘missions’** to the National Action Plan on Climate Change (NAPCC) to include “Wind energy”, “Human health”, “Coastal resources” and “Waste-to-energy” in the month of January 2015 (Indian Express (2015)).

<u>State-level plans (examples):</u>

- On a sub-national level **State Action Plans on Climate Change (SAPCC) for the then Andhra Pradesh State** were prepared in line with the strategies of NAPCC. Based on adaptation to climate change as one of the objectives of the SAPCC for Andhra Pradesh, eleven major sectors that are impacted by climate change were identified (EPTRI (2012), p. VII ff.). Also for the industrial sector, critical concerns and corresponding key interventions (both mitigative and adaptive ones) are listed in the SAPCC. Risk management actions taken by the state of Andhra Pradesh comprise implemented adaptation interventions in different sectors such as agriculture, forestry and rural and urban habitats (EPTRI (2012), p. 29 ff.). With the bifurcation of the states in 2014, both Andhra Pradesh and Telangana States are now developing their own individual SAPCC documents. This opens a window for comprehensively integrating climate change adaptation and disaster risk management aspects into the SAPCCs of Andhra Pradesh and Telangana. Dubash and Jogesh (2014) did a comparative analysis of 5 SAPCCs, i.e. from Himachala Pradesh, Madhya Pradesh, Sikkim, Odisha and Karnataka, with regard to their approach, process, outcome and implementation. The findings and recommendations of this research paper could be a valuable source of information for the formulation of the SAPCCs of Andhra Pradesh and Telangana.

- **Andhra Pradesh State Industrial Development Policy (2015-2020)** has considered measures for implementing cleaner production and green infrastructure, which includes a 25% subsidy for sustainable green measures on total fixed capital investment of the project (excluding cost of land, land development, preliminary and pre-operative expenses and consultancy fees) for green measures mentioned below with a ceiling of 50 Crore (Government of Andhra Pradesh (2015)) – several of these (though with a mitigation focus) cater directly or, mostly, indirectly for adaptation:
  a) Waste water treatment: Constructing effluent treatment plant, sewage treatment plant and especially zero discharge systems, using recycled water for industrial purpose.
  b) Green Buildings: Buildings which obtain green rating under the Indian Green Building Council (IGBC/LEED Certification) or Green Rating for Integrated Habitat Assessment (GRIHA) systems.
  c) Use of renewable source of power (erecting captive sun, wind and biomass plants etc.).
  d) Installing Continuous Emission Monitoring System (CEMS) for red category industries. The information should be disseminated continuously to APPCB.
  e) Adopting rain water harvesting; restoring water bodies by de-stilting defunct water bodies.
  f) Any other environment management project approved by Empowered Committee of Secretaries.

  MSME projects engaged in recycling waste into environment friendly products/energy (such as waste to energy, waste to bio-gas, waste to manure) will be brought under zero rated category schedule of the VAT Act. 35% subsidy on cost of plant & machinery for specific cleaner production measures limited to 35 lakhs for MSME, provided the measures are certified by Andhra Pradesh Pollution Control Board (APPCB).
- Similarly, **Telangana State Industrial Policy** has identified Green Technologies and Waste Management as priority areas of business development.

5.4.3 Steps (Processes)

The steps suggested to reach the proposed outcomes are:

Table 9: Steps for WP1B

Step	Output indicator	Status of implementation
(1) Convert the findings of tables 4, 5, 6 of the policy report into handbook training context	Introductory chapters / modules	Open
(2) Collect international and national best practice examples and categorise them, select most relevant examples for the context of this project	Categorised and selected examples	Open
(3) Detail the technical adaptation options based on case studies, and management options (including O&M and THH Plantation Programme)	Technical and managerial best practice (adaptation options)	Open
(4) (a) Compile the handbook (b) compile the respective training modules → both as per the above 4 topics	(a) Handbook, (b) Training modules	Open

(5) Exchange outputs with other working groups (in particular, Working Group 2)	Relevant information exchanges via Email; meeting held with members of other WGs once (4a) + (4b) are finalised	Open

5.4.4 Cooperation

Key stakeholders are the project partners (GIZ, Integration, APIIC/TSIIC, sub-contractors) and, in particular, Working Group 1B and Working Group 2 (for feedback on the modules and the implementation thereof). ***Primary stakeholders*** include, next to the industrial parks of the CCA project, officers / departments responsible for other sustainable industrial development, climate change adaptation and disaster risk management initiatives nationally and internationally. ***Secondary stakeholders*** should be reached through the Capacity Development process in Work Package 2.

5.4.5 Learning & Innovation

Within this Work Package, learning and innovation is primarily taking place at the ***project, organisational and individual level*** through research on the content for the handbook and modules, the exchange with other projects and working groups, and the feedback received on the draft modules. The key innovations are the handbook and respective training modules.

Work package 1B mainly contributes to learning process 1.

5.5 Work Package 2: Capacity Development (WG 2)

5.5.1 Objectives

Work Package 2 ensures that all other Work Packages can be smoothly implemented and their results can and will be applied by the target institutions and actors at national, state and local levels. In addition, lessons learned during the course of the project will already feed into the capacity building work package.

5.5.2 Outcomes

In line with its objectives, the Work Package will deliver the following outcomes (and outputs):

(1) **Information and awareness raising materials** covering the scope of the project, e.g. legal and regulatory background, compatibility between economic growth, reduction of climate risks and sustainable development; direct and indirect benefits of climate adaptation; best practice examples; policies, guidelines and standards; best practice examples.

(2) **Awareness raising** will be required for almost all target groups of the project at national, state and local levels to prepare the ground for development and application of methodologies, guidelines and standards, formulation and adaptation of policies; planning and implementation of concrete measures in industrial areas or companies, consideration of climate risks in investment planning; and up-scaling of project results both at state and national level.

(3) **Development of training modules** in cooperation with training institutes already active and experienced in the sector: Goal of the training programme is to impart the required knowledge and skills for incorporation of climate adaptation into planning and implementation processes and related decision making. The modules will also make use of already developed materials on eco-industrial estate planning and management, industrial disaster risk management, adaptation to climate change and sustainable industrial development form India and abroad, including innovative approaches, such as a training game for eco-industrial park planning developed by the consortium's affiliate Buero Happold. Following modular training courses built on four components (awareness building, hands on exposure, training and coaching, knowledge and managerial & technical skills) and based on the work of Work packages 1 and 3 will be developed.

- **Understanding the importance of climate change adaptation for sustainable industrial development** for all target groups below.
- **Risk analysis and management** for key persons of state-level Industries and Commerce Departments, industrial development agencies (HQ, zonal managers) and selected IALAs;
- **Climate resilient planning and retrofitting of industrial parks** for key persons of industrial development agencies (planning departments), engineering and planning consultants, IALAs, industrial and entrepreneurs associations, site supervisors;
- **Implementation of climate resilient measures** for key persons of industrial development agencies (O&M), selected IALAs, selected entrepreneurs/representatives, engineering and planning consultants, site supervisors. This should include financing aspects also.

(4) **Execution of Training of Trainers (ToT) and Implementation of the training modules need to be done** in cooperation with the training institutes involved in the development of the modules. Faculty and resource persons from training institutions offering the courses will undergo respective training of trainers offered by the project in cooperation with the implementing agencies. For implementation of the modules, the working group will also explore and discuss, and implement if appropriate, up-to date learning approaches like blended-learning, and web-based serious gaming approaches.

(5) **Coaching** of the management of the selected four industrial parks of the project for the development, implementation and O&M of adaptation measures.

(6) In addition to the portfolio specified in the ToR for the project, a professional qualification scheme for "**Certified Safety & Resilience Officer**" to support long-term effects and sustainability of the project could be considered. Such scheme could follow the approach of professional certification schemes offered by German Chambers of Trade and Industry. To obtain a certificate successful participation and completion of a standardized training and successful completion of a final examination executed by the Chambers is required. The certificate is issued by the Chambers and is well recognized. Similar to this approach such a scheme could be established in cooperation with FICCI, CII or a similar organisation executing the final examination and issuing the certificate and involved training institutions offering standardized training which should be supervised by the certificate issuing partner.

5.5.3 Steps (Processes)

The steps suggested to reach the proposed outcomes are:

Table10: Steps for WP2

Step	Output indicators	Status of implementation
(1) Execute a capacity and training needs assessment related to adaptation to climate change in sustainable industrial areas and identification of capable training institutions.	Capacity needs assessment including indicative curricula.	Tendering procedure
(2) Compilation of information and awareness raising materials	Introductory materials on the project Combined materials from the project and from previous materials from GIZ and other agencies Revised materials at later project stage	Initial materials available
(3) Finalisation of training modules delivered by working groups 1A, 1B, and 3 including ToT and e-learning / blended-learning components as per decision of the working group and the Steering Committee and availability of funds. Revision of the modules based on lessons learnt from implementation (work package and working group 4)	Module 0: Understanding importance of climate change adaptation for sustainable industrial development Module 1: Risk analysis and management Module 2: Climate resilient planning and retrofitting of industrial parks Module 3: Implementation of Climate Resilient Measures Revised modules	open
(4) Execution of ToT and the training modules via cooperating training institutions	MoU with implementing training institutions Faculty and resource persons trained Training courses executed as per implementation plan	open
(5) Support the mainstreaming of the courses into the curricula and training offers of the training institutions.	Training courses integrated in the standard training offers and plans of the cooperating institutions. Training modules and institutions linked to the portfolio and knowledge base of the IGEP-UID (Urban-industrial development) capacity development	open

Step	Output indicators	Status of implementation
	cell.	
(6) Establish a certification course to develop and strengthen the professional profile "Certified Safety & Resilience Officer"	Respective cooperation with relevant institutions, such as FICCI, CII, ASCI, or similar established; Standardized Training Course and certification standards developed and endorsed. Training institutions offering the courses approved Training offers established. Pilot certification course executed.	open
(7) Organize and guide awareness raising for the other output processes	Execution of respective events and activities.	open

5.5.4 Cooperation

Key stakeholders are the other working groups and selected training and research institutions contributing to the development of the modules and materials as well as those implementing the courses. ***Primary stakeholders*** are APIIC, TSIIC, industrial associations, Chambers like FICCI or CII, and key actors of up-scaling such as Departments of Industries and Commerce or DIPP. ***Secondary stakeholders*** are the target groups of the training modules and awareness raising but also financing institutions and funds (e.g. development banks SIDBI and NABARD, Industrial Investment Development Fund; Climate Change Adaptation Fund etc.) and other donors having possibilities to support the training offers at their disposal.

5.5.5 Learning & Innovation

Within Work Package 2, learning and innovation is primarily taking place at the ***organisational and individual level*** through development of materials, implementation of ToT, training modules and other capacity development measures. The key innovations are the modules developed, including innovative approaches like blended-learning and gaming, the establishment of a professional profile "Certified Safety & Resilience Officers".

Work Package 2 contributes to all learning processes ***1. Understanding climate adaptation needs in industrial sector; 2. Mainstreaming of climate adaptation needs into industrial sector strategies, policies and planning / retrofitting processes; 3. Translating adaptation needs into infrastructure, management and cooperation measures on the ground.***

5.6 Work Package 3: Policy & Up-scaling (WG 3)

5.6.1 Objectives

Objective of Work Package 3 is to ensure that the outcomes of Work Package 1 (Guidelines) are embedded in the policy and strategic framework of APIIC and TSIIC, and are mainstreamed into their strategic planning.

Second objective of Work Package 3 is to promote and foster climate change adaptation in the industry in both states as well as at national level, so that national, state-level and local institutions as well as private sector organisations actively advocate for climate adaptation in the industry.

5.6.2 Outcomes

In line with its objectives, the Work Package will deliver the following outputs and outcomes:

(1) A **Strategy Paper** on "*Climate Change Adaptation for Sustainable Industrial Development"* for sensitisation, orientation, motivation of national and regional decision makers (development of rules, regulations and processes for climate resilience in industrial development).

(2) **Inputs for training modules** on climate resilient industrial policy, and mainstreaming of climate change adaptation in industries into policies, strategies and regulations.

(3) **Policy dialogues** with decision makers and technical staff from national and state ministries and authorities (including SPCBs and Disaster Management Authorities), industrial development agencies and private sector organisations, will be a central tool for the development, approval and adoption, as well as up-scaling of policies, guidelines, and methodologies. The respective working groups will be the key actors for the dialogue activities; however working group 2 will ensure overall coherence and consistency of the dialogue process. The policy dialogue will include a seminar programme for information dissemination on Climate Resilient Industrial Development with exposure visits to sites in AP and TS, round table discussions, and workshops.

(4) **Climate Finance:** Climate finance refers to financing channelled by national, regional and international entities for climate change mitigation and adaptation projects and programs. The project will identify various avenues available in national and international markets. Also, it will try to identify and develop different business models including private investments available for adaptation projects.

(5) **Networking** to support up-scaling and dissemination of project results. The following activities will be considered in this context:

- Present findings and suggestions regularly during the annual Chemical (Industrial) Disaster Management (CIDM) conference organized by FICCI.
- Organise round table talks in selected industrial areas with industrial development agencies, Disaster Management Authorities, Chief Inspectorate of Factory and Boilers (CIF), IALAs, entrepreneurs and industrial associations;
- Present the project during the annual meeting of Practitioners Dialogue of the Climate Investment Network (PDCI). This will enable the CCA project to understand various best practices and develop a standard policy for Climate Investments in Adaptation Projects.
- Present the project during the annual meetings of the Transport, Environment, Energy, Water in Asia (TUEWAS) sector network and the SIA Task Force where exchange of findings, outcomes and lessons learned will take place.

(6) Inputs on respective approaches and tools for the **EID-Toolbox sustained by the SIA** Working Group.

(7) **Up-scaling of project results and lessons learned**, such as policies, guidelines, approaches and tools.

Successful implementation and outcomes will be reflected by the achievement of the following indicators:

- **Output indicator 1**: Two state level government or private sector organisations have developed proposals on how to integrate climate adaptation in their strategies.
- **Output indicator 2**: Proposals on how to consider climate risks in two regulations that ensure climate adaptation have been developed (e.g. EIA, environmental Audits, Assessment of Site Safety, or specific local regulations).
- **Outcome indicator 2**: Two state governments or private sector organisations have integrated the subject of climate adaptation for the industrial sector into their strategies/policies.
- **Outcome indicator 3**: One of the selected industrial development agencies has considered climate risks in at least 50% of its planned investments for the financial year 2017 (e.g. land acquisition, development, infrastructure expansion and retrofitting of industrial areas).

5.6.3 Steps (Processes)

The steps suggested to reach the proposed outcomes are:

Table 11: Steps for WP3

Step	Output indicators	Status of implementation
(1) Elaborate a policy strategy paper providing an overview and general recommendations for adaptation to climate change in sustainable industrial areas.	Policy strategy available	Draft delivered
(2) Elaboration of a policy matrix identifying pros and cons of existing policies and strategies	Policy matrix available	open
(3) Understanding Climate Financing	List different financing models available.	On-going (has been subcontracted)
(4) Elaborate a policy paper, outlining the (economic and social) need for industrial climate change adaptation plans and linking it to existing instruments of DRM such as on- and off-site emergency plans and district disaster management plans.	Collection and analysis of convincing CCA plans available; Agreement with partners obtained to integrate CCA in their policies and strategies; Policy paper available.	open
(5) Set up rounds of policy dialogues with key policy makers	Policy dialogues carried out	open
(6) Carry out networking activities	- Presentation during CIDM conference conducted	First presentation delivered in

Step	Output indicators	Status of implementation
	- Round table talks conducted - Presentation during PDCI, TUEWAS and SIA meetings conducted	Mexico in Oct 2015
(7) Develop comprehensive Plan to access Climate investment and assist partners	Climate financing identified	Open
(8) Promote the adoption of the policy paper through state governments, government and private sector organizations.	Policy paper adopted (outcome indicator 2)	open
(9) Promote the consideration of climate risks in investment planning for industrial development.	Consideration of climate risks and investments for adaptation officially adopted in investment planning (see also outcome indicator 3)	open
(10) Inputs on respective approaches and tools for the EID-Toolbox sustained by the SIA Working Group	Inputs submitted to SIA	open
(11) Promote the up-scaling of project results	Key actors and institutions of the sector actively promote mainstreaming of climate change adaptation in the industry into relevant policies, strategies, action plans, provisions and procedures. National departments and ministries such as DIPP and MoEF, as well as national level industry associations are supported by the project in up scaling and replication of project results and findings to other states and sectors	open
(12) Exchange outputs with other working groups (in particular, Working Groups 1a, and 2)	Relevant information exchanges via E-mail and moderated discussions; Meetings with other WGs during elaboration of (4)	open

5.6.4 Cooperation

Key stakeholders are the state level industrial development authorities (Industry and Commerce Departments) and the industrial infrastructure development agencies (APIIC, TSIIC), as well as Ministry of Commerce and Industry/Department of Industrial Policy and Promotion (DIPP) at national level. ***Primary stakeholders*** are industrial associations, research institutions, and key actors of up-scaling such as FICCI and CII. ***Secondary stakeholders*** are MoEF and the Climate Change initiatives, NDMA (industrial/chemical disaster management department), and financing institutions and funds (e.g. development banks SIDBI and NABARD, Industrial Investment Development Fund; Climate Change Adaptation Fund etc.).

5.6.5 Learning & Innovation

Within Work Package 3, learning and innovation is primarily taking place at the ***policy field, network and project, working group, organisational and individual level*** through research on the content for the policy paper and modules, exchange with other working groups, the feedback received on the draft modules, and, ultimately, the up-scaling efforts undertaken. The key innovations are the policy paper on mainstreaming climate change adaptation of industrial parks into industrial development strategies, policies, and regulations, respective training modules, consideration of climate change adaptation in industrial development and in investment strategies.

Work Package 3 mainly contributes to learning processes ***1. Understanding climate adaptation needs in industrial sector***, and ***2. Mainstreaming of climate adaptation needs in industrial sector into strategies, policies and planning / retrofitting processes***.

5.7 Work Package 4: Implementation and Support (WG 4)

5.7.1 Objectives

The objective of work package 4 (and thus Working Group 4) is to enable and test the planning and implementation of climate resilient industrial parks. On one hand, this is to be achieved by empowering industrial estates to incorporate climate change adaptation into their planning and implementation process and on the other hand, by engaging the financial sector. During this process of developing, budgeting and implementation, the project working team will directly support the various divisions of APIIC/TSIIC and the stakeholders involved including IALA's and Industry.

5.7.2 Outcomes

Ultimately, the outcomes of this work package should be ***four exemplary plans*** for retrofitted and newly developed sites.

It is suggested that these adaptation plans are developed in subsequent stages as the project progresses. The plans should include at least the following aspects:

Part I (as further processed outcome of the base line study):

- General profile of the industry park
- Relevant climate hazards and climate change
- Results from the climate risk assessment(including risk register that can be used as a working document)
- Adaptation options identified, potential funding sources for these options, timelines to implement these options
- Linkages to existing plans and regulations
- Additional capacity building needs that were identified

Part II:

For retrofitting:

- Selection process for adaptation measures (meetings held, stakeholders consulted etc.)
- Selection criteria
- Resulting prioritized adaptation measure(s) for the park
- Detailed description of the measure(s) including climate change risks addressed, direct & indirect additional benefits ("co-benefits"), technical specification, costs and sources of finance, implementation plan including responsibilities

- Operations and maintenance plan and budget

For newly planned:

- Standards and recommendations for industries (including local regulations) to take into account climate change adaptation
- Process for integrating CCA including suggestions for stakeholder participation

Part III (optional):

- Quantitative indicators for each pilot (benefits for Monitoring & Evaluation (M&E))

In addition, a document (e.g. **"Best practice booklet"**) should be developed that summarises the four cases for planning integration and up-scaling (link to WG3) and that develops a **Replication Plan** for other industrial parks of APIIC/TSIIC. That could also be a working document to which replication successes are added on a regular basis. The lessons learnt will be documented and come to upgrade modules of Capacity Development in WP 1 and WP 2.

5.7.3 Steps (Processes)

The outcomes (and objectives) of this work package are realized through a wide spectrum of ***technical assistance and support*** for the planning, development, construction and operational phases of climate resilient measures. The WP will use the guidelines and handbook prepared in WP 1 and trained in WP 2. The steps suggested are:

Table 12: Steps for WP4

Step	Output indicator	Status of implementation
Preparatory phase:		
1. Support other working groups (in particular WG1 and WG1B)	Meeting held with members of other WGs (in particular 1A/B)	Open
2. Assess financing options and engage with the financial sector (private and public), develop specific financing options for CCA in IPs	Financing options developed	Open
3. Selection of IPs for implementation	Agreements fixes with IPs	On-going (sub-contracted)
Implementation phase:		
4. Climate risk analysis and other preparatory assessments as per the elaborated guidelines (sub-contract)	Risk analysis reports of the selected sites (1 newly planned and 1 retrofit per State)	On-going (sub-contracted)
5. Identification and development of possible adaptation measures and prioritization (possibly sub-contract)	Ranked adaptation measures per site	Open
6. Preparation of the Climate Adaptation Plan (= chapter of the Development Plan)	Chapter	Open
7. Prepare, support and supervise the implementation (possibly sub-contract)	Site log / photo documentation	Open
8. Develop Best Practice Booklet and Replication Plan	Best Practice Booklet / Replication Plan published	Open
9. Exchange outputs with other working groups (in particular, WG3 to up-scale the best practice examples)	Relevant information exchanges via Email; meeting held with members other WGs	Open

5.7.4 Cooperation

Key stakeholders for this work package include - next to GIZ, Integration, the respective engineering sub-contractor(s) and the relevant working groups of this project – the two industry associations (APIIC, TSIIC) and, if already set up, their new CCA cell, State Disaster Management Authority, and, ultimately, IALAs of the selected industrial parks. ***Primary stakeholders*** comprise of the relevant financing institutions and planning offices. Wider up-scaling of the best practice examples generated to a wider group of ***secondary stakeholders*** is then achieved through Working Group 3.

5.7.5 Learning & Innovation

At ***policy, network and project level***, learning and innovation is mainly achieved through the generation (and dissemination) of the exemplary plans. At ***organizational level*** (industry park and its industries) and ***individual level***, the learning process will start much earlier with the information and selection phase of the industry parks and continue through the risk analysis, joint development of adaptation measures and, ultimately, the preparation of the Climate Adaptation Plan and its implementation. Key innovations are then the Climate Adaptation Plan and the measures described therein (including technical, managerial and financing aspects).

Work Package 4 mainly contributes to learning process 3.

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Annex 1: Glossary

- **Adaptive capacity** – is the capacity to better adjust a system (increase its resilience) related to future events; increasing adaptive capacity is based on strategic decisions, focus is on future conditions and predicted changes (Alliance Development Works (2013), p. 6; Lavell et al. (2012), p. 51).
- **Climate** – average weather over a period of time (e.g. 30 years) in a region.
- **Climate model (for GCM and RCM see below) - "**A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties." Climate models vary in in their degree of complexity, i.e. in the number of parameters they take into account for representing the climate system (IPCC (2012), p. 557).
- **Climate variability** – variations in the mean state of the climate, generally natural / historic.
- **Cyclone -** (also: Tropical cyclone) describes storms in the Indian Ocean and Southwest Pacific region that rotate about a centre of low atmospheric pressure. The weather phenomenon of cyclones is accompanied by torrential rain and maximum sustained wind speeds (at the centre) exceeding 119 kilometres per hour (WMO (2015)).

  O*r*: A tropical cyclone is a rotational low pressure system in tropics when the central pressure falls by 5 to 6 hPa from the surrounding and maximum sustained wind speed reaches 34 knots (about 62 kmph). It is a vast violent whirl of 150 to 800 km, spiralling around a centre and progressing along the surface of the sea at a rate of 300 to 500 km a day (IMD (2015a)).
- **Exposure** - "The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected." (IPCC (2014), p. 5).
- **Extreme weather event** – rare for a given area during a given time of the year. The IPCC defines an extreme weather or climate event as climate extreme and as such as "the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes."(IPCC (2012), p. 557).
- **Climate change –** "(…) means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." (United Nations (1992), Article 1 (2.)).
- **Coping capacity** – is the capacity to cope with the impacts of a specific hazardous event. It is determined by available resources and abilities to face adverse consequences, i.e. governance, preparedness and early warning, healthcare and social and material security (Alliance Development Works (2013), p. 6; Welle (2011)). Coping capacity is a central element in the concept of vulnerability; it is related to tactical decisions in the case of an event and focused on past events shaping current conditions, limitations and previously successful tactics (Lavell et al. (2012), p. 51). The IPCC defines it as "The ability of people, organizations, and systems, using available skills, resources, and opportunities, to address, manage, and overcome adverse conditions." (IPCC (2012), p. 558).
- **Drought –** "A period of abnormally dry weather long enough to cause a serious hydrological imbalance." Droughts can be further specified according to the part of the hydrological cycle they affect the most (e.g. abnormally low soil moisture is termed 'agricultural drought' and a reduced runoff and groundwater recharge is referred to as 'hydrological drought') (IPCC (2012), p. 558). The Indian Central Water Commission defined

drought as “a situation occurring in an area when the annual rainfall is less than 75% of the normal (defined as 30 years average) in 20% of the years examined and where less than 30% of the cultivated area is irrigated” (World Bank (2005), p. 20).**Exposure** – “the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructures or economic, social or cultural assets in places and settings that could be adversely affected.” (IPCC (2014a) p. 5). The exposure to climate signals is generally based on geographic location. Maps showing projections for different climate signals geographically could be used to identify the exposure of a certain industrial site.

- **Extreme weather event** – rare for a given area during a given time of the year. The IPCC defines an extreme weather or climate event as climate extreme and as such as “the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as ‘climate extremes“(IPCC (2012), p. 557).
- **Flood –**“The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged.” Floods can be caused by heavy rainfall and elevated water levels in rivers. In low-lying coastal areas floods can also result from rising sea levels (IPCC (2012), p. 559). According to NDMA “Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times (in a matter of minutes)” (NDMA (2015))..
- **Global Circulation Model (GCM) -**– are comprehensive climate models that represent physical processes in the atmosphere, ocean, cryosphere and land surface. GCMs are tools for simulating the response of the global climate system to increasing greenhouse gas concentrations. GCMs, possibly in association with nested regional models, have the potential to provide geographically and physically consistent estimates of regional climate change which are required in impact analysis (IPCC (2013a)).
- **Greenhouse effect** – “the infrared radiative effect of all infrared-absorbing constituents in the atmosphere.” Greenhouse gases, clouds and (to a small extent aerosols) absorb radiation emitted by the Earth’s surface and elsewhere in the atmosphere and emit themselves infrared radiation. This leads to an increase of the Earth’s surface temperature (IPCC (2014b) p. 1766).
- **Hail -**precipitation of ice particles. Depending of the size and intensity of hail it can cause severe damage, e.g. to agriculture and infrastructure (American Meteorological Society (2012)).
- **Hazard** - “A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage” (UNISDR (2015)). According to the IPCC:“The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.”(IPCC (2014), p. 5)
- **Heat wave -** is an extended period of hot weather relative to the expected conditions of the area at that time of year. The WMO’s definition of a heat wave is that “the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C, the normal period being 1961-1990" (Met Office (2015)). For India the IMD further specifies that “heat waves need not be considered till maximum temperature of a station reaches at least 40º C for Plains and at least 30º C for Hilly regions” (IMD (2015b)).

- **Hydro-meteorological hazard** - Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Hydro-meteorological hazards include tropical cyclones (also known as typhoons and hurricanes), thunderstorms, hailstorms, tornados, blizzards, heavy snowfall, avalanches, coastal storm surges, floods including flash floods, drought, heat waves and cold spells. Hydro-meteorological conditions also can be a factor in other hazards such as landslides, wild land fires, locust plagues, epidemics, and in the transport and dispersal of toxic substances and volcanic eruption material (UNISDR (2015)).
- **Impact** – The IPCC defines impacts as (IPCC 2014, p.5): "Effects on natural and human systems. (…) Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. (…)."
- **Impact area**– for this study, parts of the system of interest (i.e. industrial park and its industries) that are affected by climate change.
- **Impact chains** - Impact chains can be useful tools as they show cause-effect relations (EURAC (2011), p. 125). They can be a good visual method to identify how climate drivers cause direct and indirect impacts in a system, e.g. industry.This analysis could then be extended to a vulnerability analysis by adding sensitivity and adaptive capacity.
- **Regional Climate Model (RCM)** - – are one way to downscale climate projections from a global (e.g. derived. by GCMs) to a regional level. "The full GCM determines the very large scale effects of changing greenhouse gas concentrations and volcanic eruptions on global climate. The climate calculated by the GCM is used as input at the edges of the RCM for factors such as temperature and wind. RCMs can then resolve the local impacts given small scale information about orography (land height) and land use, giving weather and climate information at resolutions as fine as 50 or 25km. Regional Climate Models (RCMs) work by increasing the resolution of the GCM in a small, limited area of interest" (Climate prediction (2014)). One example for a regional climate modelling system is PRECIS which was also used to derive regional climate change predictions for India (MoEF (GoI) (2012), pp. 99 - 101).
- **RCP - Representative Concentration Pathway -**A RCP scenario basically consists of numbers organized in tables. For each category of emissions, an RCP contains a set of starting values and the estimated emissions up to 2100, based on assumptions about economic activity, energy sources, population growth and other socio-economic factors. But the data also contain historic, real-world information. Modellers use the database sets to initialise their models, which jump-starts what would otherwise be a very lengthy process. One that each modelling team would have to attempt, thus duplicating effort. RCPs and previous scenarios were created exactly to avoid such duplication, and the inevitable initialisation inconsistencies that would ensue (Wayne (2013), p. 5).
- **Resilience** – The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. Comment: Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need. (UNISDR (2015)). According to the IPCC: "The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation."(IPCC (2014), p. 5)

- **Risks** - The latest IPCC report now focuses more on risks whereas earlier reports applied the concept of vulnerability. The IPCC defines risk as (IPCC (2014a), p.5): "The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. (…) the term risk is used primarily to refer to the risks of climate-change impacts."
- **Sensitivity** – "Degree to which a system is affected by or responsive to climate stimuli (note that sensitivity includes responsiveness to both problematic stimuli and beneficial stimuli)"(IPCC (2014), Table 18-5).
- **Storm surge -** "The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place." (IPCC (2012), p. 563)
- **Susceptibility** – describes the predisposition of a system, e.g. an ecosystem or the society to suffer harm from a hazardous event. Or according to the IPCC: "Degree to which a system is open, liable, or sensitive to climate stimuli (similar to sensitivity, with some connotations toward damage)." (IPCC (2014), Table 18-5)
- **Vulnerability** – In previous definitions, vulnerability was defined as "a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC (2007), Glossary). For example, a vulnerability analysis could look at the exposure to climate signals (e.g. a coastal industrial park might be subject to flooding from sea-level rise) and the sensitivity of the system (e.g. the buildings in the industrial parks might already be elevated and thus not as sensitive) to derive a potential impact (e.g. damage to buildings from floods). This impact is then matched against the adaptive capacity of the system (e.g. flexibility of the industry on site to move to less threatened buildings). In its most recent assessment report, the IPCC defines vulnerability more as a type of sensitivity: "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." (IPCC (2014a) p. 5).
- **Weather** – state of the atmosphere at a given time with regard to temperature, rainfall, wind etc.

Annex 2: Map of Andhra Pradesh and Telangana

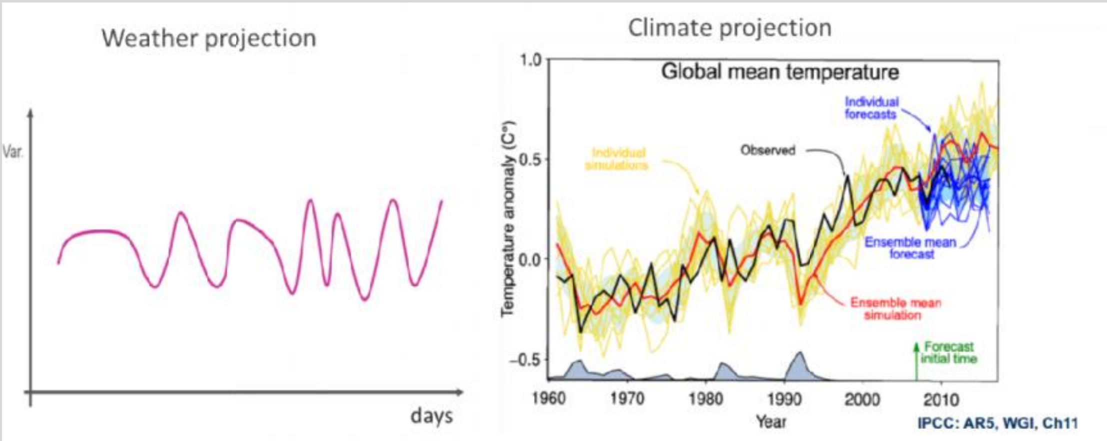
Source: Own elaboration based on Wikimedia

Annex 3: General climate change terminology

In order to make the best adaptation choices, decision makers in policy and industry should be well-informed regarding climate change. This includes understanding the basic concepts and terminology which are provided in the following.

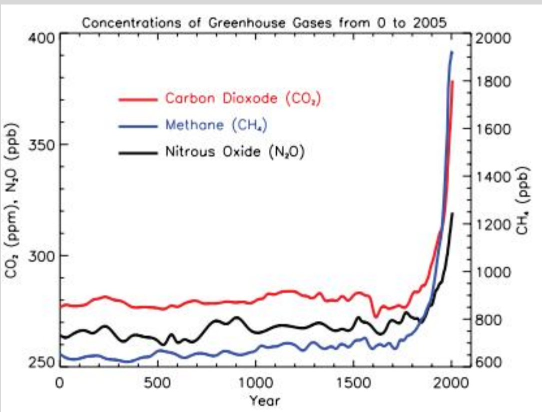
Let's start with the somewhat intertwined yet different concepts of weather and climate. ***Climate*** can be seen as the average weather over a longer period of time (in general 30 years). In contrast, ***weather*** is the actual state of the atmosphere in a particular area, as perceived daily with a regard to temperature, rainfall, wind etc. – i.e. weather is what you see and experience every day when you are outside. ***Climate change*** then means the statistical change of weather over a longer time period.

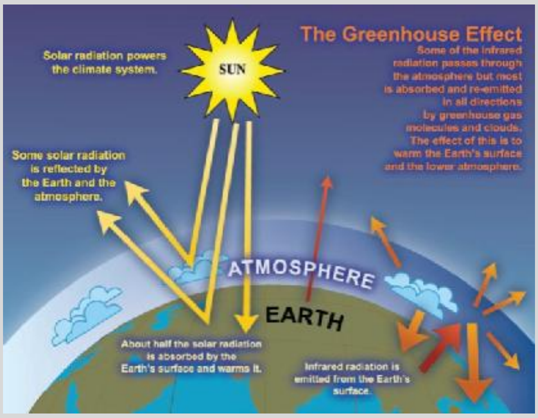
It is the nature of weather to be very chaotic and variable which is why weather forecasts are only valid for a few days in advance (e.g. "Will it rain tomorrow?"). In contrast, climate forecasts do not attempt to predict on a daily basis but on the evolution of climate statistic (e.g. global mean temperature for a period). The contrast is shown by below graphics (left weather, right climate).



Source (right): IPCC (2013b), ch. 11, p. 959

The earth's climate has been changing ever since, but especially due to man-made influences in the past centuries, the pace and extent of those changes has increased considerably. Among scientific researchers, there is a general consensus that climate change is caused to a large extent by anthropocentric ***greenhouse gas emissions***. By far the largest share of these emissions is CO_2 (e.g. from fossil fuel use and deforestation). Adding more of of these greenhouse gases to the atmosphere intensifies the natural ***greenhouse effect*** (as depicted below) and therefore contributes to a warming of the earth's climate.

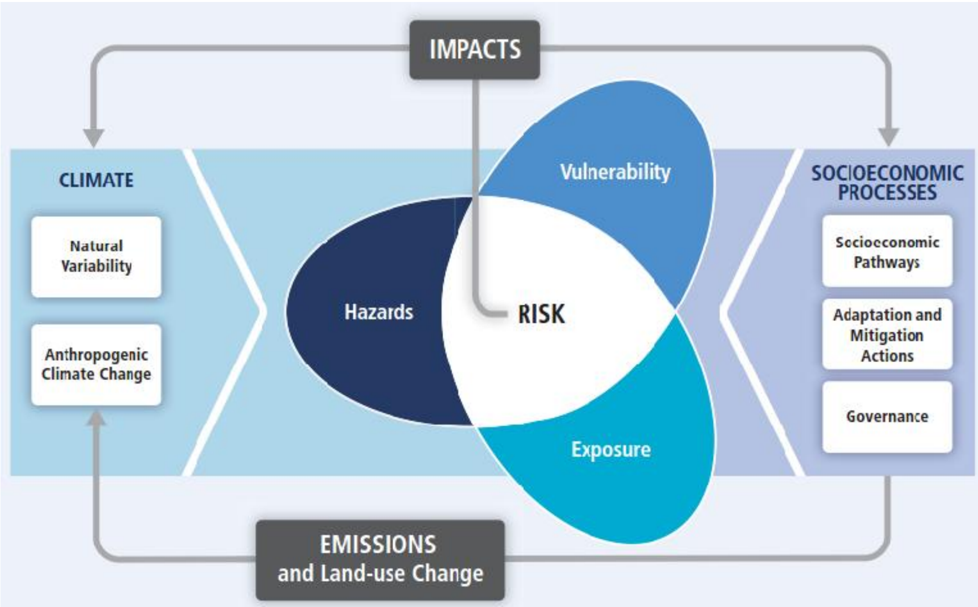




Source: IPCC (2007), FAQ, left p. 100, right p. 98

The global warming of air temperature is then associated with other environmental changes.

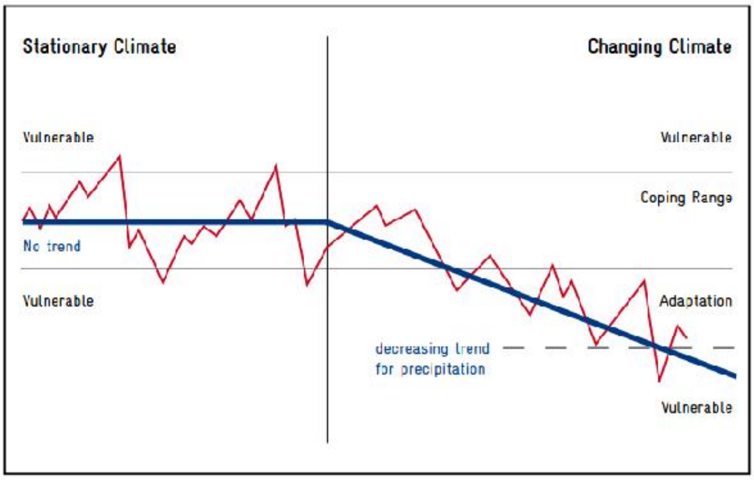
Depending on how climate-related hazards work together with the exposure and vulnerability /sensitivity of human or natural systems, certain ***risks from climate-related impacts*** arise (IPCC (2014), p. 3) as illustrated by below graphic. Hazards, exposure and vulnerability (sensitivity) are then driven by changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) (ibid.).



Source: IPCC (2014), WGII SPM, p. 3

When dealing with climate change, ultimately, the topics of ***"mitigation" and "adaptation"*** arise. Climate change mitigation and adaptation are two sides of the same coin. Whilst mitigation aims at reducing the emission of greenhouse gases globally, adaptation tries to address the local impacts. This policy paper focuses on climate change adaptation.

Below graphic illustrates some more of the terminology surrounding climate change adaptation based on an example (GIZ/PIK (2009), p. 10): "The zigzag curve shows a potential development of precipitation (here rainfall) in a country. Such variables are often referred to as ***"climate stimuli"***. Historically, subsistence farmers have developed strategies to cope with varying levels of precipitation, which has resulted in a ***coping range***. …

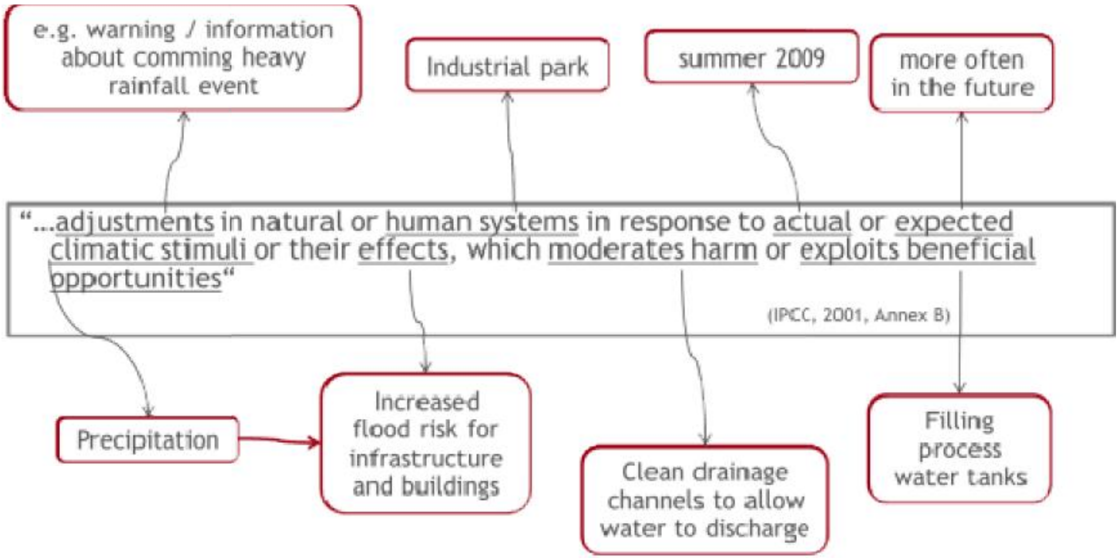


Source: GIZ/PIK (2009), p. 11

…metimes too extreme to cope with (too much or too little rain), and the farmers lost their crops. In other words, they were ***vulnerable*** to these extremes, even before the climate changed (stationary climate). With the changing climate, the trend in the curve is downwards (decreasing precipitation) and conditions exceed the coping range more often.

This is the point at which ***adaptation*** becomes relevant. Using climate change information in a proactive manner and applying measures such as improved watershed management or growing drought resistant crops, the coping range of the subsistence farmers can be expanded. Nevertheless, there will be limits to the adaptation and, in the future, some areas might no longer be suitable for agricultural production."

Below graphic further explores the different elements of climate change adaptation:



Source: Based on adelphi (2011), slide 62

Annex 4: Climate information

Past and current climatic data for Andhra Pradesh and Telangana

Generally, there is good information available regarding past climatic data for the former State of Andhra Pradesh including Telangana.

The following data can be obtained from IMD at http://www.imd.gov.in/:

- Tabular information on ***state-level*** annual, seasonal and even monthly ***mean temperature trends*** (for the former State of Andhra Pradesh including Telangana)
- Tabular information on state-level, annual, seasonal and even monthly ***rainfall trends***(for the former State of Andhra Pradesh including Telangana)

Map-based climatic information from IMD that can be accessed within the “Climate Profile for India” athttp://www.imd.gov.in/doc/climate_profile.pdf:

- Trend in ***sub-divisional rainfall data*** (increase/decrease in rainfall in mm) for different seasons (1901-2003) (several maps (per season) that show Andhra Pradesh, Telangana and the Rayalaseema region)
- Trend for ***sub-divisional rainfall dataof monsoon months*** (increase/decrease in rainfall in percentage) to annual rainfall (1901-2003) (several maps (per season) that show Andhra Pradesh, Telangana and the Rayalaseema region)
- ***Flood-prone areas of India***
- Probability & occurrence of ***drought and drought-prone areas of India*** (1875-2004)
- ***District-wise*** percentage of incidences (probability) of ***drought*** of (a) moderate intensity and (b) severe intensity during the southwest ***monsoon season*** for the period 1901-2003
- ***District-wise*** percentage of incidences (probability) of ***drought*** of (a) moderate and above intensity, (b) severe and above intensity, and (c) extreme intensity during the southwest ***monsoon season*** based on SPI during the period 1901-2003
- Long-term linear trends in the ***district-wise*** SPI (drought) during the period 1901-2003

The Disaster Mitigation Unit of the Andhra Pradesh State Development Planning Society provides several vulnerability maps based on past climatic information here http://www.apsdps.ap.gov.in/vm.html:

- ***Storm surge inundation*** map for Andhra Pradesh
- ***Flood inundation*** map for Andhra Pradesh
- ***Drought situation*** map for Andhra Pradesh (Mandal prioritization)

The same society also provides current cyclone information:

- ***Cyclone information*** maps (mostly based on recent cyclone) including inundation maps for Andhra Pradesh; in addition, there are Excel tables available detailing damages per village (e.g. rooftop damages)

Likewise, the Disaster Mitigation Unit of the Telangana State Development Planning Society provides a few vulnerability maps (http://117.247.178.102/tsdps/):

- ***Drought vulnerability*** map of Telangana
- Related to ***floods***: Map with water level graphs at various stations in Godavari River in Telangana

Analysis of SwissRe Sigma Reports for India

Floods

Reporting Year	Date	Event	State(s)	Victims				Damage [mUSD]	
				Dead	Missing	Injured	Homeless	Insured	Total
2005	9.4.	Flash Flood	Madhya Pradesh	65	85				
	28.6. - 9.7.	Heavy flooding due to monsoon	Gujarat	142			500000	156	444
	7.7. - 21.7.	Floods and landslides caused by monsoon	Assam, Arunachal Pradesh, Uttar Pradesh, Bihar, West Bengal,	83			4000		
	9.7. - 1.8.	Floods and landslides caused by monsoon, damage to vehicles and warehouses	Maharashtra, Gujarad, Madhya Pradesh	1050	100		15000	840	3330
	26.8. - 28.8.	Floods and Landslides caused by heavy rain	Uttar Pradesh	21	6				
	8.9.	Floods following torrential rain	Himachal Pradesh, Karnataka	20	13	5			
	19.9. - 22. 9.	Floods caused by torrential rain, windstorms	Andhra Pradesh	91					400
	21.10. - 26.10.	Floods caused by heavy rain, 60000 houses destroyed	West Bengal, Odisha	19			250000		117
	23.10. - 8.11.	Floods caused by heavy rain and strong winds, large parts of Chennai and Bangalore city under water	Andhra Pradesh, Karnataka, Tamil Nadu	164	6				
Sum				1655	210	5	769000	996	4291
2006	9.3. - 10.3.	Floods caused by heavy rains and hailstorms	Madhya Pradesh, Maharashtra, Rajasthan	61		113			
	31.5. - 26.6.	Floods caused by heavy rain, storm	Kerala, Gujarat, Mahrahstra, West Bengal, Uttar Pradesh, Assam	133					
	3.7. - 9.7.	Floods and landslides caused by heavy rain, strong wind	Uttar Pradesh, Gujarat, Odisha, Maharashtra	81					
	1.8. - 6.8.	Floods caused by monsoon rains, 200000 ha of rice and crop flooded	Maharashtra, Andhra Pradesh, Odisha, Chhattisgarh, Gujarat,	350			4000000	407	3390
	18.8. - 2.9.	Floods caused by heavy rain	Rajasthan	150	300				
	31.8. - 6.9.	Floods and landslides caused by heavy rain, Srinagar-Leh highway flooded	Jammu and Kashmir	39			2000		43
	1.10.	Flash flood after release of water at dam	Madhya Pradesh	39					
Sum				853	300	113	4002000	407	3433
2007	11.2. - 16.2.	Floods caused by heavy rain, hail and storm	Rajasthan, Uttar Pradesh	40		8			
	21.6. - 3.7.	Floods, landslides caused by heavy monsoon rains	Andhra Pradesh, Kerala, Karnataka, Maharashtra	144					
	1.7. - 13.7.	Floods caused by heavy rain	Gujarat, Madhya Pradesh, Odisha	42	10				
	16.7. - 25.8.	Floods caused by monsoon rain, Brahmaputra river bursts ist banks, homes, industry, 825000 ha of farmland flooded	West Bengal, Bihar, Uttar Pradesh, Assam	1500			3500000		320
	9.9. - 20.9.	Floods caused by heavy rain, national Highway flooded	Andhra Pradesh, Karnataka	60					
Sum				1786	10	8	3500000	0	320
2008	20.3. - 27.3.	Floods caused by heavy rains	Tamil Nadu, Karnataka	37					2
	10.6. - 27.3.	Floods caused by monsoon rain	Uttar Pradesh, Odisha, Assam, West Bengal	950			300000		123
	8.8. - 12- 8.	Floods and landslides caused by heavy rain	Telangana (Hyderabad)	130					195
	15.8. - 28.8.	Floods caused by heavy rain	Uttar Pradesh, West Bengal, Assam, Odisha	180					
	18.8. - 31.8.	Monsoon rains, dyke bursts, Kosi river bursts its banks and changed course, caused flooding 300000 houses, 100000 ha of farmland destroyed	Bihar	140			3000000		
	30.8. - 8.9.	Floods caused by heavy rain, 3.7 million ha of farmland flooded	Assam, Bihar	35					20
	19.9. - 23.9.	Floods and landslides caused by heavy rain	Uttar Pradesh, Himachal Pradesh, Odisha, Bihar	230			500000		
Sum				1702	0	0	3800000	0	340
2009	1.7. - 27.7.	Floods caused by monsoon rain	Assam, Odisha, Bihar, West Bengal, Kerala, Gujarat, Karnataka	520			25000		
	9.8.	Floods and landslides caused by heavy rain, villages wahshed away	Uttarakhand	45					
	26.8. - 29.8.	Floods caused by heavy rain	Bihar,	52					
	29.9. - 12.10.	Floods caused by heavy rain, Tungabhadra and Krishna Rivers burst their banks, cropland, sugarcane plantations flooded	Karnataka, Andhra Pradesh, Telangana	300			2000000	51	2150
	8.11. - 11.11	Floods and landslides caused by heavy rain	Tamil Nadu	42		8			64
Sum				959	0	8	2025000	51	2214
2010	6.7. - 8.7.	Floods caused by monsoonal rains, damage to houses, cropland	Assam, Kerala	53			400000		447
	5.8. - 8.8.	Floods caused by heavy rains, 10000 houses destroyed, 5000000 ha of cropland flooded	Jammu and Kashmir	198		200			
	17.9. - 27.9.	Floods caused by monsoonal rains, 150000 houses destroyed, 500000 ha of cropland flooded, damage to transport infrastructure	Uttar Pradesh, Bihar, Uttarakhand	200			2000000		1680
	1.12. - 16.12.	Floods caused by heavy rains	Tamil Nadu	150					22
Sum				601	0	200	2400000	0	2149
2011	15.6. - 16.7.	Floods caused by monsoonal rains	Uttar Pradesh, Uttarakhand	50					20
	4.8. - 31.8.	Floods caused by heavy rains, several rivers burst their banks, damage to houses and cropland	West Bengal	100					239
	5.9. - 19.9.	Floods caused by heavy rains, over 100000 houses destroyed	Odisha	39					430
	23.9. - 3.10.	Floods caused by heavy rains, 50 000 houses destroyed, over 200000 ha of cropland destroyed	Odisha, Bihar, Uttar Pradesh	51					527
Sum				240	0	0	0	0	1216
2012	22.6. - 19.7.	Floods caused by heavy monsoonal rains	Assam	120					
	16.9. - 18.9.	Floods caused by heavy rains	Uttarakhand	45					20
	19.9. - 23.9.	Floods caused by heavy monsoonal rains	Assam	21					
	29.10. - 31.10.	Tropical Storm Nilam	India (not specified)	40			4627		56
Sum				226	0	0	4627	0	76
2013	14.6. - 18.6.	Floods caused by heavy monsoon rains, 35875 ho	Uttarakhand, Bihar, Karnataka, Himachal Pradesh, Kerala, Gujarat, West Bengal	1537	4211		271931	500	
	23.6. - 15.7.	Floods caused by heavy monsoon rains, 35875 ho	Assam	80					
	9.7. - 10-7.	Severe floods	Uttar Pradesh	174					
	22.8. - 27.8.	Floods caused by heavy monsoon rains, 35875 ho	Uttar Pradesh, Madhya Pradesh, Assam	73					
	21.10. - 28.10.	Floods caused by torrential rains	Odisha, Andhra Pradesh	58					
Sum				1922	4211	0	271931	500	0
2014	30.7.	Landslide triggered by heavy rains	Maharashtra	209					
	23.6. - 25.8.	Floods	Assam	27					
	7.8. - 8.8.	Floods caused by monsoon rains	Odisha	45					100
	3.9. - 10.9.	Severe monsoon floods	Jammu and Kashmir	665		53735		237	5970
	20.9. - 25.9.	Floods following Typhoon Kalmaegi	Assam, Meghalaya	73					158
Sum				1019	0	53735	0	237	6228
				Victims				Damage [mUSD]	
				Dead	Missing	Injured	Homeless	Insured	Total
Total Sum				10963	4731	54069	16772558	2191	20267
Total Sum AP&TS and neighbour states				1297	6	0	6000000	458	6135
% of total India				12%	0%	0%	36%	21%	30%

Storms

Reporting Year	Date	Event	State(s)	Victims				Damage [mUSD]	
				Dead	Missing	Injured	Homeless	Insured	Total
2005	12.10. - 17.10.	Tropical Storms, Monsoon rains and floods	Andhra Pradesh, Tamil Nadu	33					
Sum				33	0	0	0	0	0
2006	2.6.	Thunderstorms with heavy rain and lightning	Uttar Pradesh, Gujarat	76					
	18.9. - 26.9.	Heavy storms cause flooding	West Bengal, Bihar	200	400	300	375000		1
	28.10. - 2.1.1.	Cyclone Ogni, heavy rain, floods, damage to 12000 houses and 300000 ha of crop	Andhra Pradesh, Tamil Nadu	58			60000		
Sum				334	400	300	435000	0	1
2007	11.5. - 12.5.	Thunderstorm with heavy rain	Uttar Pradesh	27		24			
	15.11. - 23.11.	Cyclone Sidr, winds up to 240 km/h, floods, 500000 homes, 647500 ha of crops destroyed, over 1.5m livestock lost	Bay of Bengal,	3363	871	34500	2000000		2310
Sum				3390	871	34524	2000000	0	2310
2008	14.5.	Dust storms with winds up to 110 km/h, heavy rain and floods	Uttar Pradesh	111		50			
	26.11. - 30.11.	Cyclone Nisha, winds up to 80 km/h, heavy rain, floods, 550000 ha of farmland flooded	Tamil Nadu, Puducherry	190			2680000		102
Sum				301	0	50	2680000	0	102
2009	31.3.	Thunderstorms, hail	Odisha	15		50			
	11.5.	Storm winds up to 110 km/h, hail	Uttar Pradesh	32		23			
	7.6.	Thunderstorms, heayvy rain, floods	Uttar Pradesh	20					
	29.6.	Storm, lightning, heavy rain	Bihar, Jharkhand	35		12			
Sum				102	0	85	0	0	0
2010	13.4.	Tropical storm with winds up to 160 km/h, 200000 houses destroyed	Bihar, West Bengal	145		300	100000		
	7.5.	Thunderstorm, heavy rain, floods	Bihar	54					
	20.5. - 22.5.	Cyclone Laila with winds up to 155 km/h, heavy rain, floods, 5800 ha of crops destroyed	Andhra Pradesh	58					100
	24.5.	Storm, hail, dwellings destroyed	Uttar Pradesh	12		30	2000		
	31.10. - 3.11.	Cyclone Jal with winds up to 100 km/h, heavy rains, floods, damage to crops and transport infrastructure	Andhra Pradesh58	22					
Sum				291	0	330	102000	0	100
2011	20.5. - 22.5.	Thunderstorm with winds up to 70 km/h, heavy rains	Uttar Pradesh	42		50			
	29.12. - 30.12.	Tropical Cyclone Thane with winds up to 125 km/h, 200000 houses damaged	Tamil Nadu	47					
Sum				89	0	50	0	0	0
2012	29.10. - 31.10.	Tropical Storm Nilam	India (not specified)	40			4627		56
Sum				40	0	0	4627	0	56
2013	12.10. - 14.10.	Cyclone Phailin with wind speeds up to 200 km/h, floods, over 100000 houses destroyed, over 3000000 houses damaged, 1336325 ha of cropland damaged, 162430 livestock killed	Odisha	58				100	4500
	22.11. - 24.11.	Cyclone Helen	Andhra Pradesh	10					262
Sum				68	0	0	0	100	4762
2014	3.3. - 4.3.	Thunderstorms, hail, flash floods, 374 houses damaged	Telangana	7		58			
	17.4. - 20.4.	Storms	India (not specified)	27					
	12.10. - 13.10.	Cyclone Hudhud	Andhra Pradesh	68		43		632	7000
Sum				102	0	101	0	632	7000
				Victims				**Damage [mUSD]**	
				Dead	**Missing**	**Injured**	**Homeless**	**Insured**	**Total**
Total Sum				1360	400	916	3221627	732	12021
Total Sum AP&TS and neighbour states				256	0	101	60000	632	7362
% of total India				19%	0%	11%	2%	86%	61%

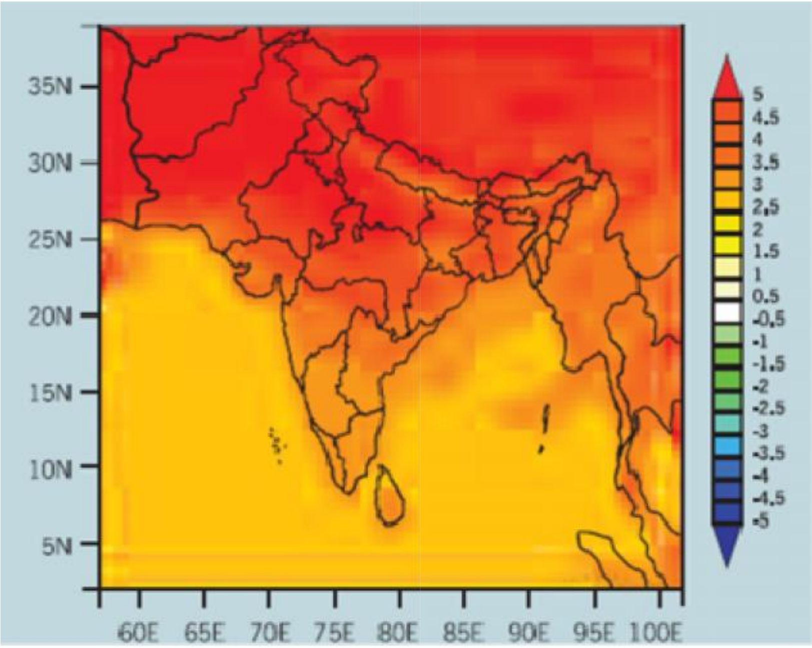
Heatwaves

Reporting Year	Date	Event	State(s)	Victims				Damage [mUSD]	
				Dead	Missing	Injured	Homeless	Insured	Total
2005	6.5. - 20.5.	Heat wave with temperatures >44 °C	Andhra Pradesh, Odisha	150					
	21.06. - 22.6	Heat wave with temperatures >45 °C	Andhra Pradesh, Odisha	375					
Sum				525					
2006	1.5. - 28.5.	Heat wave with temperatures of up to 48 °C, water shortage, power outages	Uttar Pradesh, Punjab, Odisha	80					
2007	8.6. - 13.6.	Heat wave with temperatures of over 50 °C	Rajasthan, Uttar Pradesh	120					
2009	14.4. - 26.6.	Heat wave with temperatures of over 42 °C	Odisha, Bihar, Uttar Pradesh	142					
2010	1.3. - 20.5.	Heat wave with temperatures of over 47 °C	Odisha, Rajasthan, Punjab, Haryana	250					
2013	1.4. - 30.5.	Heat wave	India (not specified)	531					
				Victims				**Damage [mUSD]**	
				Dead	**Missing**	**Injured**	**Homeless**	**Insured**	**Total**
Total Sum				1648					
Total Sum AP&TS				525					
% of total India				32%					

Source: Own analysis based on SWISS RE Sigma Reports (2005-2015)

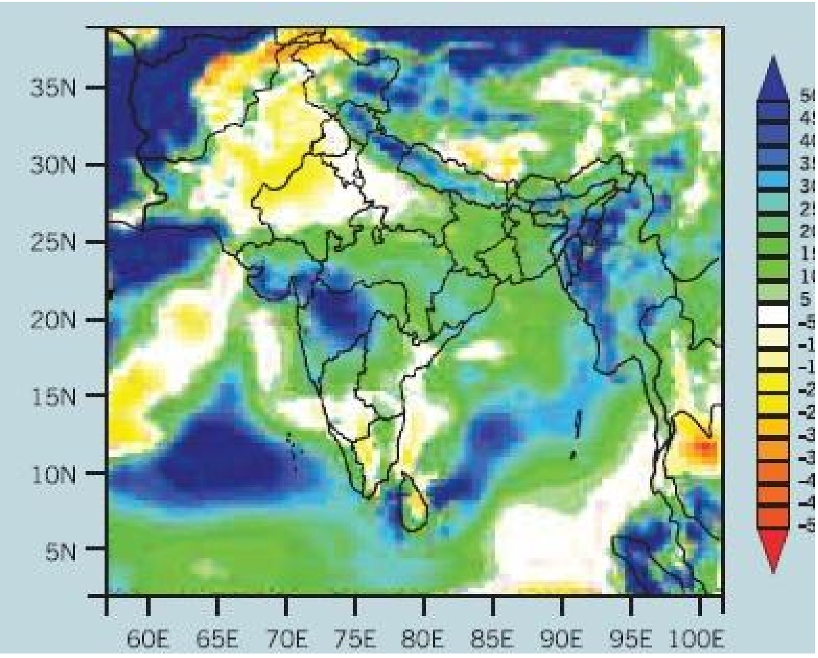
Climate projections for India

Annual ***mean surface air temperature*** increase (ºC, right) for the period 2071-2100 with reference to the baseline of 1961-1990, under the A2 scenario:



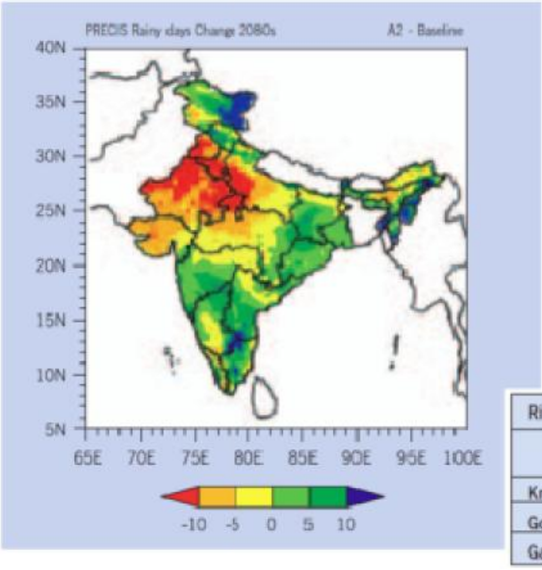
Source: IITM/MoEF(no year),Keysheet 2, p. 3

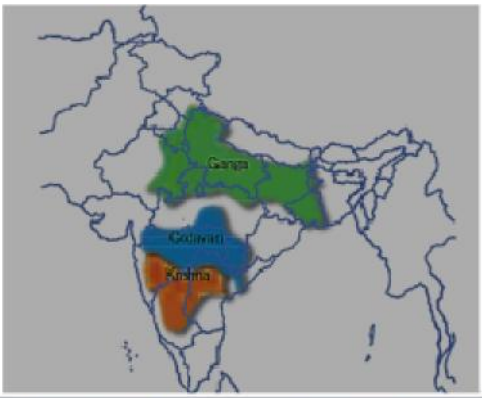
Spatial patterns of the ***changes in summer monsoon rainfall*** (mm, for the period 2071-2100 with reference to the baseline of 1961-1990, under the A2 scenario):



Source: IITM/MoEF (no year), Keysheet 2, p. 3

Changes in ***annual number of rainy days*** in India (left) and its ***three major river basins***(right): the Krishna, the Ganga, and the Godavari. Summer monsoon rainfall contributed 70 – 90% of rainfall in these basins:

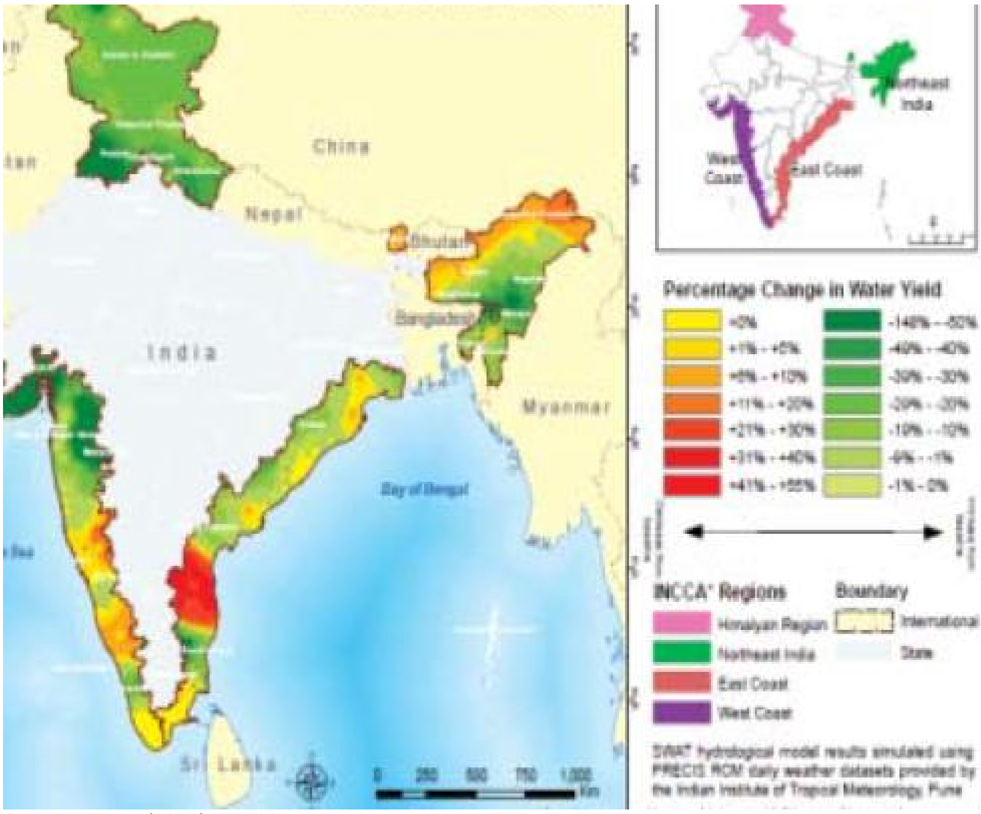




River Basin	Baseline (1961-1990)		Future (2071-2100)	
	Annual Rainfall (cm)	Annual Flow (km³)	Annual Rainfall (cm)	Annual Flow (km³)
Krishna	91	60	112	67
Godavari	166	98	201	116
Ganga	134	482	150	543

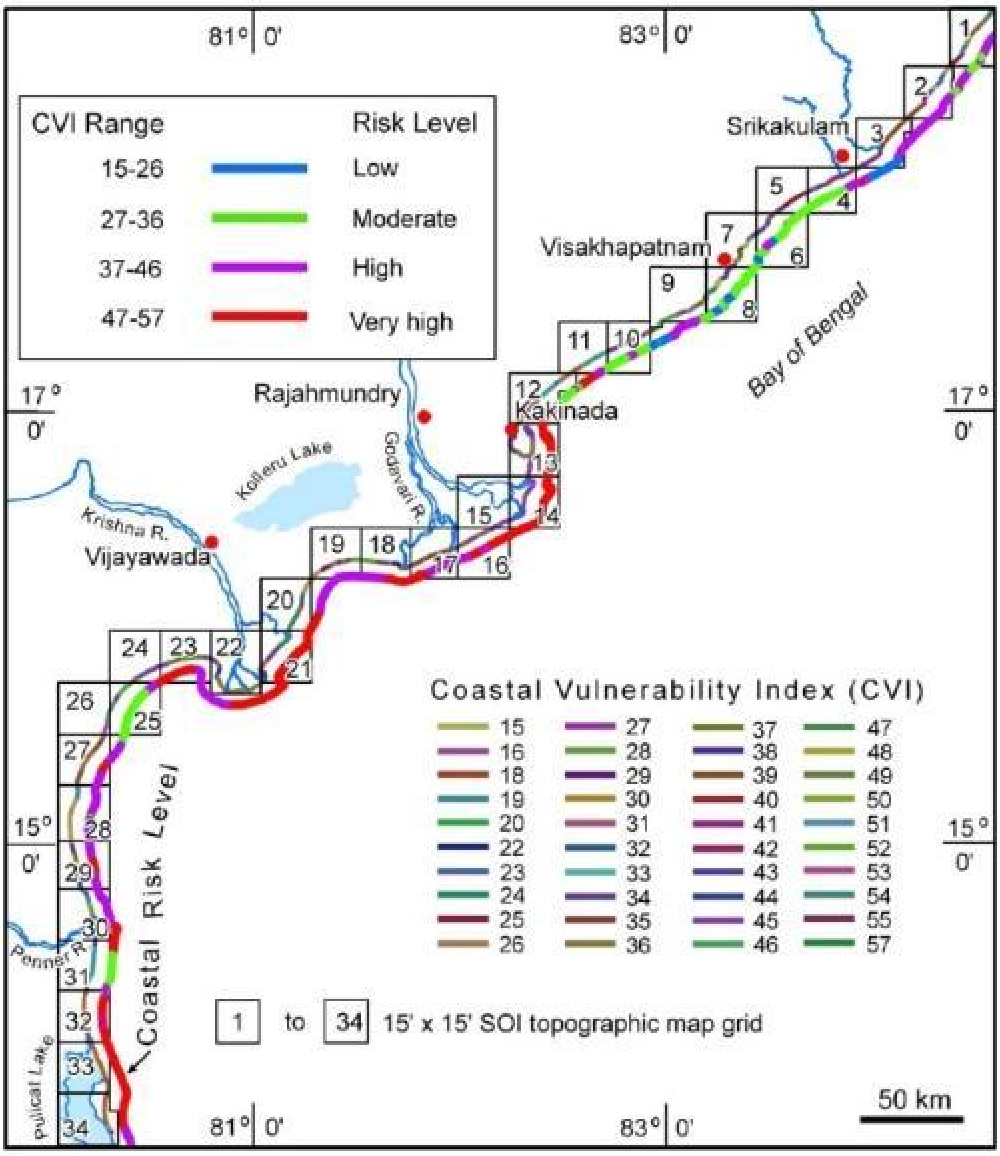
Source: IITM/MoEF (no year), Keysheet 5, p. 3

Expected ***changes in water yields*** 2030:



Source: MoEF (2010), p. 123

Rao et al. (2008) have developed a ***coastal vulnerability index*** for greater Andhra Pradesh by applying five physical variables (i.e. coastal geomorphology, coastal slope, shoreline change, mean springtide range, significant wave height) to different coastline segments in the light of climate change. Their results show that around 43% of Andhra Pradesh's coast is at very high risk and 35% at high risk if the sea level rises by approx. 60cm (ibid.)



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Source: Rao et al. (2008), p. 204

Annex 5: Long list of different types of risks for industry and industrial estates

Below list is a compilation of secondary sources to provide a general literature overview on risks globally.

Impact area	Risk type	Description	Climate signal	Source
Industrial park and industries				
Buildings	Dampening and impairment of building material	Erosion of building material due to dampening of masonry	Heavy rains	PROGNOS/adelphi (2014)
	Structural damages due to sewerage backwater	Sewerage backwater results from overload or congestion. Waste water spills from manhole covers and causes local inundations that can impair buildings.	Heavy rains	PROGNOS/adelphi (2014)
	Structural damages due to landslides	Under certain conditions (soil type, slope) persisting strong rainfalls can induce landslides which possibly induce structural damages	Heavy rains	PROGNOS/adelphi (2014)
	Storm damages of areas and buildings	Damages, especially of roofs and facades, due to strong winds	Storms	PROGNOS/adelphi (2014)
	Flood damages of areas and buildings	Rising water levels of neighbouring rivers and creeks can inundate operational area	Floods	PROGNOS/adelphi (2014)
	Hail damage of buildings	Damage of sensitive facilities (e.g. glass roofs)	Hail	PROGNOS/adelphi (2014)

	Overheating of buildings and increased energy demand for cooling	Limited usability and/or elevated need for cooling (costs) due to temporary overheating of buildings	Heat waves	EURAC (2013), IPCC (2014a) p.19, PROGNOS/adelphi (2014)
	Flood damages of coastal areas and buildings	Sea level rise can jeopardize coastal operational areas and buildings and, in extreme cases, necessitate relocation	Sea level rise	PROGNOS/adelphi (2014)
	Structural damages due to lightnings or consequential smoulder or fires	Lightning strikes can directly damage facades and roofs. They often cause smoulder and fires that damage buildings.	Lightning	PROGNOS/adelphi (2014)
Infrastructure (energy supply)	Power cuts	Climate Change poses a risk to energy infrastructure. Extreme weather events can destroy transmission lines and power plants or lead to network overload. A potential consequence is power cuts.	Floods, storms, heavy rains, lightnings	GIZ/SIDBI/adelphi (2013), PROGNOS/adelphi (2014)
	Damage of own facilities for power production	Damage of own facilities for power production (e.g. photovoltaic, wind power, cogeneration units) because of extreme weather conditions.	Floods, storms, heavy rains, hail, lightnings	PROGNOS/adelphi (2014)
	Increase of energy costs	Climate change can influence the availability of fossil fuels and lead to changes in energy demand. This is expected to induce increases in costs.	General	EURAC (2013) PROGNOS/adelphi (2014)
Infrastructure (water issues)	Limited availability of water	Limited availability of process water for industries, tightening of limits for warm water emissions, failure of cooling systems	Dry periods	EURAC (2013) PROGNOS/adelphi (2014)

	Tightening of limit values for temperature of waste water	(Seasonally) increased limitation of discharging cooling and process water into surrounding water bodies due to limit values for water temperature	Dry periods	PROGNOS/adelphi (2014)
	Fluctuations in the quality of service water	Seasonal water pollution caused by low groundwater levels	Dry periods	PROGNOS/adelphi (2014)
Infrastructure (ICT)	Failure and damage of operational IT systems due to inundations	Failure of operational IT systems due to inundations and consequentially costs of disruptions, reestablishment and repair	Floods	PROGNOS/adelphi (2014)
	Failure and damage of operational IT systems due to overheating	Failure of operational IT systems due to overheating and consequentially costs of disruptions, reestablishment and repair	Heat waves	PROGNOS/adelphi (2014)
	Disturbance and failure of communication networks	Disturbance and failure of communication networks due to inundations or other extreme weather events	Floods, storms, heavy rains	PROGNOS/adelphi (2014)
Industrial processes	Flood damage of (industrial) plants	Flood induced minor damages of plants or damages of plants that are not crucial for production, possibly with minor operational delays afterwards	Floods	PROGNOS/adelphi (2014)
	Flood induced damage of crucial plants entailing operational interruptions	Flood induced damage of plants that are crucial for production, entailing operational interruptions or production stops	Floods	PROGNOS/adelphi (2014)

	Surge damage of plants and machines due to lightning	Lightning strikes can flash over to electric lines and damage electric plants or cause short circuits	Lightning	PROGNOS/adelphi (2014)
	Efficiency reduction of machines and plants due to increased outdoor temperatures	Increased outdoor temperatures can lead to a reduction of efficiency of machines and plants or even cause damages or temporary shutdown of plants due to overheating	Heat waves	PROGNOS/adelphi (2014)
Stock	Flood induced damage of stock	Flood induced damage of inventories stored in- or outdoor	Floods	PROGNOS/adelphi (2014)
	Storm induced damage of stock	Damage of outdoor inventories by storms and their consequences	Storms	PROGNOS/adelphi (2014)
	Hail induced damage of stock	Damage of outdoor inventories by hail and their consequences	Hail	PROGNOS/adelphi (2014)
	Damage of stock due to heat	Damage of outdoor inventories that are exposed solar radiation and strong heat during heat waves	Heat waves	PROGNOS/adelphi (2014)
Employees	Heat-related decrease of staff productivity	Exhaustion due to increased room- and outside-temperatures, bad air quality and elevated levels of UV radiation	Heat waves	EURAC (2013) PROGNOS/adelphi (2014)
	Obstruction of outdoor work by hail	Hailstorms obstruct work in the open air	Hail	PROGNOS/adelphi (2014)

	Obstruction of outdoor work by landslides	Under certain conditions (soil type, slope) persisting strong rainfalls can induce landslides which possibly obstruct work in the open air	Heavy rains	PROGNOS/adelphi (2014)
	Obstruction of work by inundations	In case of inundations staff members can't access indoor or outdoor areas	Floods	PROGNOS/adelphi (2014)
	Obstruction of outdoor work by storms	Strong winds can obstruct the work in the open air obstructed or even make it unreasonable due to safety hazards	Storms	PROGNOS/adelphi (2014)
	Increase of staff failure due to illness	Warmer climate favors vectors of several infectious diseases	General	PROGNOS/adelphi (2014)
Management	Higher demand of management	Increasing risks and changes of economic and societal framework conditions increase the requirements to management	General	PROGNOS/adelphi (2014)
	Reputation risks	The public or respectively clients expect companies to take over societal responsibility and to seize cost-intensive measures for environmental and climate protection. Otherwise there is the risk of declining demands and negative campaigns	General	PROGNOS/adelphi (2014)

	More planning needs (e.g. check on global locations and suppliers)	(Resulting (partly) from requirements for environmental technologies)	(Global climate change and other drivers)	EURAC (2013)
Market, supply chain, finance and insurance				
Supply chain	Changes in the quality of raw materials	(Resulting (partly) from requirements for environmental technologies)	(Global climate change and other drivers)	EURAC (2013)
	Procurement problems due to process disruptions of suppli-ers	Failure or delay of deliveries due to sup-pliers' process disruptions in conse-quence of extreme weather conditions	Floods, storms, heavy rains, heat waves	PROGNOS/adelphi (2014)
	Procurement problems due to disruptions of road haulage	Damage or delay of deliveries due to dis-ruptions of road traffic (blockades, road or bridge closure, structural damages, heat-induced increased risk of accident) be-cause of extreme weather conditions	Floods, storms, heavy rains, heat waves, hail	EURAC (2013), PROGNOS/adelphi (2014)
	Procurement problems due to disruptions of rail transport	Damage or delay of deliveries due to dis-ruptions of railway transportation (block-ades, closure of bridges and railroad sec-tions, damages of railway tracks and overhead lines) because of extreme weather conditions	Floods, storms, heavy rains, heat waves	EURAC (2013), PROGNOS/adelphi (2014)

	Procurement problems due to disruptions of inland shipping	Damage or delay of deliveries due to disruptions of inland shipping because of floods (increased flow velocity, shoals) or reduced water levels of rivers. Possibly restrictions of the ships' load capacity. In extreme cases cessation of shipping	Floods, dry periods	EURAC (2013), PROGNOS/adelphi (2014)
	Chain reaction of procurement problems	Failure or delay of deliveries due to subcontractors' process disruptions in consequence of extreme weather conditions	Floods, storms, heavy rains, heat waves	PROGNOS/adelphi (2014)
	Problematic distribution of goods due to disruption of road haulage	Damage of goods or delivery delays due to disruptions of road transportation (blockades, closure of bridges, structural deficits of roads or heat induced increase of accident risk) caused by extreme weather events	Floods, storms, heavy rains, heat waves, hail	EURAC (2013), PROGNOS/adelphi (2014)
	Problematic distribution of goods due to disruption of rail transportation	Damage of goods or delivery delays due to disruptions of railway transportation (blockades, closure of bridges and railroad sections, damages of railway tracks and overhead lines) caused by extreme weather conditions	Floods, storms, heavy rains, heat waves	EURAC (2013), PROGNOS/adelphi (2014)
	Problematic distribution of goods due to disruption of rail transportation	Damage of goods or delivery delays due to flood-induced disruptions of inland shipping (increased flow velocity, shoals) or due to reduced water levels of rivers. Possibly restrictions of the ships' load capacity. In extreme cases cessation of shipping	Floods, dry periods	EURAC (2013), PROGNOS/adelphi (2014)

Finance & insurance	Costs of emission certificates	With the increase of climate change impacts the number of available emission certificates is likely to be reduced whereas their retail price will increase	General	PROGNOS/adelphi (2014)
	Financial risks	Increasing significance of climate-related aspects for listed and non-listed (credit granting) companies	General	PROGNOS/adelphi (2014)
	Less affordable insurances available	Less insurances available that offer affordable coverage due to increased losses and loss variability. Climate change can increase the vulnerability of a site and thus lead to higher insurance fees or even un-insurability	General	IPCC (2014a) p. 19, PROGNOS/adelphi (2014)
Market	Changes in (selling) markets	(Resulting (partly) from requirements for environmental technologies)	(Global climate change and other drivers)	EURAC (2013)
	Fluctuation in demand	Long-term changes of weather conditions can alter consumption patterns of certain product groups. Threat of lower sales prices or sales losses	General	PROGNOS/adelphi (2014)
Surrounding communities, wider infrastructure and environment				

Environment	Discharge of hazardous substances	N/A [Authors note: causing the discharge could be damage of storage facilities, damage of production facilities due to either direct impact of floods, storms etc. or through indirect impacts of fires, shortage of energy supply or other.]	Floods	EURAC (2013)
Community	Potential for conflicts with neighbouring communities	Relationship between industrial parks and surrounding communities may increasingly suffer from climate change impacts (e.g. even more competition for resources such as falling water tables)	General	GIZ/SIDBI/adelphi (2013)

Annex 6: Climate change risks in various industry sectors

business sector	Expected risks	Concerns
Agriculture, Food & Beverage	• Water scarcity • Crop damage due to weather extremes • Increased exposure to new pests and disease • Transportation problems	• Water scarcity is primary vulnerability. • Impact of climate change on agri-products is increasing
Energy & Utilities	• Reputational risk • Physical risk due to extreme weather events • Peak demand could outstrip capacity; • Hot weather may reduce efficiency of extraction	• Climate change risk includes potential physical damage to personnel and equipment, and potential disruption of the production activities of offshore installations • Significant climate variability from one year to another can cause substantial variations in the balance of supply and demand for electricity and gas • Water shortages can reduce hydroelectric power production
Manufacturing & Consumer Goods	• Higher prices of raw materials • Higher energy prices • Anticipated changes in customer preferences • Supply chain disruptions	• Dramatically rising energy prices will have a negative impact on the operating costs of companies • Reduced availability, supply and quality of raw materials is a concern • Industry could face a production bottleneck due to a functional failure in supply chain

Banking & Finance	• Macroeconomic downturn hurts volume • Customer defaults in retail sector • Uninsured damage to project assets • Exposure to indirect risks through investment portfolio	• Certain agricultural products might be affected by the intensification of Drought • It is necessary to put climate impacts into monetary terms to “wake up” the banking system • Climate change changes our risk profile for certain sectors that we lend to and thus our lending “appetite” within those sectors.
Construction & Building Materials	• Changes in building codes and regulations • Reduced worker productivity due to heat • Disruptions in delivery of materials • Disruptions due to extreme weather events	• Legal risks take on considerable significance in the context of adaptation • Tougher legislation may give rise to a greater number of lawsuits due to cases of infringement. • Many industries are vulnerable because they are located in coastal areas
Health care & Pharmaceuticals	• Changing disease vectors • Increased waterborne illness • Higher health insurance costs	• Potential and actual drought situations present a risk • Water availability in several manufacturing regions is a concern
Mining & Industrial Metals	• Regulatory risk • Vulnerable to energy and water shortages due to intensity of use • Rainfall and flooding creates risk of overflow of storage • Reservoirs containing contaminants	• Increasing regulatory pressure will impact the steel industry in terms of impacts on the process, location of facilities and availability of raw materials. • Main concern is energy and water security (energy intensive sector)
Insurance	• Increased volume of claims • Historical loss information less reliable • Risk modelling and product pricing more complex • Some risks may be uninsurable	• Changing weather patterns and an increase in insured losses in some geographical areas already experienced

Source: UN Global Compact / Oxfam / World Resources Institute (2011)

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