Guideline for Adaptation and Increasing Resilience of Industrial Parks to the Impacts of Climate Change

in Andhra Pradesh and Telangana State, India

Climate Risk Analysis and Adaptation Planning

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Authors (Organisations in Alphabetical Order)

Adelphi
Sibylle Kabisch

Buro Happold
Sebastian Seelig, Oyku Ulguner

Green Infra Creations
Uttam Banerjee, Devottama Banerjee

Ifanos
Peter Bank

INTEGRATION
Dieter Brulez, R. Hrishikesh Mahadev, Rajani Ganta

Tata Institute of Social Science (TISS) (Reviewer)
T. Jayaraman, Kamal Kumar Murari

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List of Abbreviations

APIIC	Andhra Pradesh Industrial Infrastructure Corporation
APITCO	Andhra Pradesh Industrial and Technical Consultancy Organisation Ltd.
CCA	Climate Change Adaptation
CEAC	Central Environmental Appraisal Committee
CETP	Common Effluent Treatment Plant
CPCB	Central Pollution Control Board
CRA	Climate Risk Analysis
CZMA	Coastal Zone Management Authority
CFO	Consent for Operation
CFE	Consent for Establishment
DPR	Detailed Project Report
EIA	Environmental Impact Assessment
EIP	Eco-industrial Park
GoI	Government of India
IALA	Industrial Area Local Authority
IC	Industrial Corridor
IP	Industrial Park
IMD	Indian Meteorological Department
MoEF&CC	Ministry of Environment, Forests and Climate Change
MSME	Micro, Small and Medium Enterprises
NIMZ	National Investment and Manufacturing Zones
NLP	National Land Use Planning
PF&IC	Price Fixation & Infrastructure Committee
SAR	Site Analysis Report
SC/ ST	Scheduled Castes/ Schedule Tribes

SEA	Strategic Environmental Assessment
SEAC	State Level Environmental Appraisal Committee
SEZ	Special Economic Zone
SFC	State Financial Corporation
SPCB	State Pollution Control Board
ST/SC	Scheduled Tribes / Scheduled Casts
SMP	Site Master Planning
SLAC	State Level Allotment Committee
TSIIC	Telangana State Industrial Infrastructure Corporation
USP	(Unique Selling Proposition)
ZM	Zonal Manager

Glossary

Adaptation	Any activity that reduces the negative impact of climate change, while taking advantage of new opportunities that may be presented as a result of climate change.
Cloud Burst	A cloudburst is an extreme amount of precipitation, sometimes accompanied by hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. A cloudburst can suddenly dump large amounts of water e.g. 25 mm of precipitation corresponds to 25000 metric tons/km2 (1 inch corresponds to 72,300 short tons over one square mile). However, cloudbursts are infrequent as they occur only via orographic lift or occasionally when a warm air parcel mixes with cooler air, resulting in sudden condensation.
Coastal inundation	The flooding of normally dry, low-lying coastal land, primarily caused by severe weather events along the coasts, estuaries, and adjoining rivers or caused by rise in mean sea level. The winds drive large waves and storm surge on shore, and heavy rains raise rivers and overall water level.
Conducted Strike	This occurs when lightning strikes a conductor and that in turn induces the current into an area some distance away from the ground strike point. Unprotected connected equipment can be damaged if they become an indirect path in the completion of the ground circuit.
Cyclone	A cyclone is an intense low pressure area or a whirl in the atmosphere over tropical or sub-tropical waters, with organised convection (i.e. thunderstorm activity) and winds at low levels, circulating either anti-clockwise (in the northern hemisphere) or clockwise (in the southern hemisphere). From the centre of a cyclonic storm, pressure increases outwards. The amount of the pressure drop in the centre and the rate at which it increases outwards gives the intensity of the cyclones and the strength of winds.
Direct Strike	This is the most dangerous form, wherein the structure is a direct path for lightning currents to seek ground. The extent of the current determines its effects.
Down-slope wind	These are the winds blowing at / with very high speed down the slope of mountains
Drought	Droughts are periods of abnormally dry weather that results in serious hydrological imbalance. Droughts can be divided within the different hydrological cycle that they affect the most. Agricultural drought refers to abnormally low soil moisture, and hydrological drought implies a reduced runoff and groundwater recharge. 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”.
Flood	A flood is an overflow of water that submerges land which is usually dry. Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries, or it may occur

	due to an accumulation of rainwater on saturated ground.
Flood Plain	A lowland area, whether diked, flood proofed, or not, which, by reasons of land elevation, is susceptible to flooding from an adjoining watercourse, ocean, lake or other body of water and for administration purposes is taken to be that area submerged at the Designated Flood Level.
Heat Stress	Heat stress refers to the severe consequences of extreme heat for human health, affecting most strongly the vulnerable groups such as elderly, infants and children, as well as people with chronic heart or lung disease. Severe cases of heat stroke can cause death. It affects the labour productivity significantly in industrial parks.
Heat wave	Heat waves, also referred to as extreme heat events, are periods of abnormally hot weather, relative to the expected conditions of the area at that time of the year. IMD (India Meteorological Department) specifies heat waves by the maximum temperature of a station of at least 40°C for plains and at least 30°C for hilly regions.
Heavy Rainfall	Precipitation falling with an intensity in excess of > 7.6 mm (0.30 in) per hour, or between 10 mm (0.39 in) and 50 mm (2.0 in) per hour. Short periods of intense rainfall can cause flash flooding, longer periods of widespread heavy rain can cause rivers to overflow.
Lightening	Lightning is a sudden electrostatic discharge during an electrical storm between electrically charged regions of a cloud (called intra-cloud lightning or IC), between that cloud and another cloud (CC lightning), or between a cloud and the ground (CG lightning). The charged regions in the atmosphere temporarily equalize themselves through this discharge referred to as a strike if it hits an object on the ground, and a flash, if it occurs within a cloud. Lightning causes light in the form of plasma, and sound in the form of thunder. Lightning may be seen and not heard when it occurs at a distance too great for the sound to carry as far as the light from the strike or flash.
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, Climate Change 2014. Impacts, Adaptation and Vulnerability. Summary for Policy Makers. Working Group II, 2014), p. 5)
Risk	The latest IPCC report now focuses more on risks whereas earlier reports applied the concept of vulnerability. The IPCC defines risk as ((IPCC, Climate Change 2014. Impacts, Adaptation and Vulnerability. Summary for

	Policy Makers. Working Group II, 2014), 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."
Sea Dike	A dike, floodwall or any other thing that prevents flooding of land by the sea. As defined in the Dike Maintenance Act, "dike" means "an embankment, wall, fill, piling, pump, gate, flood box, pipe, sluice, culvert, canal, ditch, drain"
Sea level rise	An increase in the mean level of the ocean. Seal levels can rise at a global level through an increase in the volume of the world's oceans or at a local level due to ocean rise or land level subsidence. Sea level rises can considerably influence human populations in coastal and island regions and natural environments like marine ecosystems. Sea level rise is expected to continue for centuries. Because of the slow inertia, long response time for parts of the climate system, it has been estimated that we are already committed to a sea-level rise of approximately 2.3 metres (7.5 ft) for each degree Celsius of temperature rise within the next 2,000 years.
Sediment Control	Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave a site.
Setback	Means withdrawal or siting of a building or landfill away from the natural boundary or other reference line to maintain a floodway and to allow for potential land erosion.
Sewer Backflow Flood Event	This type of flood event is noticeable in places where the sewer system is combined. When both storm-water and sewage flows through a single pipe, there would be situations of sewer system backflow, resulting in underground flooding.
Sheet erosion	This is the uniform removal of soil in thin layers from the land surface by winds. It occurs in areas where loose, shallow topsoil overlies compact soil.
Shortages in Energy Supply	Shortages in energy supply refers to the problems occurring in the electricity sector due to heat waves and droughts, which cause blackouts and brownouts.
Side Strike	This results from the disintegration of the direct strike when alternate parallel paths of current flow into the ground via structure. When the determined current path has some hindrance to current flow, a potential above ground develops and the structure's resistance to ground becomes the alternate path of conduction.
Splash erosion	This erosion occurs due to the impact of falling raindrop on the surface of soil.

Storm Surge	A change in water level caused by the action of wind and atmospheric pressure variation on the sea surface. The typical effect is to raise the level of the sea above the predicted astronomical tide level, although in some situations, such as when winds blow offshore, the actual water level may be lower than that predicted. The rise in water level can cause extreme flooding in coastal areas particularly when storm surge coincides with normal high tide, resulting in storm tides, reaching up to 20 feet or more in some cases.
Storm tide	Storm tide is the resulting water level produced by the combined effect of storm surge and astronomical tides. It is therefore an absolute water level as recorded. The storm tide level may be lower than a high astronomical tidal level if there is a storm surge that occurs at low tide. The storm tide therefore depends on the storm surge level, the astronomical tide level and the timing of the storm surge relative to the timing of the astronomical tides.
Straight-line wind	High winds associated with intense low pressure can last for approximately a day at a given location. The blow in a straight line
Surface flood	Here the flood event is noticeable above ground and it occurs mainly due to overflow of water from any nearby river, lake or as a result of storm surge, heavy rainfall, or coastal inundation
Surge Protection Device	SPD also known as a transient voltage surge suppressor (TVSS), is designed to divert high-current surges to ground and bypass your equipment, thereby limiting the voltage that is impressed on the equipment.
Thunderstorm	They can form rapidly and produce high wind speeds. Thunderstorms often create heavy rain and they move very rapidly, causing high winds for few minutes at a location.
Water scarcity	Water scarcity is the lack of water due to low water availability and water demand exceeding the supply capacity – affected by the severity and frequency of droughts. Water scarcity has significant impacts on industrial parks in terms of production and processes.

1. Adaptation to Climate Change of Industrial areas

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 the challenges of climate change with a focus on Andhra Pradesh and Telangana.

Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC), an undertaking of Government of Andhra Pradesh, is a premier organization, vested with the objective and responsibility of building and holding land banks, developing Industrial Parks/Estates and Special Economic Zones by providing necessary Industrial infrastructure. Over 201 Industrial Parks have been established throughout the State in eight (8) industrial zones covering an extent of 57, 836 Acres. These industrial parks are prone to various types of extreme climate events such as Cyclones, Drought, Floods, Heat Waves, etc.

Telangana State Industrial Infrastructure Corporation Limited (TSIIC), an undertaking of Government of Telangana State, is a premier organization in the state, vested with the objective of providing Industrial infrastructure through development of Industrial Parks and Special Economic Zones. Over 131 Industrial Parks have been established throughout the State of Telangana covered under 6 zones of the TSIIC. Telangana state is threatened by disasters like floods, drought, heat waves, etc.

During the course of the project, both, APIIC and TSIIC may adopt a policy (APIIC, TSIIC, GIZ, 2016a) to make existing and upcoming industrial areas in Andhra Pradesh and Telangana State, India, more climate resilient. The aim of this guideline is to anchor the consideration of Climate Change Adaptation (CCA) in the planning process [1] of new industrial areas (APIIC, TSIIC, GIZ, 2016b), as well as in further development and refurbishment of existing ones. The incorporation of CCA into planning, development and implementation processes of industrial areas will result in IPs, SEZs, ICs, and NIMZs that are more resilient towards climatic change. The following guidelines are generally applicable to all these types of industrial development lands. The example is focussing on Industrial Parks, which is the most widespread type of industrial agglomerations; however, main procedures and planning steps are similar for all types. In order to simplify the reading of the guidelines, the text will refer to IPs only, subsuming the above listed types.

Generally, there are two possible scenarios for CCA planning:

1. For **new IPs** the preparation of a master plan is a mandatory step. In the future, CCA concerns need to be integrated comprehensively in such master plans and the related planning and decision making processes.
2. For **existing IPs,** a CCA action plan needs to be prepared containing actual CCA measures. There are two sub-scenarios: (a) making an entire IP climate resilient and (b) implementing a specific measure or several measures.

In general, the following steps need to be considered and completed:

[1] Planning and Implementation Framework for Industrial Parks In Andhra Pradesh and Telangana State, India, INTEGRATION Energy and Environment GmbH (2016)

(1) A climate risk analysis identifying the main hazards the IP is exposed to, the IPs vulnerability and the resulting risks;
(2) The identification, selection, and prioritization of CCA measures based on specific criteria of importance and cost;
(3) Funding and implementation of the identified measures;
(4) Continuous monitoring, evaluation and learning.

1.1 Adaptation Planning

Climate change adaptation in Industrial Parks refers to the adjustments of physical and non-physical systems in parks in response to climate change hazards and their impacts. Adaptation planning is a process, which should be taken care within a structured approach and progressive steps.

The United Nations Framework Convention on Climate Change (UNFCCC) defines five general components of adaptation activities. These components are:

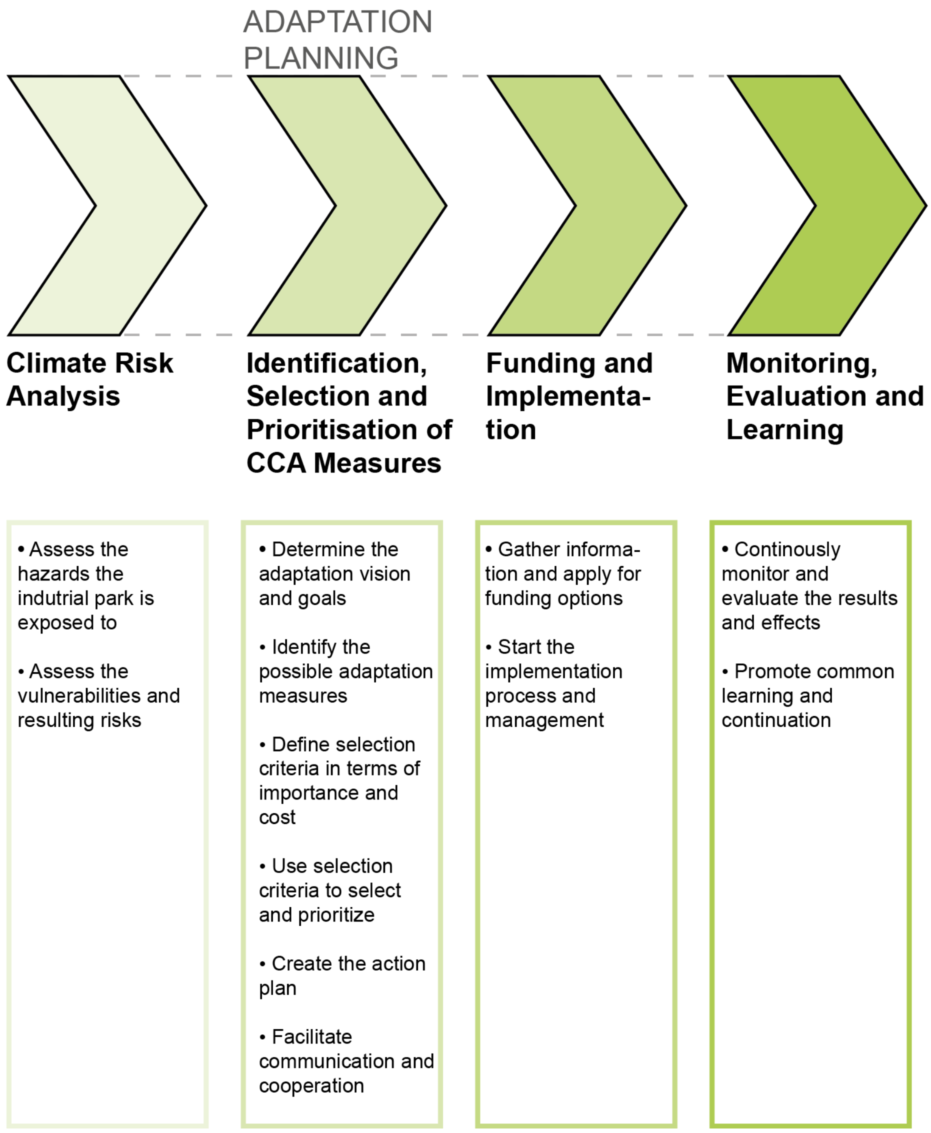
1. Observation of climatic and non-climatic variables
2. Assessment of climate impacts and vulnerability
3. Planning of adaptation measures
4. Implementation of adaptation measures
5. Monitoring and evaluation of adaptation actors.

In this context, adaptation planning refers to the step of adaptation after the necessary observations and assessments are carried out in terms of related hazards, impacts and risks[2].

In a similar manner ICLEI (Local Governments for Sustainability) defines five milestones for climate change adaptation. These steps are to initiate, to research, to plan, to implement, and to monitor and review. In this case the step of adaptation planning comes as the third step that follows the initiation of the adaptation process and the research phase.[3]

Summarising both approaches, one can conclude that the climate change adaptation in Industrial Parks follows four progressive steps with the second being referred as Adaption Planning:

[2] http://unfccc.int/focus/adaptation/items/6999.php
[3] http://www.iclei-europe.org/topics/climate-change-adaptation/



Consequently, **Adaptation Planning** refers to the planning and decision-making process for the authorities to reduce the climate change related vulnerabilities in the system of interest and how these measures can be implemented in the most effective manner. A wide range of possible adaptation measures can be applied, including changes in various physical impact areas such as industrial production and processes, buildings, site layout and infrastructure. Beyond that, Adaptation Planning also refers to enabling Industrial Parks to adapt to the hazards of climate change by initiating change of non-physical systems through labour management, awareness raising and education.

The steps of Adaptation Planning include:

- Determining the adaptation vision and goals
- Identifying the possible adaptation measures
- Defining selection criteria in terms of importance, severity, and cost
- Using selection criteria to select and prioritize
- Creating the action plan
- Establishing an implementation schedule
- Facilitating communication and cooperation

The following figures 1 and 2 provides the linkages between Guidelines, Manual 1 and 2.

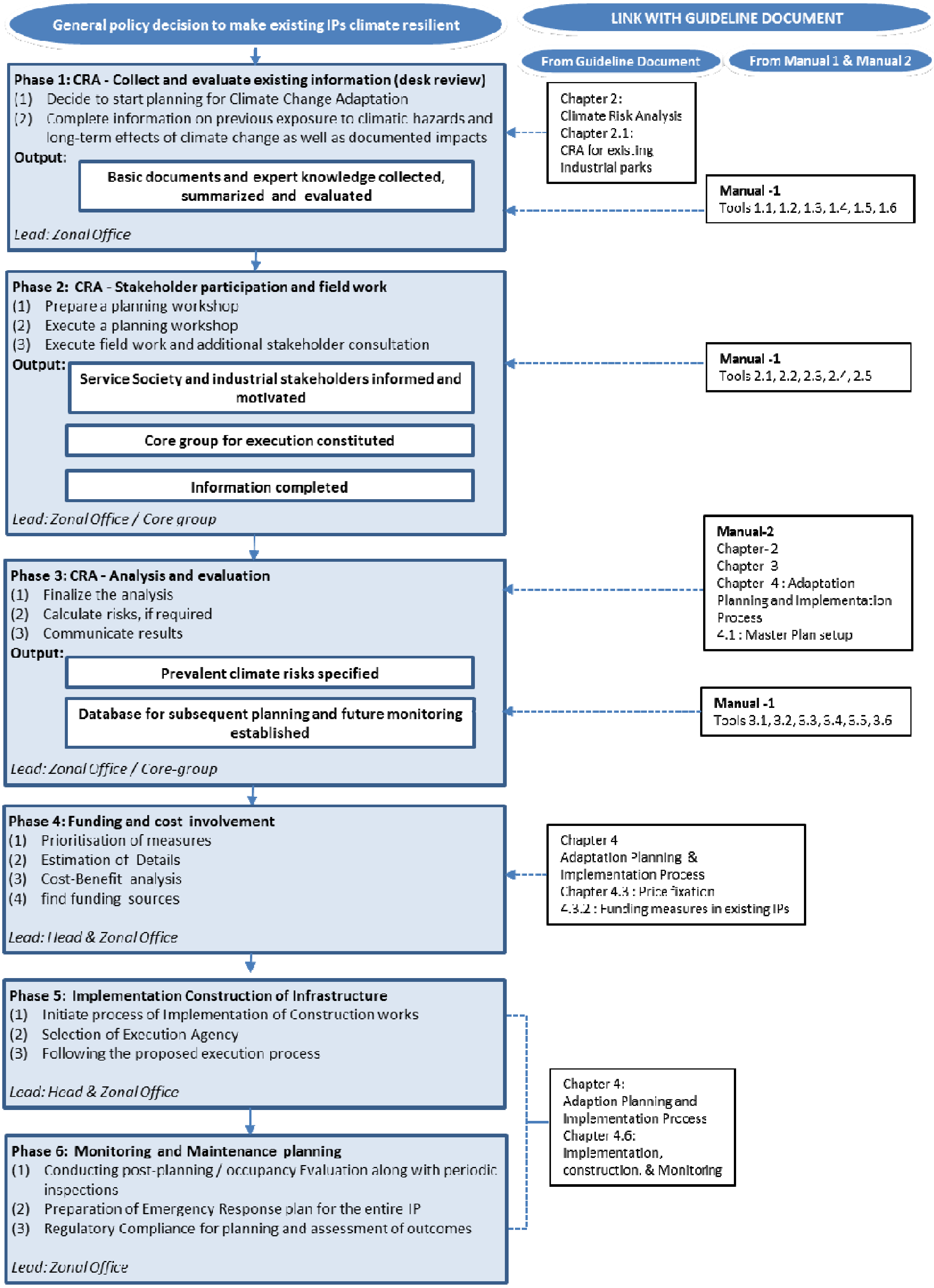


Figure 1: Flow Chart for Existing Industrial Parks

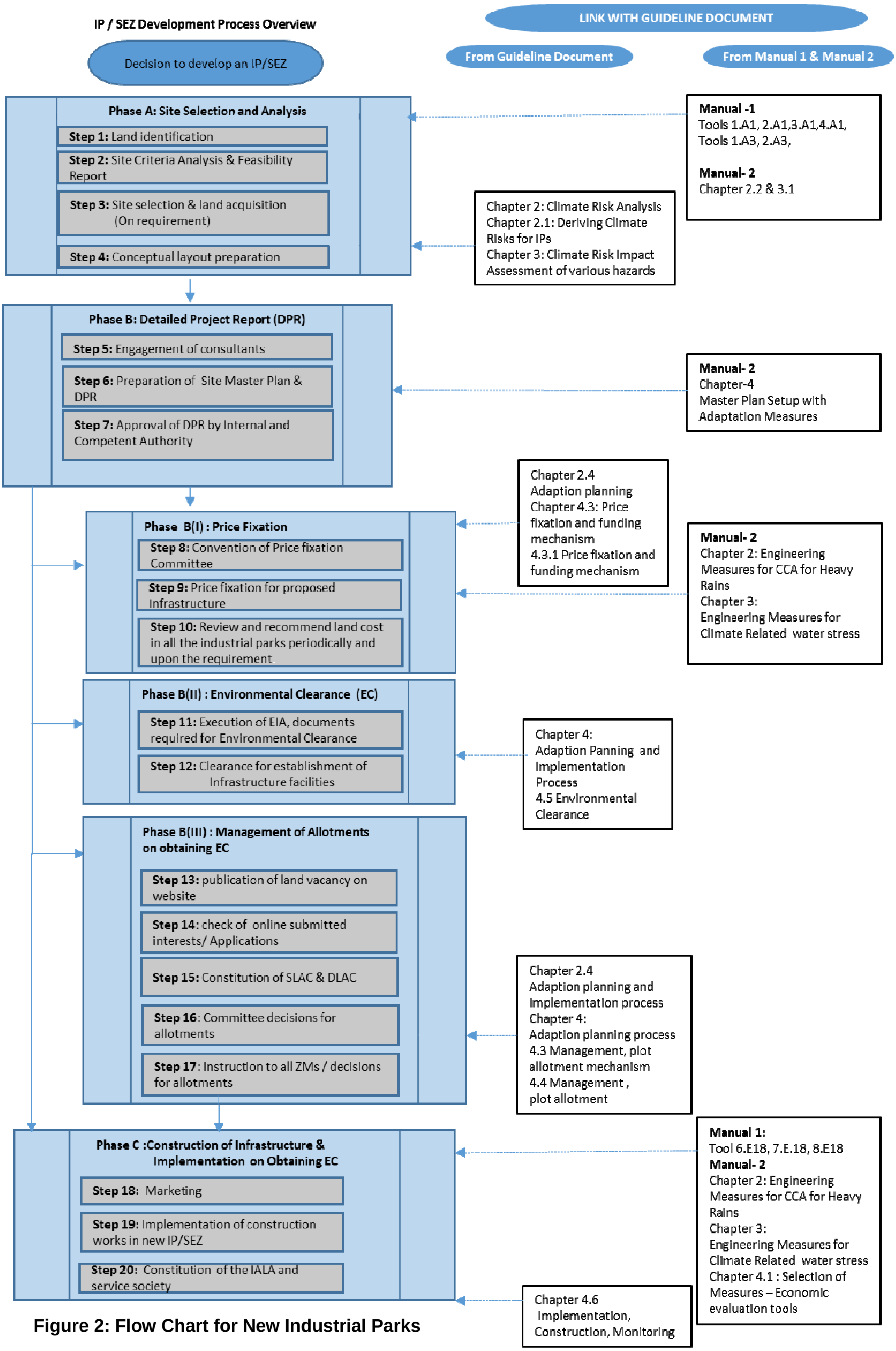


Figure 2: Flow Chart for New Industrial Parks

The following chapters provide a guideline on how to anchor the consideration of CCA and planning of required measures in the planning procedures for new IPs, as well as in further development / retrofitting of existing ones. Based on the results of preparatory studies it was agreed to limit the scope of the Guidelines to the most prominent climatic hazards and related impacts occurring in Andhra Pradesh and Telangana, i.e. ***extreme weather events*** such as heavy rainfalls, droughts, heat waves in both states, plus cyclones, floods and storm surges in Andhra Pradesh, and ***long-term effects*** such as deterioration of water resources in both states, plus sea level rise in Andhra Pradesh. However, hazards to be considered, as well as their regional relevance has to be reappraised regularly in the light of new findings and understanding of climate change and its impacts, as well as considering latest occurrence of extreme events and visibility of long-term effects.

1.2 Climate Change Adaptation Document Series

TSIIC/APIIC, in cooperation and with support from GIZ, developed a set of documents targeting adaptation to climate change of existing and upcoming industrial areas in Telangana States / Andhra Pradesh, India. The following table gives an overview on the various documents and their scope. The present document covers the various climate risk analysis for new and existing parks and how to plan for adaptation for these parks. Also, this document gives a layout of various impacts on industries and industrial parks due to climate change and list of measures required to adapt to CC. This manual should be used along with Manual 1 and Manual 2.

	Document	Scope
1	Policy for Climate Change Adaptation in Industrial Areas	The policy is setting the frame for AP/ TS IIC's strategy to promote and implement adaptation of existing and upcoming industrial areas in AP to make the State industry and economy more climate resilient.
2	**Guideline for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change**	**The guideline provides orientation and develops a standard approach and methodology on how to plan for adaptation and increasing resilience of existing and upcoming industrial areas in APIIC/TSIIC.**
3	Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change, **Part 1: Tools for Planning and Resilience Measures**	Part 1 of the manual includes the tools required to execute a climate risk analysis for existing and upcoming industrial areas. The results of the risk analysis provide a sound baseline to further plan and implement concrete adaptation measures, both in terms of infrastructure and operation, management and maintenance of the industrial parks in APIIC/TSIIC.
4	Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change – **Part 2: Engineering measures for planning adaptation and resilience measures**	Part 2 of the manual includes the engineering required to translate the results of the risk analysis into co concrete adaptation measures. According to the prevailing climate hazards in the state the tools focus on adaptation to heavy rainfalls and related impacts, and to heat waves and droughts and related impacts in APIIC/TSIIC.
5	Manual for Adaptation and	Part 3 of the manual presents a collection of national

	increasing Resilience of Industrial Parks to the Impacts of Climate Change – **Part 3: Best practice examples**	and international best practice examples and lessons learnt on adaptation of industrial areas, urban areas and infrastructures to the impacts of climate change. This also includes best practices on law and policies on climate change adaptation in APIIC/TSIIC..
6	Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change – **Part 4: Financing of plans and measures**	Part 4 of the manual includes a collection of financing instruments and best practices for financing of adaptation measures in existing and upcoming industrial parks in APIIC/TSIIC.
7	Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change – **Part 5: Existing Planning and Implementation Procedure for Industrial Parks**	Part 5 of the manual providers gives an overview on relevant actors and stakeholders and provides orientation on how the planning steps described in the guideline document are embedded in existing planning and working processes of in APIIC/TSIIC..
8	Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change – **Part 6: Baseline studies in TS and AP**	Part 6 of the manual presents the results of a pilot risk analysis and baseline study executed in selected industrial areas in APIIC/TSIIC.
9	Training modules on execution of a climate risk analysis for existing and upcoming industrial parks and their adaptation to the impacts of climate change	To successfully implement the guidelines and even more important the respective adaptation measures in planning and refurbishment of industrial parks, APIIC/TSIIC has to develop the respective capacities in planning and operational departments. Furthermore, external capacities have to be supported and developed to be able to provide the required services to the infrastructure corporations and to individual industries and companies, particularly to (M)SMEs.

2. Climate Risk Analysis of Industrial Parks

2.1 Deriving climate risks for industrial parks

Generally, the proper identification of risks is a long process. For a full risk assessment, one needs to identify the relevant risk types, quantify the expected impact, analyse its resilience and assess the likelihood that the risk will occur of each site. 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 3[4] shows how ***hazards*** interact with the system of interest ultimately resulting in potential risks. The logic of the figure can be understood as follows:

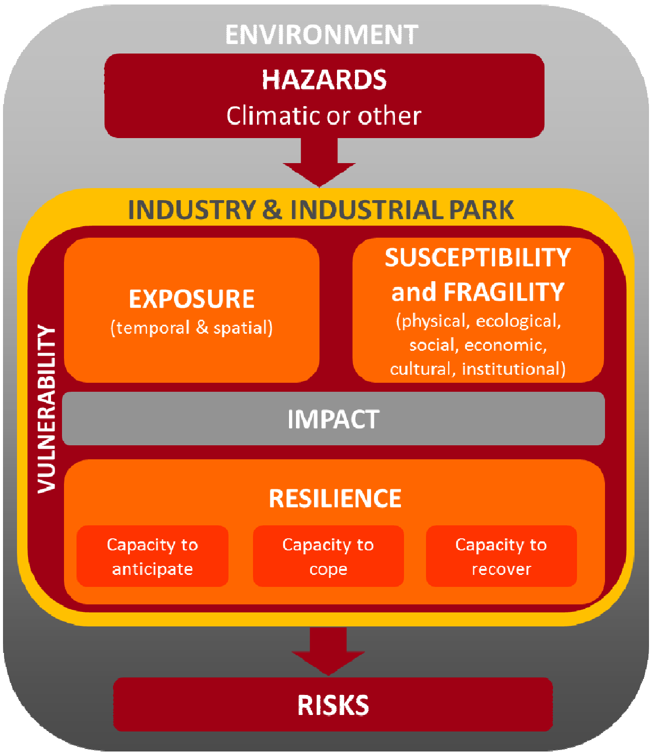


Figure 3: From hazards, to vulnerability and risks

The ***system of interest***, e.g. an industrial park, 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 IP;
(2) The industrial park's ***susceptibility and fragility*** 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.

Climate Risk Analysis builds on the above described occurrence of risks aiming at understanding the constituents thereof and helps identifying risks in order to address them in the planning processes for climate resilient IPs.

[4] Source: Amended from (Presentation of Dr. Torsten Welle, UNU-EHS, at Session G4, Resiliency Cities Conference, 2011), slide 5

Principles of CRA include:

- Use evidence-based facts from renown organisations (e.g. IMD) wherever possible;
- Involve all relevant local stakeholders at the IPs for acceptance;
- Fill data gaps together with support of stakeholders where needed;
- Be clear from the beginning about the results (detail of data) you want to achieve.

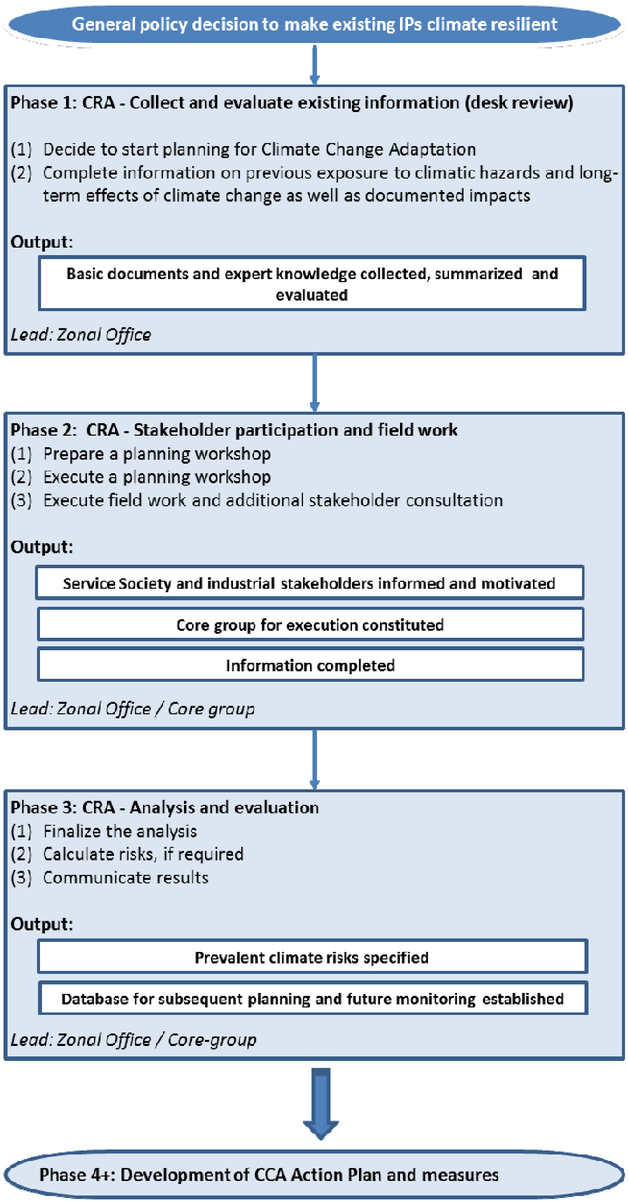


Figure 4: Process for execution of a CRA as first part for elaboration of a CCA Action Plan for existing IPs

2.2 Climate Risk Analysis for existing industrial parks

A defined procedure to achieve increased climate resilience of existing IPs has to be established. The output of this procedure is a CCA Action Plan for the IP. The CCA Action Plan will comprise a list of prioritized measures for adaptation. It can be utilized for mobilization of funds and be translated into DPRs and implementation plans. Climate change adaptation of existing industrial parks is a specific type of retrofitting planning; however, not for single measures like roads or shelters, but to develop an integrated CCA Action Plan with prioritized measures.

The Climate Risk Analysis (CRA) is the first element to compile such an integrated CCA action plan. In order to make the work process more efficient, the CRA will be executed in the three initial working phases for elaboration of a CCA Action Plan (Figure 4):

1. Collection and evaluation of existing information (focus on evidence-based data);
2. Stakeholder participation and field work;
3. Analysis and evaluation.

Each of these three phases is further described in this chapter. Phase 4 and the following of the CCA Action Planning in existing IPs are dedicated to identification and planning of adaptation measures. This part of the process is described in Part 2 of the guidelines.

For each of the three CRA phases there is a corresponding toolset which comprises the adequate tools for the execution of the CRA. The individual tools are described in more detail in (INTEGRATION, 2016d).

Phase 1 of the CRA: Collect and evaluate existing information for the specific IP

Responsible	Zonal Office, EMP Cell
Participating stakeholders (Annex VIII of Manual 1)	Headquarter, IALAs, DRM Authorities, Meteorological Services, Environmental Authorities
Output and rationale:	**After having taken the decision to elaborate a CCA action plan for a specific IP / group of IPs (e.g.) in one zone, the aim of Phase 1 is to collect and evaluate basic documents and all written and oral information and evidence-based data on the specific IP relevant for the execution of the CRA and elaboration of the CCA action plan.** The amount and quality of available data and information will be different from IP to IP. Hence, scope of the subsequent phases and application of the tools will be depending on the outcome of the desktop research in Phase 1.
Existing information	In both States a pilot rapid climate screening of existing IPs was already executed including 100 industrial parks in AP and 53 in Telangana State. A full-fledged Rapid Climate Risk Analysis was implemented for the top 5 ranked industrial parks in both states. Respective data are available in in the reports (CoreCarbonX, 2016a), (CoreCarbonX, 2016b), (CoreCarbonX, 2016c), (CoreCarbonX, 2016d), (CoreCarbonX, 2016e)
Working steps	**(1) Decide to start planning for CCA:** The decision to start planning for Climate Change Adaptation of a specific IP (or a set of IPs) can be taken by the Headquarter, the Zonal Office or the IALA of a specific IP based on the results of the preliminary climate screening mentioned above. [For this specific project, it has been approved by the board members of both IICs and each IIC has allotted a certain amount for the project as per

the agreement between states and GIZ.]

(2) **Desktop research: Complete information on previous exposure to climatic hazards and long-term effects of climate change and documented impacts:** Check already existing information or start from the scratch evaluating existing information on previous exposure and impacts filling the respective tables of Tools 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6. Focus on evidence-based, hard data where possible. Sources of information are: Expert knowledge from IIC Headquarter, Zonal Office, the respective IALA, DRM & State Planning authorities, Meteorological Services (IMD etc.), Coastal Zone Authority, Environment Authorities etc.

Tools

(see Annex A and Annex XI of Manual 1)

CRA Toolset 1 (, INTEGRATION, 2016d)**:**

- **Tool 1.1 Define the system of interest:** The table is to be filled at the beginning and during implementation of refurbishment planning.
- **Tool 1.2 Identify climatic hazards:** Complete the table with relevant hazards and sources. Use hard data where possible.
- **Tool 1.3 Collect information on previous exposure to climatic hazards:** Document and evaluate existing documents and expert knowledge in the respective tables where hard data is not available.
- **Tool 1.4 Collect information on industries located in the IP (susceptibility and fragility):** Please fill the respective table indicating which industrial sectors are represented at the IP.
- **Tool 1.5: Collect information on impacts observed in the past:** Document already observed impacts in the respective table.
- **Tool 1.6: Collect information on existing resilience:** Document basic information on resilience of the IP in the respective table.

Phase 2 of the CRA: Stakeholder participation and field work

Responsible: Zonal Office

Participating stakeholders: IALA, Service Society, industries at site

Output and rationale: **The aim of the planning workshop, stakeholder consultation and field work is**

a) to inform Service Society and industrial stakeholders on the initiative to elaborate a CCA action plan and the planning process and to motivate them to participate;

b) to amend and verify the findings of Phase 1;

c) to constitute a core group or sub-committee of the IALA for execution of the planning process (potentially including a training for the core group), and

d) to collect additional information as instant input for the subsequent planning steps.

The planning workshop and stakeholder consultation enables a complete view of all relevant stakeholders of the respective IP, especially the industries.

Existing information

In the course of the project, stakeholder consultations were executed in 5 IPs in AP and 5 IPs in TS. The content and results of the stakeholder consultation are documented in the reports on Rapid Climate Risk Analysis for Andhra Pradesh and Telangana, respectively ((CoreCarbonX, 2016c) and (CoreCarbonX, 2016d)).

Working steps

(1) Prepare the workshop:

- Summarize the findings of Phase 1 for the audience.
- Develop an agenda and invitation for the workshop (participants could include: Stakeholders/industry, IALA, IIC, DRM & PCB officials)
- Prepare the working materials
- Organize venue, catering, and external assistance, if required

(2) Execute workshop:

- Explain objective of the workshop
- Identify topics, areas and stakeholders to be involved in field work and additional stakeholder participation
- Record participation of stakeholders
- Document the results of the workshop and summarise the main findings
- Revise and amend tables from phase 1 if required
- Circulate summary report and key findings to the participants

(3) Field work and additional stakeholder consultation (Tools 2.1 – 2.4)

- Plan and organize additional stakeholder participation, plan interviews and prepare checklists, questionnaires, materials for field work (maps, plans, photos, checklists etc.);
- Execute stakeholder consultation and field work
- Document results (update tables from CRA tools, compile photo documentation, summarize findings and observations)

- Circulate results to stakeholders concerned, considering privacy matters;
- Validate the results from field work as per the discussions held from previous consultations**,**

Tools and materials

(see Annex A of Manual 1)

CRA Toolset 2 (APIIC, TSIIC, INTEGRATION, 2016d)**:**

- **Tool 2.1: Specify information on previous exposure to climatic hazards**: Further analysis of previous exposure to climatic hazards during Phase 2 consists of three elements: The establishment of a timeline of climate events, the identification of parts or specific locations of the industries are been hit by the events, and finally specification of the events in terms of frequency, strength/intensity and duration.
- **Tool 2.2: Identify the main impact areas in the IP**: During the workshop, preliminary information on observed impacts can be collected, which shall be further specified during stakeholder interaction and field work. Prioritization of impact areas should be discussed during the workshop before working on the susceptibility (Tool 2.3).
- **Tool 2.3: Specify information on susceptibility of the IP**: Please keep in mind that it is advisable to apply tool 2.3 during the stakeholder workshop only after having finalized prioritization of impact areas (Tool 2.2). Otherwise too much time might be spent to further specify susceptibility.
- **Tool 2.4: Specify information on existing resilience**: Information on elements important to understand the resilience of the industrial area shall be collected and further specified during the workshop and subsequent stakeholder interactions. Respective documents should be collected for further analysis during Phase 3.

Other Tools:

- **Planning Workshop**: Gives orientation for preparation and execution of the workshop. The tool includes a draft Power Point Presentation. The findings of Phase 1 have to be included in this presentation.

Phase 3 of the CRA: Analysis and evaluation

Responsible: Zonal Office, Core Group or Sub Committee

Participating stakeholders: IALA, Headquarter; Service Society, Industries

Output and rationale:

The aim of the analysis and evaluation is

a) to specify the prevalent climate risks for the industrial park;

b) to establish sound information and data base for execution of the subsequent planning steps for the Climate Change Action Plan (see chapters 3 and 4 of this guideline);

c) to establish a base-line for future monitoring of results and impacts of the adaptation process.

d) to communicate results of the analysis to the stakeholders and HQ;

Existing information	Baseline studies for IP Autonagar Gajuwaka in AP and for IP Jeedimetla in TS can serve as blueprint (CoreCarbonX, 2016e).
Working steps	1. **Finalize analysis** of exposure, susceptibility / fragility, impacts and resilience to determine the IPs vulnerability. 2. If required conduct tool 3.6 to **calculate risks** (this would require monetarized values). **3. Communicate results:** Summarize the findings (vulnerability or risks) to the core group or sub-committee, IIC management and to the stakeholders.
Tools and materials (see Annex A of Manual 1)	**CRA Toolset 3** (APIIC, TSIIC, INTEGRATION, 2016d)**:** • **Tool 3.1 Analysis of previous exposure to climatic hazards**: Based on the information collected before exposure to specific climatic hazards is classified according to a three-(five) class system. • **Tool 3.2 Analysis of susceptibility of the IP**: Based on the information obtained during phases 1 and 2 the susceptibility of the various sub-systems of the IP, such as buildings, roads, drainage systems etc. can be assessed. It has to be kept in mind, and documented in the assessment, whether the susceptibility is classified evenly for the whole park, or whether specific areas have higher or lower susceptibility than others (spatial dimension). • **Tool 3.3 Analysis of impacts**: Observed and prospective future impacts have to be analysed and documented. Outputs are a set of maps and tables. • **Tool 3.4 Analyse resilience**: Resilience of the IP against the various climatic hazards, considering both IALA and management as well as industries has to be summarized and assessed doing a SWOT-Analysis and classification for the various elements. • **Tool 3.5 Derive vulnerability:** The vulnerability analysis provides an assessment of the various sub-systems against the selected climatic hazards considering the various resilience capacities and a set of maps identifying specifically vulnerable areas of the IP. • **Tool 3.6 Risk analysis**: For a classical risk analysis, vulnerability has to be combined with the probability of the

	various events and monetarization of the expected impacts. This is an extensive task and the effort has to be weighted versus its use. Future probability of the various events is already included in the first step, specifically in the future part of the temporal dimension. Hence, there is no need to again consider probability. For the current project, it seems to be highly ambitious to include the monetary dimension into the analysis. However, if exchange with stakeholders would allow performing a preliminary, rough quantification, this can be included and combined with the vulnerability analysis.
Further remarks	Make sure to re-align your work in this phase with the system of interest (and outputs defined) from Phase 1. I.e. one can easily calculate too much in this phase and lose focus.

2.3 Climate Risk Analysis for new industrial parks

The overall planning procedure of new IP areas as applied by TSIIC and APIIC consists of three phases covering 20 steps (A-C) as depicted in Figure 1 (INTEGRATION, 2016b). By integrating the climate risk analysis (CRA) elements into the **planning process for a new IP**, future climate risks are anticipated so that the planned infrastructures and management and administration structures are designed from scratch in a way to minimize exposure, susceptibility and fragility while maximizing resilience. Finally, this results in a lower vulnerability of the new IP towards climatic hazards.

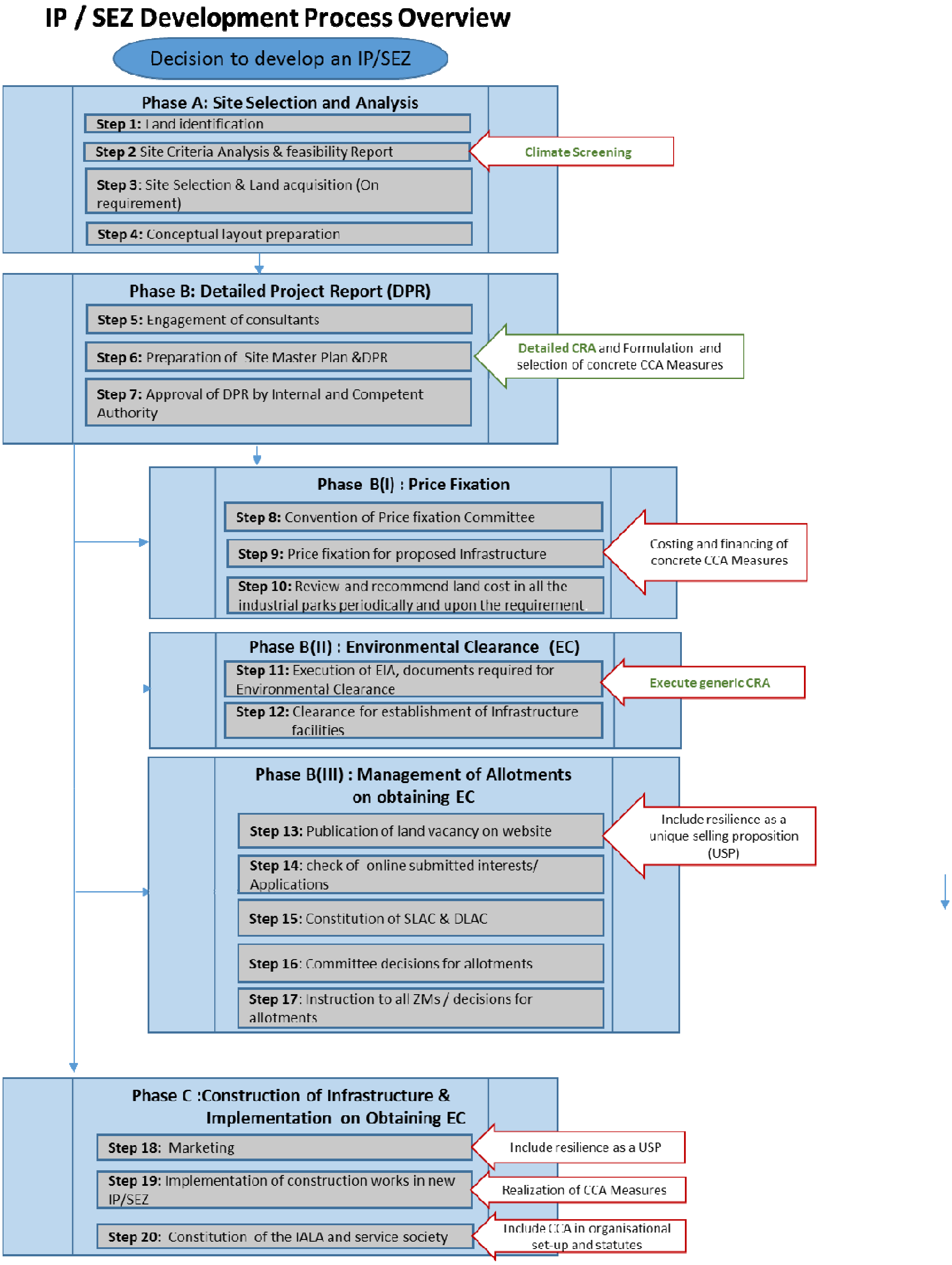


Figure 5: Planning process for new IPs indicating entry points for CCA Planning (CRA elements in green)

Advisable entry points for consideration of Climate Change Adaptation shown in Figure 5. It is discussed in these Guidelines. Specific entry points for the CRA are represented by the green text in arrows, black text in arrows representing planning steps for adaptation measures. Climate Risk Analysis for new parks will be executed during steps 2 of Phase A 'Site Selection and Analysis', Step 6 of Phase B 'Detailed Project Report' and Step 11 of

Phase B (II) ‘Environmental Clearance’. The system of interest of the analysis, i.e. the IP does not yet exist. The goal of the exercise is to optimize it regarding its vulnerability to climate change. Hence, all steps of the analysis targeting the features of the system, i.e. its resilience, vulnerability, and finally pertaining risks, cannot be addressed during the preliminary analytical steps. Susceptibility of the IP and its industries and possible impacts can only be assessed generically. However, these criteria have to be duly considered during subsequent planning. After having developed the planning concept and the organisational set-up of the park management, a generic risk analysis can be executed to specify the remaining vulnerability and risk for later monitoring and learning (Step 11).

This will result in:

1) Consideration of exposure of the future IP to climate risks during site selection, i.e. comparing grade of exposure of various sites, and considering grade of susceptibility of proposed industries to the climate hazards prevailing at the explored sites during the selection process.

2) Integrating the results of the CRA as a separate chapter / module in the Site Selection and Analysis Report elaborated under Phase A Step 3.

3) Translate and integrate the findings of the CRA into infrastructure measures and proposal for administrative and organisational set-up of the new IP in Phase B ‘Detailed Project Report’; and consideration of costs for CCA in Phase B (I) ‘Price Fixation’. Planning of measures will be discussed in chapters 3 and 4 of this guideline

4) The findings of the CRA supported with prioritized mitigation measures and the related concept for governance, administration and management will be integrated into the Environmental Impact Assessment executed as Step 11, Phase B (II).

5) CCA features of the IP will function as USP (Unique Selling Proposition) during marketing in Phases B (III) and C.

The following paragraphs provide guidance how to apply the respective tools during steps 2, 6 and 11 of Figure 5. Please note that guidance on actual CCA measures (i.e. steps 6, 9, 13, 16)) is included in chapters 3 and 4.

1. Climate screening as part of Step 1-3 under Phase A 'Site Selection and Analysis'

Responsible	Zonal Office
Participating stakeholders (Annex VIII of Manual 1)	Headquarter, DRM Authorities, Meteorological Services, Environmental Authorities
Output and rationale:	**Take into account exposure to climate hazards during site selection (i.e. across different potential sites), to a) possibly avoid highly exposed areas, and b) consider climate risks when defining industrial sectors for the IP.** A **Climate Screening** comprising preliminary parts of steps 1, 2, 3, and 4 of the CRA shall be executed during Phase A, Step 2. The function of the Climate Screening is to (1) avoid locations with high exposure to climatic hazards from the outset, (2) apply occurrence and future probability of climatic hazards as comparative criterion for site selection.
Existing information	In both States a pilot rapid climate screening of existing IPs was already executed including 100 industrial parks in AP and 53 in Telangana State. A full-fledged Rapid Climate Risk Analysis was implemented for the top 5 ranked industrial parks in both states. Respective data are available in in the reports (CoreCarbonX, 2016a), (CoreCarbonX, 2016b), (CoreCarbonX, 2016c), (CoreCarbonX, 2016d), (CoreCarbonX, 2016e). If Strategic Environmental Assessment (SEA) is required, the climate screening can provide useful climatic information for industrial development in suitable zones.[5] In some cases, a State Environmental Atlas[6] is available; which is a compilation of environment related information in the form of maps, texts and statistical data. It includes maps on general features (i.e. administrative boundaries, major settlements, transportation networks etc.), on physical characteristics (i.e. land use, physiography, land capability etc.), on surface/ground water features (i.e. drainage pattern, use, quality, flow and table etc.), on environmentally sensitive zones (i.e. biological diversity, incompatible land uses etc.), on major sources of pollution and also on environmental quality.
Working steps	**(1) Describe the prospective sites for the IP:** At the beginning of the CRA process some basic information on

[5] http://www.cpcb.nic.in/Env_Planning.php
[6] http://www.cpcb.nic.in/State_Environmental_Atlas.php

the prospective IP shall be documented as reference for the further process.

(2) Desktop research: Collect information on previous exposure of the prospective sites to climatic hazards and long-term effects of climate change and documented impacts: Check already existing information or start from the scratch evaluating existing information on previous exposure and impacts filling the respective tables of Tools 2.A1, 3.A1, 4.A1, and 5.A1. Sources of information are: Expert knowledge from IIC Headquarter, Zonal Office, the respective DRM & State Planning authorities, Meteorological Services (IMD etc.), Coastal Zone Authority, Environment Authorities etc.

(3) Take a decision, which site should be selected for the new IP: After having finalized the screening, a decision should be taken, which of the prospective sites should be further examined for the new IP. In case the decision cannot be taken yet, all working steps under Step 2, Phase A have to be executed for all prospective sites.

(4) Include findings in the proposal for Site analysis: In case various sites are to be compared during Site Selection the respective information for all sites shall be included in the report and be considered during final selection. Specific information regarding susceptibility of industries to the prevailing hazards needs also to be discussed.

Tools

Toolkit A1 (INTEGRATION, 2016d)

(see Annex B of Manual 1)

- **Tool 1.A1 Description of prospective sites for the IP:** The table is to be filled at the beginning for each site and further amended during the sub-sequent steps of the planning process for the selected one.
- **Tool 2.A1 Identify prevailing climatic hazards at the prospective sites:** Complete the table for the prospective sites with relevant hazards and sources.
- **Tool 3.A1 Collect information on previous exposure of prospective sites to climatic hazards:** Document and evaluate existing documents and expert knowledge in the respective tables.
- **Tool 4.A1 Identify industrial sectors susceptible to prevailing climate hazards at the prospective sites:** Please fill the respective table for the industrial sectors expected to be placed in the prospective IP and specify their susceptibility related to the climate hazards prevailing at the various sites examined(non-susceptible, susceptible, highly susceptible).

2. Detailing of Climate Screening as part of Step 6 under Phase B 'Detailed Project Report'

Responsible	Engineering Department
Participating stakeholders (Annex VIII of Manual 1)	DRM Authorities, Meteorological Services, Environmental Authorities
Output and rationale:	**Integration of preliminary consideration and scope for CCA in the Detailed Project Report for the selected site.** The Detailing of the **Climate Screening** focuses on further elaboration of steps 3 and 4 of the CRA. The function of the detailing of Climate Screening is to (1) discuss prevailing climate hazards, and already observed exposure and impacts at the site, (2) document generic susceptibility of industrial sectors at site, (3) execute a preliminary and generic impact analysis for the site, and **(4)** define the scope for further consideration of CCA needs and requirements during subsequent course planning phases as part of the Detailed Project Report.
Existing information	Outputs of previous Climate Screening.
Working steps	**(1) Desktop research, interviews, field work: Collect information on previous exposure of the prospective sites to climatic hazards and long-term effects of climate change and documented impacts:** Information on previous exposure to climate hazards collected during Climate Screening was quite general. It is now task of this step to further detail the information for the selected site only. This will be done through further desk research, interviews with local / regional experts, field work, and GIS analysis if respective Geodata (e.g. a digital surface model, water courses, roads, settlements, land uses etc.) are available. Document findings with Tool 1.A3. **(2) Execute a preliminary generic impact analysis:** Using the results from analysis of exposure (Tool 1.A3) and susceptibility analysis (Tool 4.A1) a preliminary generic impact analysis can be executed with tool 2.A3. (3) **Define scope and requirements of planning for CCA and compile the respective chapters / documents for the Detailed Project Report:** Considering outputs of Steps 2, 3, 4 and 5 of the CRA, Scope and require-

ments for further planning of risk minimization / adaptation to climate change of the new IP can be outlined as contribution to the Detailed Project Report. This should include:

a) Specification of climatic hazards prevalent at the site (Step 2 of CRA).

b) Description and assessment of temporal and spatial exposure in the past. Expected exposure for the future shall be deducted from climate projections and expert knowledge (Step 3 of CRA).

c) Description of general susceptibility of the sub-systems of an IP and the prospective industries in the new IP to the prevalent climatic hazards (Step 4 of CRA).

d) Description of possible impacts (Step 5 of CRA).

e) Focal areas for subsequent planning steps:

   a. Technical areas to be covered by the master plan

   b. Technical recommendations for the industries

   c. Governance and management to be addressed by the IALA / Service Society / Zonal Office

   d. Governance and management to be addressed by the industries

   e. Capacity development

f) Lessons learned

Tools	**Toolkit A3** (INTEGRATION, 2016d)
(see Annex B of Manual 1)	• **Tool 1.A3 Specify further information on previous exposure of prospective site to climatic hazards:** The table provides guidance and is to be filled during work. Spatial dimension should be supported by maps, plans, or GIS based analysis. • **Tool 2.A3 Preliminary generic impact analysis for the new IP:** Apply the tool to identify prospective impact areas and generic impacts which can be expected. Based on the results scope and requirements for sub-sequent planning can be formulated.
Further remarks	The findings of this step are to be included in the DPR.

3. Execution of a generic CRA as part of Step 11 'Execution of EIA'under Phase B (II) 'Environmental Clearance'

Note: Please refer to Manual 1 and Manual 2 for the development on concrete CCA measures (i.e. for Phases B onwards). Below description then covers the Environmental Clearance including such CCA measures. I.e. please make sure that all CCA measures have been fully developed before starting this CRA in Phase B (II).

Responsible	Environmental Management and Planning (EMP)
Participating stakeholders (Annex VIII)	Environmental Management & Planning (EMP) & Engineering wing of IIC Project developers, Zonal Manager
Output and rationale:	The aim of this step is a final proof of resilience against climate change of the respective IP as part of the Environmental Impact Assessment (EIA) if applied or the Environmental Clearance. i.e., now that a climate screening has been conducted and CCA measures have been included, this step is a final check that all climate change considerations have properly been taken care of.
Existing information	Previous climate screenings, exemplary CCA measures (see chapter 3 and 4), guidance from OECD on how to include CCA in EIAs[7].
Working steps	There are Three variants:

- EIA is required to Obtain Environmental clearance (EC) for Category "A" (EC from Central Committee/ Govt. of India) & "B" (EC from respective state committee / state govt.)
- Only EIA is required & not EC for Category 'B1' projects. (Public consultation is required (as applicable))
- EIA & EC both are not required for Category 'B2' projects (pre-feasibility report (as applicable)

Note: For categorization of projects into B1 or B2, Ministry of Environment and Forests, Govt. of India shall issue appropriate guidelines from time to time.

I.

Variant I: With EIA

Generally, including CCA considerations into the EIA process requires no change to the essential steps or sequence of the EIA process itself. CRA elements can generally be included in the main steps of the EIA as follows:

1. **Screening:** Determine whether climate change impacts

[7] Agrawala S., A. Matus Kramer, G. Prudent-Richard and M. Sainsbury (2010), "Incorporating climate change impacts and adaptation in Environmental Impact Assessments: Opportunities and Challenges", OECD Environmental Working Paper No. 24, OECD Publishing, © OECD.

are likely to have significant effects on the project (IP development), and therefore require further studying as part of the EIA. This can be based on information on climatic hazards/exposure (e.g. if tool 1.A3 from above shows significant exposure of the IP, then the following steps need to be executed); the lifetime of the project is also a key aspect which is usually given through longevity of an IP and its assets.

2. **Scoping:** Determine what needs to be assessed in the EIA. I.e. derive what climate hazards and impact areas need to be taken into account for the site (see also Tool 1.A3 for hazards / exposure and tool 2.A3 for impact areas with information given from previous phases).

3. **Prediction and mitigation:** This is the core step. Determine whether climate vulnerability / risks and adaptation measures have correctly been identified and included in the project (IP development). And on the other hand, check if there is potential for maladaptation. The following substeps are required within the EIA analysis:

(a) Include climate information in the environmental baseline (use information from tool 2.A1, tool 3.A1, and tool 1.A3 for the selected site).

(b) Determine the resilience of the IP including the related concept for governance, administration and management (use tool 1.E18).

(c) Examine the vulnerability of the selected IP with the CCA measures in place (use tool 2.E18).

(d) Estimate the remaining risk for the planned IP (use tool 3.E18)

4. **Management, implementation and monitoring:**

Determine what climate change variables and KPIs of the adaptation measures can be monitored for proper climate proofing over time (see Manual 2).

<u>**Variant II**: Without EIA (Environmental Clearance only)</u>

Without an EIA, the three core steps (and tools as below) should be applied as part of the environmental clearance:

1. **Determine the resilience** of the IP including the related concept for governance, administration and management (use tool 1.E18).

2. **Examine the vulnerability** of the selected IP with the CCA measures in place (use tool 2.E18).

3. **Estimate the remaining risk** for the planned IP (use tool 3.E18).

<u>Ultimately, for both Variants I and II:</u>

A discussion is then required, whether these remaining vulnerability/risks are within the risk tolerance of the respective IP or if CCA measures need to be amended.

Environment Management Plan[8]: Adaptation measures can be included in following EMP as component of

- Liquid Effluents: for promoting reuse and recycle of wastewater
- House-Keeping:
- Human Settlements
- Transport Systems
- Recovery - reuse of waste products
- Vegetal Cover
- Disaster Planning
- Environment Management Cell

Tools	**Toolkit E18** (INTEGRATION, 2016d)
(see Annex B of Manual 1)	• **Tool 6.E18 Examination of resilience of the planned IP:** The resilience of the IP against the various climatic hazards, considering both, IALA and management, as well as industries has to be summarized and assessed doing a SWOT-Analysis and classification for the various elements. This should include all CCA aspects implemented in previous phases. • **Tool 7.E18 Examination of vulnerability of the planned IP:** The vulnerability analysis provides a specific assessment of the various sub-system against the selected climatic hazards considering the various resilience capacities and a set of maps identifying specifically vulnerable areas of the IP. At EIA stage, this should include all CCA aspects/measures implemented in previous phases. • **Tool 8.E18 Assessment of remaining risk for the planned IP:** For a classical risk analysis, vulnerability has to be combined with the probability of the various events and cost estimation of the expected impacts. This is an extensive task and the effort has to be weighted versus its use. At EIA stage, this would show the residual risk, after CCA measures have been included in previous planning phases.
Further remarks	A strong interchange of climate and CCA related information should take place between all internal and external experts during this stage (in particular, where processes are run in parallel).

[8] http://www.moef.gov.in/citizen/specinfo/emp.html

3. Climate Risk Impact Assessment of various Hazards

Before applying the climate risk analysis for individual Parks it is important to generally understand the corresponding impacts of particular climate change hazards to Industrial Parks. Every climate change hazard has particular impacts on Industrial Parks and potential damages that these cause.

Detailed adaptation measures are explained in the Manual 2 (INTEGRATION 2016e).

3.1 Heavy Rainfall and Flooding

In this chapter Heavy Rainfall and Flooding related impacts, viz. High Wind, Lightning, storm surge and coastal inundation, soil erosion, and Flood have been enumerated addressing the Climate Risk Impact Assessments actions highlighted through a) susceptibility and fragility determination, b) potential impacts, c) causes of structural damages, d) types of damages, and e) pre-planning and pre-design guidelines, enumerated under various impacts

3.1.1 Impact: High Wind

Climate Risk Impact Assessment

High winds generating from cyclones are one of the major hazards which is responsible for causing immense loss of life and destruction to properties. Cyclones in India specifically at Andhra Pradesh coastal area are generally severe in nature. The destructive components of cyclones are high winds, lightning, and heavy rainfall and hail storms.

The various types of high winds are straight-line wind, Down-slope wind & thunderstorms. The level of exposure of an Industrial park to high wind and the extent of performance based design required to reduce its impact are provided in the climate risk assessment matrix in Table 1 of Annex X.

(1) Potential Impacts

Wind with high intensity can cause substantial damage to industrial infrastructures. Even a well-designed, sturdy and properly maintained facility may be vulnerable to the impacts of high winds. The magnitude and frequency of cyclone vary by location, but preparedness is a necessity.

The extent of damages would depend on multiple factors like:

- Velocity of the wind flow
- Intensity of cyclone
- Period of storm
- Location of the industrial site and its orientation to the wind flow. The building oriented towards the windward side would be more prone damage compared to the buildings on leeward side.
- Shape of the building

- Materials used for construction

(2) Causes of Damages

- The interactions between winds and buildings create positive and negative pressures. These have been depicted in detail in Figure 6. The structures must have enough strength to resist the applied load from these pressures in order to prevent structural failure.

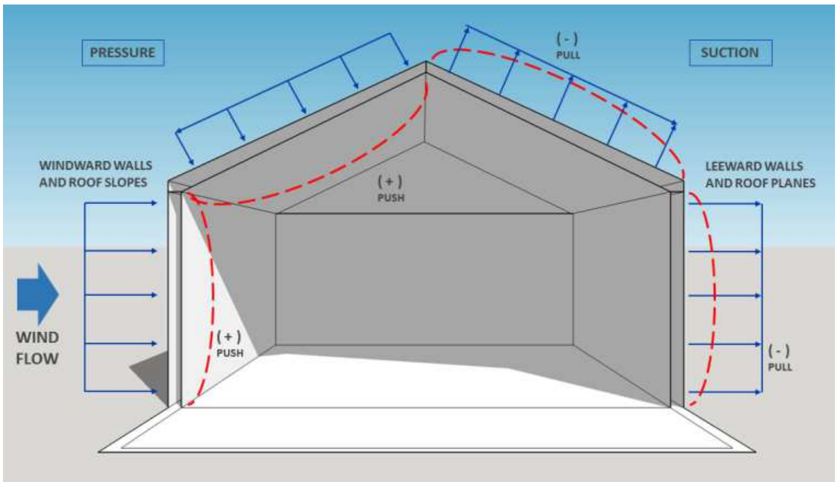


Figure 6: Positive and Negative Pressures of wind on building

- *Topography*

  Abrupt changes in topography within or near the industrial site can cause the wind speed to escalate.

- *Building Height*

  Wind speed generally increases with increase in height. Taller the building, more it would be exposed to wind speed and pressure.

- *Building pressurization/depressurization*

  Wind's internal pressure increases when the wind combines with openings through the building envelope. During a cyclone, open doors and windows can highly influence the magnitude of wind pressure.

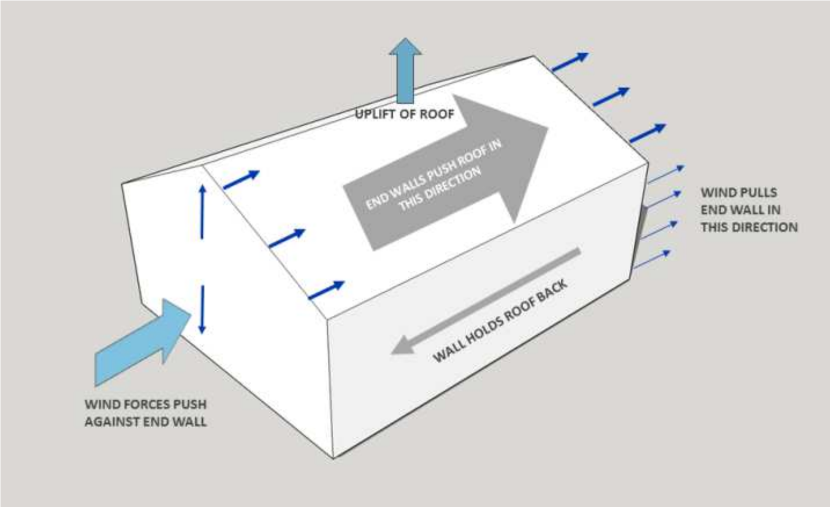


Figure 7: Direction and Effect of Wind Force

(3) Type of damages

The damages occurring due to the effect of high winds would lead to failure of various key structures of IP. The damages would be at IP level and building level.

- **IP level damages**
  - Disturbance in electrical power and communication / distribution network,
  - Damage to the major transmission lines and secondary feeders,
  - Contamination of drinking water pipelines,
  - Damage to effluent /sewerage treatment pipelines,
  - Uprooting of trees/plantation etc.

- **Building level damages**
  - Damage of roof covering, roof deck, overall roof lift-off and loose aggregate blowing-off
  - Fatigue damage of truss members
  - Wind-induced noise
  - Exterior glazing would be broken or damaged due to wind pressure
  - Window pane might break of due to wind-borne debris
  - Vortex resonance of steel chimneys
  - Collapse of RC block fences
  - Damage might be observed on exterior wall cladding, shutters and doors
  - Non-load bearing exterior walls might collapse

(4) Pre-planning and Pre-design Guidelines

- Identify the type, velocity and intensity of wind flowing through the area during storms and normal days from the past records.
- Analyse the Wind directionality factor to assess the reduced probability of maximum winds coming from any given direction. This can be obtained from the local meteorological station data.
- The design professionals would determine the loads for the building envelope by preparing allowable stress design, strength design, load combinations and rooftop equipment as per BIS codes and standards.
- Determine Load Resistance and select a reasonable safety factor.
  - For building envelope systems, a recommended minimum safety factor is 2.
  - For anchoring exterior-mounted mechanical, electrical, and communications equipment, a minimum recommended safety factor is 3.

3.1.2 Impact: Lightning

Climate Risk Impact Assessment

Lightning activities occurring during cyclone hazards are responsible for causing immense loss of life and destruction to electrical systems and equipment.

The types of lightning strikes affecting a structure are direct strikes, side strikes, conducted strikes and dry lightning. The detailed definition of the strikes have been provided in the Glossary. The level of exposure of an Industrial park to lightning activity and the extent of performance based design required to reduce its impact are provided in the climate risk assessment matrix in Table 2 of Annex X.

(1) Potential Impacts

Lightning hazard has the greatest potential for loss or harm to the environment and habitats. The extent of damages caused would be dependent on location and time of strike. The common impacts are:

- **Fire danger**: Wood and other combustible building materials can be ignited anywhere an exposed lightning channel comes in contact with them. When lightning current travels through wires, it will commonly burn them up, resulting in a fire ignition hazard anywhere along the affected circuits.
- **Power surge damage**: If lightning follow's the electrical wiring as its primary or secondary path, the explosive surge can damage even non-electronic appliances that are connected.
- **Shock wave damage**: The shock waves created by lightning can easily fracture concrete, brick, and stone. They can blow out plaster walls, shatter glass, create trenches in soil and crack foundations.

(2) Type of Damages

Damages caused by lightning activity are fatal, irreversible and irreparable. The probability of damage at the point of impact is very high. The types of damages caused by lightning strikes are:

- **IP level damages**
  - Electric shock suffered by habitants as a result of a direct lightning strike on the utility lines.
  - Fire, explosion, mechanical and chemical reactions resulting from a direct lightning strike on a utility line.
  - Failure of electrical / electronic systems due to a lightning strike on the ground next to the building or structure.
  - Failure of electrical / electronic systems due to a direct lightning strike on a utility line entering the building or structure or on ground next to a utility line.
- **Building level damages**
  - Electric shock suffered by habitants as a result of a direct lightning strike on the building or structure.
  - Fire, explosion, mechanical and chemical reactions resulting from a direct lightning strike on the building or structure.
  - Failure of electrical / electronic due to direct lightning strike on the building or structure.

(3) Pre-planning and Pre-design Guidelines

- All the safe evacuation sites must be listed. They would contain the following:
  - Substantial buildings
  - Low ground -- seek cover in clumps of bushes.
  - Fully enclosed metal vehicles with windows up
  - Trees of uniform height, such as a forest
- All the sites which would be unsafe during lightning activities must be listed. They would include the sites with :
  - Fences and gates
  - High mast light poles
  - Metal construction equipment
  - Electrical equipment
  - Outdoor metal objects
  - Power poles

A written lightning safety plan has to be maintained. This would include written instructions on how to contact local emergency management and a weather service provider.

3.1.3 Impact: Storm Surge and Coastal Inundation

Climate Risk Impact Assessment

The impacts of climate change on industrial areas located near coastal regions are in the form of storm surges and tides resulting from wind and atmospheric pressure changes associated with a storm. They give an abnormal rise to the sea water level resulting in coastal flooding.

The level of exposure of an Industrial park, to the hazard impact and the extent of performance based design required to reduce its impact, are provided in the climate risk assessment matrix in Table 3 of Annex X.

Figure 8 illustrates the height of storm surge and storm tides due to coastal cyclones and level coastal inundation due to rise in mean sea level respectively.

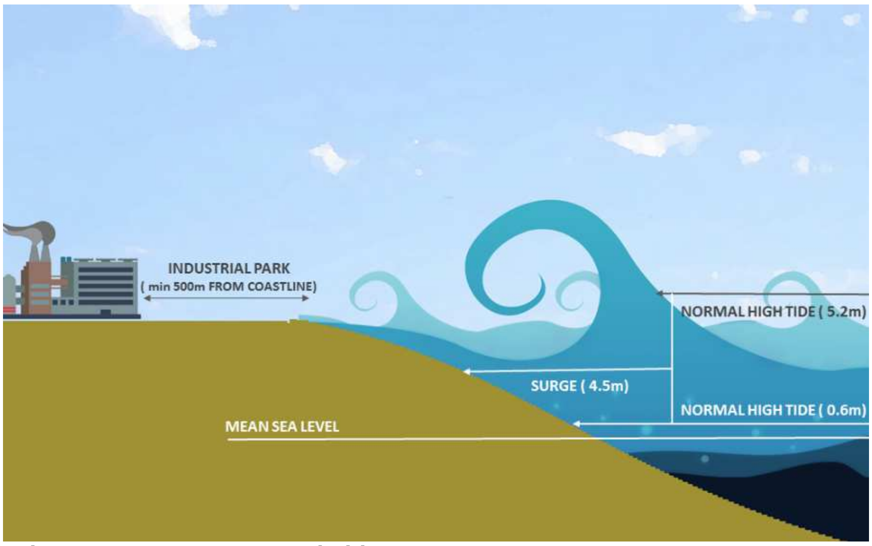


Figure 8: Storm Surge and Tide

(1) Potential Impacts

Storm surge and Coastal Inundation are hazards with the greatest potential for loss or harm to the habitats and the environment. Mitigation is usually thought of in terms of prevention and stakeholder preparedness. The extent of damages would depend of multiple factors like,

- Location of industrial site and its proximity to the coastal region
- Position of the industrial site and its orientation to the wind flow
- Materials used for construction
- Local regional storm water flow;

- Velocity of the wind flow and water
- Period of storm

Sea level rise would increase the apparent severity and frequency of storm tide inundation and will cause inundation to occur further inland.

(2) Causes for Structural Damages

The damages to the structure of the building mainly occur due to the following.

- Inundated water creating localized softening and scour of soil around buildings and their foundation. This scour might cause the loss of bearing capacity or anchoring resistance of the foundation elements.
- Sediment transport patterns may be altered by shifts in inundation direction triggering changes to the form and location of shorelines.
- Low-lying land may be permanently inundated.
- Shifting of foundations due to geotechnical failure.
- Exposure of building materials to saline water and high salt laden wind, leading to their immediate or long term deterioration due to corrosion.
- Collapse of boundary walls due to forces exerted by breaking waves.
- Floodwater currents and waves creating localized scour around a building and its foundation. This scour might cause the loss of bearing capacity or anchoring resistance of the foundation elements.

The damages leading to failure of structures are due to different forces exerted by the floodwater resulting from a storm surge as listed below.

- Lateral hydrostatic forces
- Vertical (buoyant) hydrostatic forces
- Hydrodynamic forces
- Impact forces of inundation-borne debris
- Localized scour
- Surge forces
- Breaking wave forces

(3) Type of Damages

Storm surge and Coastal inundation tend to leave a considerable amount of impact on the footprint area of effect. Various types of damages that could be observed in the Industrial park and its vicinity are:

- **IP level damages**
  - Erosion of top soil
  - Excessive increase in sub-surface and surface water levels
  - Pollution and salinization of ground water and soil
  - Damage or failure to the infrastructural elements such as roads and utility network

- **Building level damages**
  - The types of structural damages occurring in a building due to storm surge and coastal inundation are similar to that of damages caused by flood.

3.1.4 Impact: Soil Erosion

Climate Risk Impact Assessment

Erosion of soil refers to the wearing away, detachment and movement of the soil or rock fragments from land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. The types of soil erosion affecting an industrial park are Splash erosion and Sheet erosion.

The level of exposure of an Industrial park to erosions of soil and the amount of performance based design required to reduce its impact are provided in the climate risk assessment matrix in Table 4 of Annex X.

(1) Potential Impacts

Soil erosion has the potential to cause substantial damage to top soil of the impact area. The kinds of impacts, which may arise, are listed below:

- On-Site
  - Removal of topsoil and Loss of natural nutrient
  -
  - Degradation of soil quality, structure and texture of soil
  - Reduction of water-retention capacity of the soil, making it vulnerable to drought conditions
  - Breaking down of aggregates and weakening the structure
- Off-Site
  - Deposition of eroded soil in downslope
  - Contributing to damaging of roads

(2) Types of Damages

The damages which could occur due to soil erosion are:

- **IP level damages**
  - Underground service lines get exposed, becoming vulnerable to external damages and contamination
  - Tree roots get exposed due to soil movement resulting into instability and subsequent fall of trees.
  - Road services become dysfunctional
- **Building level damages**

- o Shifting of foundation resulting in weakening of structures
- o Generation of cracks on walls due to Soil subsidence
- o Settling of ground floor
- o Concentrated accumulation of debris and mud exerting load on the building floors

3.1.5 Impact: Flood

Climate Risk Impact Assessment

It is important to evaluate the situations of floodplains and the impacts of climate changes on any given region. This evaluation would help in developing adaptation measures and methods to avoid, reduce, transfer and retain risks on structures and functions of an Industrial park located in or near a floodplains. The two types of flooding events which can cause substantial amount of damage are surface flood & sewer backflow flood event.

. The level of exposure of an Industrial park to flood and the extent of performance based design required to reduce its impact are provided in the climate risk assessment matrix in Table 5 of Annex X.

(1) Potential Impacts

The extent of damages, the level of inconvenience faced during debris cleaning activity and the cost incurred for repairing and renovation would depend of multiple factors listed below:

- Depth and velocity of the water;
- Period of inundation;
- Debris loads and silt in the water;
- Location of the industrial site and its orientation to the flow;
- Spacing of buildings (which would influence the velocity of the flow between structures);
- Materials used for construction;

(2) Causes of Structural Damages

The construction process followed and the materials used for construction of the building have an immense role determining the vulnerability of the building to component damage.

The damages leading to failure of structures are due to the different forces exerted by floodwater, such as hydrodynamic forces, hydrostatic forces, Impact forces, long-term erosion and localized scour.

- **Hydrodynamic forces**

  The flowing water would exert pressures on the sides of any objects in its path. The magnitude of the force conveyed on the object would mainly be dependent on the flow velocity. Significant suction loads would be created on the side walls as the water would flow along the sides of the building. This suction load would tend to pull the walls away from the structure. The direction and effect of forces have been illustrated in Figure No. 9 below.

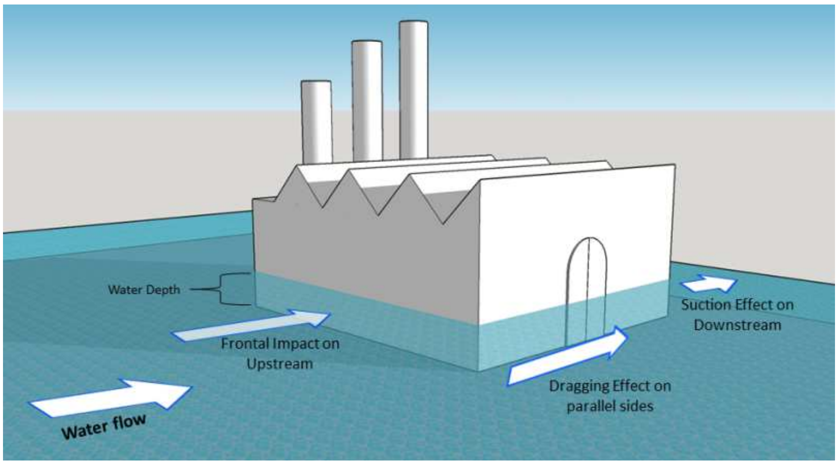


Figure 9: Hydrodynamic Forces acting on Building

- **Hydrostatic forces**
  - **Lateral hydrostatic forces**

    Lateral hydrostatic forces act in a horizontal direction, against vertical or inclined surfaces, both above and below the ground surface. These pressures as depicted in Figure No. 10 tend to cause sideways displacement and overturning of the building, structure, or components.

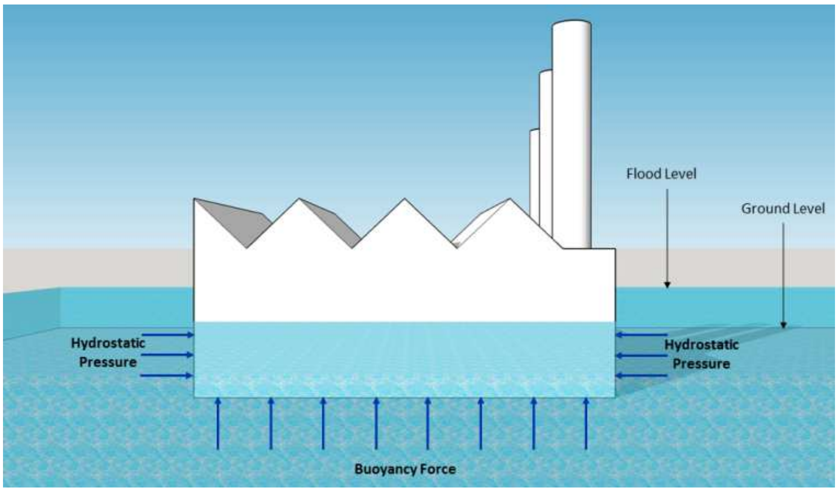


Figure 10: Lateral Hydrostatic Forces acting on Building

o **Vertical hydrostatic forces**

These pressures act vertically downward on horizontal or inclined surfaces of buildings or structural elements, such as roofs and floors, caused by the weight of floodwater, and water absorbed building components above them. The direction of forces exerted on building has been shown in Figure No. 11

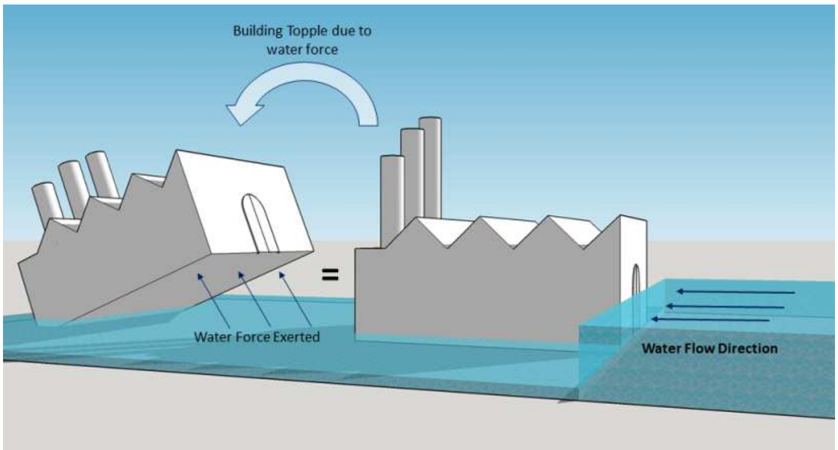


Figure 11: Vertical Hydrostatic Forces acting on Building

- **Impact forces from Debris**

  Huge amount of floating objects are carried inward by floodwaters. The debris could contain objects of varied weight, shape and dimensions. The debris could cause damage to the structure in two ways, such as

  - Increased drag from an accumulation of debris mass e.g. vegetation pushing against a building,
  - Impact from single floating objects such as trees and cars striking part of the building.

(3) Type of Damages

The types of damages caused by flood are:

- **IP level damages**
  - Inundation damage to industrial equipment and furniture
  - Inundation damage to business inventory and infrastructure
  - Deposition of sediments carried by floodwaters
  - Business interruption damage due to hindrance to regular activities
  - Interruption of production activities
  - Damage due to interruption of the supply of electricity, water and gas
  - Cost of emergency measures
  - Decrease in production leading to financial loss.

- **Building level damages**
    - Collapse of all or a section of external wall either inward or outward, and Collapse of cladding material either inward or outward,
    - Bloating and cracks in surface finishes,
    - Generation of cracks in brickwork
    - Inundation damage to the buildings and depreciable fixed properties like buildings and land

3.2 Heat waves and Droughts

Heat waves (i.e. abnormally high temperatures compared to mean temperatures) is a climate change hazard that significantly affects the states of Andhra Pradesh and Telangana in the recent years. Occurring mostly between April and June, heat waves have severe effects on human health and wellbeing, as well as different sectors of local economies and Industrial Parks.

Drought is also a frequently observed hazard in Telangana and Andhra Pradesh – it is the third highest drought prone state of India with 12.5 million ha of drought prone land area. One of the most significant features of droughts is the water scarcity due to reduced rainfall and runoff.[9]

The most significant impacts of heat waves and droughts for Industrial Parks are:

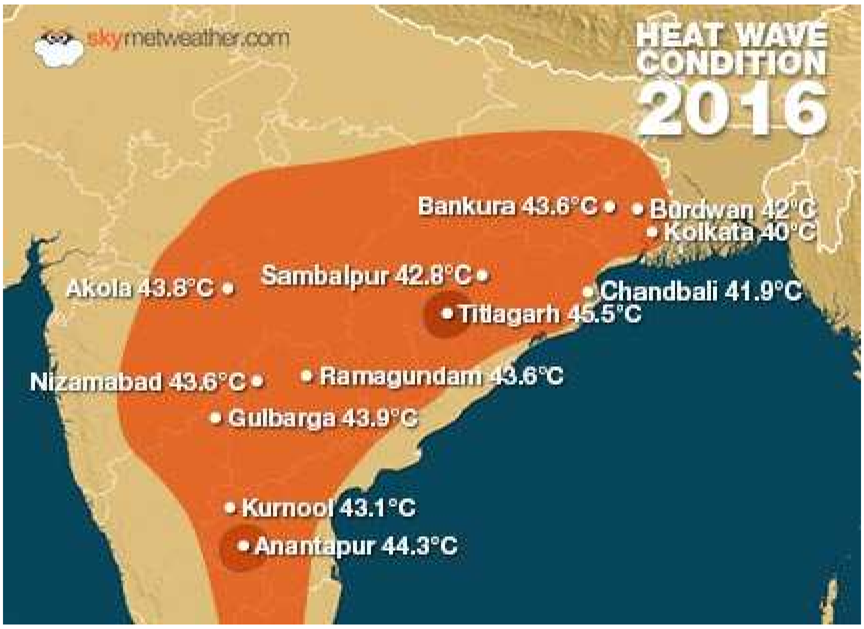
- heat stress,
- water scarcity, and
- shortages in energy supply.[10]

3.2.1 Impact: Heat Stress

Heat stress refers to the impact of the climate change hazard of heat waves in terms of human health and productivity. Exposure to extreme heat may have severe consequences for human health, affecting most strongly the vulnerable groups such as elderly, infants and children, as well as people with chronic heart or lung disease. Severe cases of heat stroke can cause death.

In urban areas with high percentage of development (such as in Industrial Parks), one significant source of heat stress is the Heat Island Effect. The term Heat Island refers to the relative warmth of a built up area compared to the surrounding rural areas. The graph below shows as an example the heat wave condition in the year 2016 as per skymet data covering both Andhra Pradesh (Kurnool and Anantpur) and Telangana (Nizamabad and Ramagundam) apart from other parts of the country[11].

[9] GIZ, Strategy for CCA in Industrial Areas, 2015
[10] The particular impacts of heatwaves and droughts in this scope are grouped and appropriate climate change adaptation measures are summarized, identified and explained by Happold Ingenieurbüro GmbH.
[11] http://www.skymetweather.com/content/weather-news-and-analysis/heatwave-2016-large-chunk-of-india-witnessing-oppressive-heat-simultaneously/



Extreme temperatures and heat stress will cause a variety of damages within Industrial Parks related to human health, physical infrastructure, materials and structures, and industrial processes.

- Firstly, heat stress caused by extreme heat events and heat waves are significantly affecting the human health. Extreme heat exacerbates underlying health conditions, and may lead to increased risk of death, and non-fatal impacts such as heat stroke and heat exhaustion. The heat wave in Andhra Pradesh in 2015 from 22 May - 1 June claimed 2677 lives[12]. For workers, heat exhaustion and heat stroke are of particular importance for the occupational health, which are commonly seen in different industrial sectors in Andhra Pradesh and Telangana.[13]
- Extreme heat significantly affects the workers' strength and labour productivity, but also causes negative impacts on the industrial production and processes, by affecting the storage facilities and machinery as well as increasing the energy demand for cooling.
- Due to extreme heat, industrial materials and structures experience damages as well. When the necessary measures are not implemented, the materials can be severely damaged and industrial processes can be interrupted or cut.

3.2.2 Impact: Water Scarcity

Water scarcity refers to the water imbalances, combining low water availability with water demand exceeding the supply capacity. The severity and frequency of droughts

[12] Malini et al., Severe heat wave during May 2015 in Andhra Pradesh, Scientific Correspondence, February 2016
[13] Dash, S.K , Kjellstrom, T., Workplace heat stress in the context of rising temperature in India, Current Science, vol. 101, No. 4, August 2011

can lead to water scarcity situations, especially in regions with low water resources or with an improper water management.[14]

The lack of water may cause interruptions and difficulties for industrial production and processes, as well as causing restrictions on water uses and allocation policies for other user sectors such as particularly agriculture. Natural fresh water bodies have a limited capacity in terms of increasing water demands and climate change conditions.[15] The following damages in terms of health, industrial processes and environment may occur due to increasing drought and water scarcity:

- Environmental damages such as degradation of surface water and groundwater quality, and ground water over abstraction
- Economic losses, due to water supply shortages and cuts in production
- Health problems due to lack of water, deterioration of the groundwater and surface waters and improper distribution and sewage systems.[16]

3.2.3 Impact: Shortages in Energy Supply

Third major impact identified are **shortages in the energy supply.** During a heat wave, it is highly likely that the electricity sector will experience problems in terms of generation, transmission and distribution, which would then cause a blackout or a brownout. Blackout refers to the complete failure of the electricity distribution, and a brownout to the reduced supply.[17] Drought-induced water scarcity and lack in water supply have severe impacts on the energy infrastructure as well, such as negatively affecting the electricity generation and cooling processes in power plants. [18]

Urban areas in general and Industrial Parks in particular highly depend on electricity, which causes severe damages and effects in terms of economy and well-being during blackouts or brownouts. They cause damages and interruptions in terms of all following aspects:

- Industrial production,
- Cooling,
- Communication,
- Transportation,
- Lightning,
- Daily needs etc.

As the duration of the shortages vary, the severity, duration and general effect of these damages also varies. In general, longer interruptions have larger impacts.

These guidelines define appropriate strategies and corresponding adaptation measures in order to successfully cope with these impacts of heat waves and droughts in Industrial

[14] European Commission, Water Scarcity and Droughts in the EU, ec.europa.eu/environment/water/quantity/about.htm
[15] Pereira, S., Cordery, I., Iocavides, I., Coping with Water Scarcity : Addressing the challenges, Nicosia, 2007
[16] Schmidt, G., Benitez-Sanz, C., Topic report on : Assessment of Water Scarcity and Drought Aspects in a Selection of European Union River Basin Management Plans, Study by Intecsa-Inersa for the European Commission, 2012
[17] Aivalioti, S., Sabin Center for Climate Change Law, Columbia Law School, Electricity Sector Adaptation to Heat Waves, New York, 2015
[18] Rübbelke, D., Vögele, S., Impacts of climate change on European critical infrastructures : The case of the power sector, Environmental Science and Policy 14, 2011

Parks. The selection of the appropriate measure also depends on the severity of the risk and effectiveness of the measure in the particular case, which will also be defined throughout these guidelines.

The impacts of heat waves and droughts are surely not limited to the Industrial Parks and apply to a larger scale. These larger scale impacts cause possible damages to the Industrial Parks and the production processes. Failure or delay of deliveries due to supplier's or sub-contractor's process disruptions is a common consequence of extreme weather conditions such as heat waves. Transportation means are as well affected; heat-induced risk of accidents increase in the road traffic, and damages occur in the railway tracks and overhead lines in railway transportation. This highlights the importance of adaptation policies being widespread, and adaptation measures applied as wide as possible.[19]

[19] GIZ, Climate Change Adaptation for Sustainable Industrial development, November 2015

4. Adaptation Planning & Implementation Process

The following chapter describes the process after carrying out the climate risk analysis, which is the adaptation planning and implementation process. This is the step, where the adaptation action plan is established. Adaptation measures are firstly defined and identified, then selected regarding their cost and effectiveness within the industrial park of interest. This process includes adaptation planning and the implementation process, and the establishment of an adaptation action plan.

The chapter also includes the aspects of price fixation and potential methods for management, plot allotment mechanism, environmental clearance and finally the implementation of the measures.

The detailed adaptation measure is mentioned in the Manual 2 on Tools for Planning and Resilience Measures for Climate Change Adaptation in Industrial Parks.

4.1 Set-up of Adaptation Action Plan

4.1.2 Heavy Rain and Flood Related Impacts

The hazards and their corresponding impacts to be addressed in this guideline have been presented in the Table below. Each hazard may have multiple impacts and the level of impact would vary with the degree of hazard

Table 3.1: Hazard and Impact Matrix for Heavy rain and Flood Impacts

Hazard	Impacts					
	High Winds	Lightning	Storm surge	Soil Erosion	Flood	Coastal inundation
Cyclone & Storms			■	■	■	
Cloud Burst		■	■	■	■	
Heavy Rainfall	■	■	■			
Sea Level Rise				■	■	■

The table 4.1 above explains the various hazards associated to heavy rain and their corresponding impacts. Different hazards may have the same impacts. The consequences of the impacts would vary significantly depending on their location, speed, duration and depth of their occurrences.

The immediate impacts of cyclone, cloud burst heavy rainfall and rise in sea level include loss of life and damage to property and infrastructure. They greatly affect the environmental, social and economic balance of the region. In industrial parks, massive floods and high winds triggered by heavy rain and cyclones respectively are the main reasons for the extensive damage to critical infrastructures. Disruption to transportation works, supplies of water and electricity and waste treatment could make the industries economically vulnerable. Therefore it is necessary to identify, assess and secure the critical infrastructures ahead of time in order to decrease the severity of impacts on the functioning and economy of industrial parks.

In order to efficiently manage and protect the industrial parks from the effects of climate change impacts, it is necessary to develop adaptation strategies. These strategies along with their set of engineering measures would ascertain a safe and interruption free functioning of the IPs

The adaptation strategies regarding each hazard and their impacts have been illustrated below in figure 12;

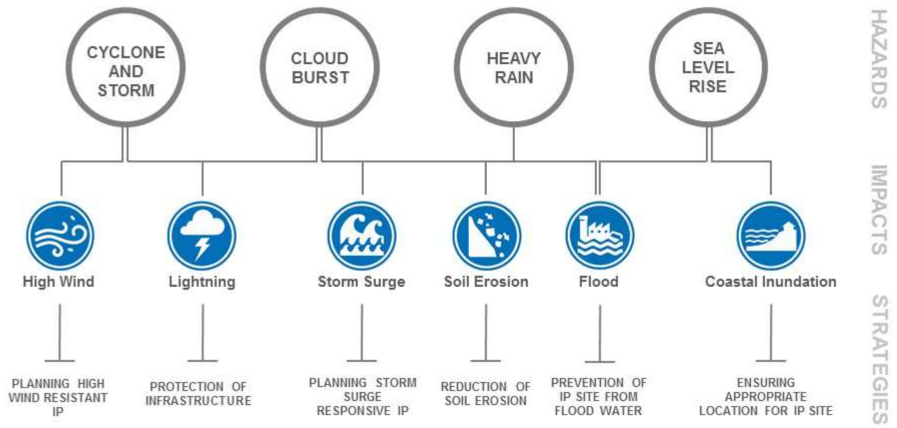


Figure 12: The adaptation strategies for the impacts, caused by heavy rain, cloud Burst, cyclone and sea level rise

- **Planning High Wind Resistant IP:** Strategies to combat the high wind oriented impacts are manifold depending on the point of impacts, such as at building levels (light-weight roofs, parapets etc.) and/or at the infrastructure components levels (electrical lines and posts, water tanks, network towers etc.)
- **Protection of Infrastructure:** Prime strategy of adaptation to the Lightning hazard is to ascertain identify the frequency of Lightning hazard occurrence and the potential points of attraction to the buildings and high mast infrastructure components. Necessary technical measures listed in the Manual 2 to be adopted to direct the lightening surges to the directly to the ground without causing any damage to the buildings.
- **Planning Storm Surge Responsive IP:** Storm surge is a geo-climatic phenomenon subject to wind direction and land mass profile of the region. Strategy for addressing storm surge impact is to make appropriate shelter-belt vegetation planning.

- **Reduction of Soil Erosion:** The strategy for reduction of soil erosion to reduce the chances of degradation of soil quality, soil structure and soil texture, will be manifested with appropriate reduction of flood water flows and channelization of water with well laid out storm water drainage systems.
- **Prevention of IP Site from Flood Water:** Potential impacts from flood water to be reduced through site level strategies, by impeding the velocity of water flow and reducing period of inundation, minimising debris load and silting.
- **Ensuring Appropriate Location for IP Site:** Impact of coastal inundation need to be minimised through appropriate site selection and landform profile planning.

The climate change adaptation measures corresponding to the impacts of heavy rain and flood related impacts are listed under every adaptation strategy in the figures below. Summary of all adaptation measures are mentioned below and detailed explanation is explained in Manual 2: Manual for Adaptation and increasing Resilience of Industrial Parks to the Impacts of Climate Change

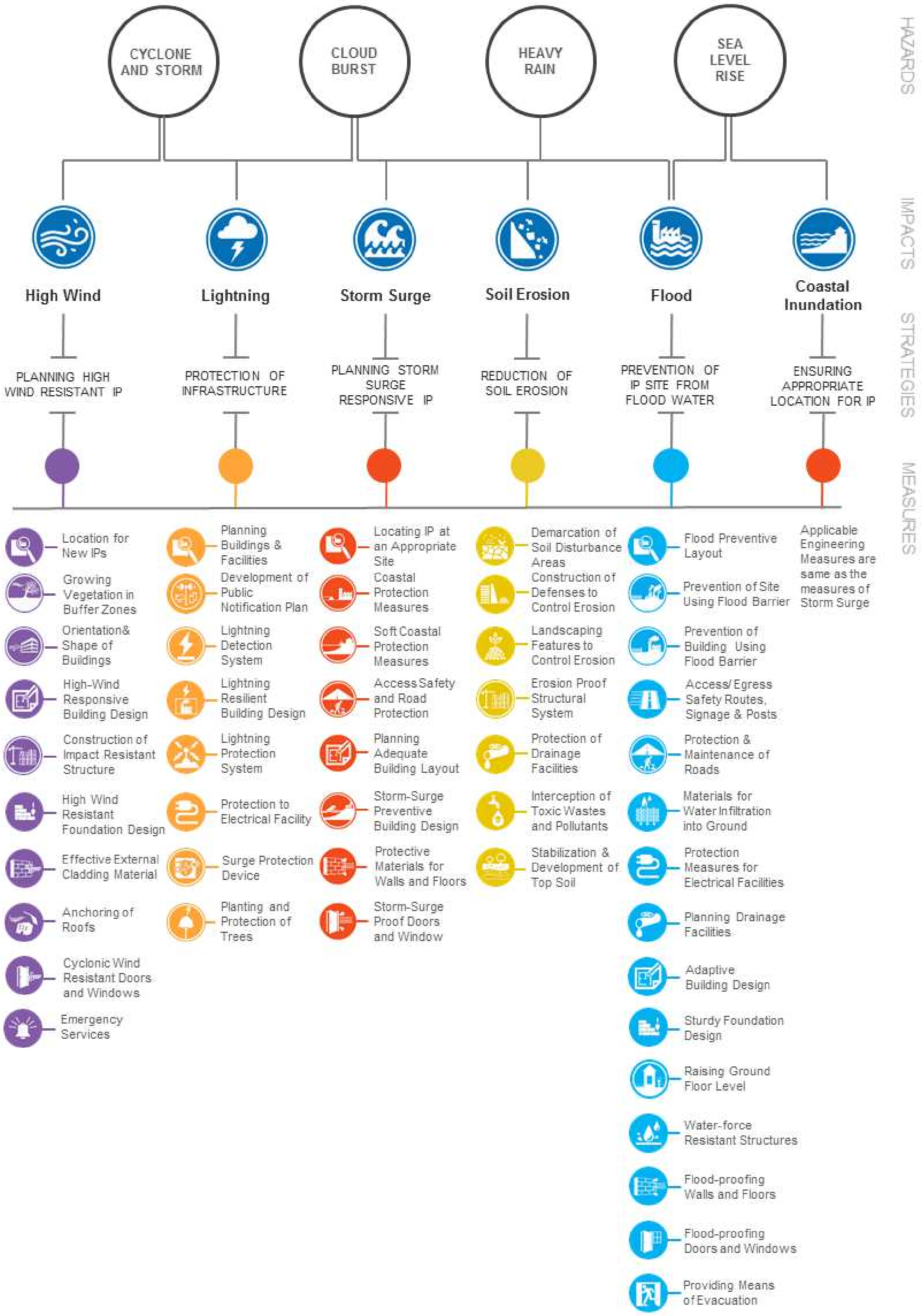


Figure 13: Summary of Adaptation strategies and measures

4.2 Heat waves and Droughts

The hazards to be addressed in this section and the corresponding impacts are summarized in the matrix below. The hazards may have multiple impacts and the level of impact varies with the degree of the hazard.

Table 3.2: Hazard and Impact Matrix for Heat wave and Drought Impacts

Hazard	**Impact**		
	Heat Stress 	**Water Scarcity** 	**Shortages in Energy Supply** 
Heat wave			
Drought			

It is essential to consider the impacts of heat waves, including heat stress, water scarcity and shortages in energy supply while planning for IPs. Heat waves have various impacts on industrial parks, such as affecting employees` health and productivity (the health impacts of heat waves typically involve dehydration, heat cramps, heat exhaustion and/or heat stroke[20]), increasing the energy demand for cooling facilities, and disruptions in various production lines and processes due to extreme heat and water scarcity.

Water scarcity, triggered by heat waves and drought, have various consequences for industrial parks, which highlights the importance of taking the necessary steps for implementing climate change adaptation measures. Different industrial sectors have different footprints and consumption, but all industries require water for production as well as sustaining the labour productivity. For example, fresh water is an essential resource for textile processing such as dyeing or bleaching, as well as an important resource for the high-tech industry in terms of semiconductor manufacturing.

Successful adaptation to these hazards and securing healthy and productive environments within IPs are utmost priority. The adaptation strategies cover measures that deal with the impacts of heat waves and droughts firstly in terms of human health and environmental quality, and also in terms of water scarcity and vulnerability of the technical infrastructure and power supply.

[20] http://www.ndma.gov.in/en/media-public-awareness/disaster/natural-disaster/heat-wave.html

The particular adaptation strategies concerning each impact can be seen in the figure 14 below.

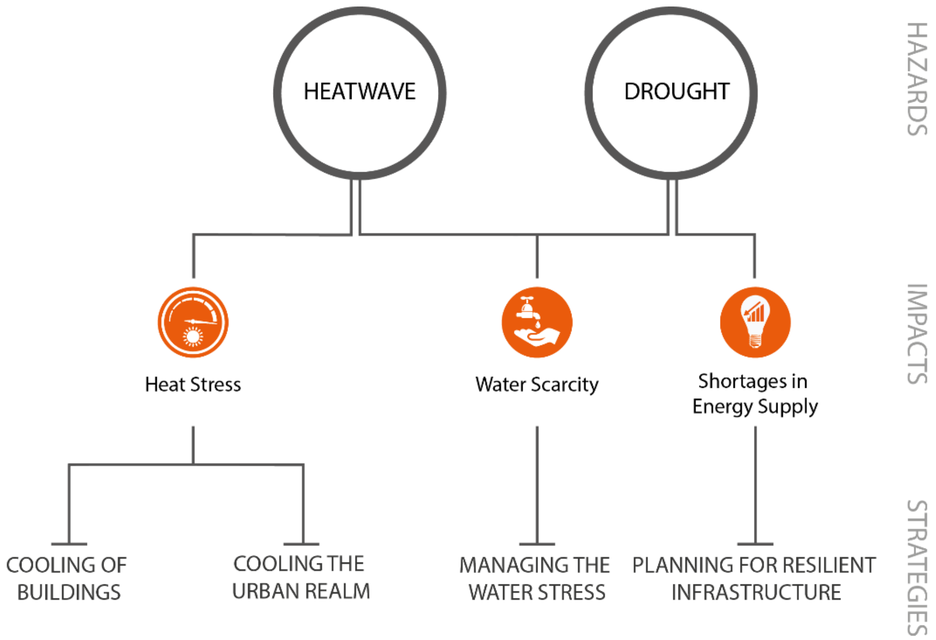


Figure 14: The adaptation strategies for the impacts, caused by heat waves and droughts

- **Cooling of Buildings**

  Cooling of buildings is an essential strategy for providing healthy and productive work environments within IPs. Considering the increase in energy demand and water scarcity, this strategy aims to bring passive measures and sustainable solutions to provide cooling in the interior spaces of office buildings, warehouses, industrial halls and utility buildings.

- **Cooling the Urban Realm**

  Various methods and measures applied effectively could provide naturally cooled spaces within the Industrial Park, which minimizes the health issues in terms of heat stress for workers, as well as securing the industrial materials, structures and processes in a sustainable way. The urban realm in this context refers to the built / developed areas in terms of industrial parks. It includes all exterior places, linkages and built form elements within the developed area.

- **Management of Water Stress**

  Water scarcity is vital component in terms of climate change and managing water stress is a key element of sustainable IPs to reduce the vulnerability. Water sensitive planning and design is crucial for securing sustainable and continuous industrial processes and development. There are various measures, which can be applied to provide appropriate infrastructure and facilities in terms of managing water stress. Dealing with water scarcity requires not only engineering and management measures in terms of water conservation, but also preparedness and emergency measures.

- **Planning for Resilient Infrastructure**

  In order to successfully cope with the impacts of climate change hazards to infrastructure – especially to the power supply, there are various appropriate measures. It is not only important to keep the peak demand in mind while designing and implementing the infrastructure, and to plan for resilience within materials and systems, but also to prioritize green sources of energy that minimizes risks, reduce costs and contributes to sustainable development.

The corresponding adaptation measures concerning the impacts of heat waves and droughts are listed under every adaptation strategy in the figure 15 below.

Below is a diagram that gives an overview of all related measures concerning the impacts of heat waves and droughts in industrial parks. The measures are grouped according the impacts and adaptation strategies.

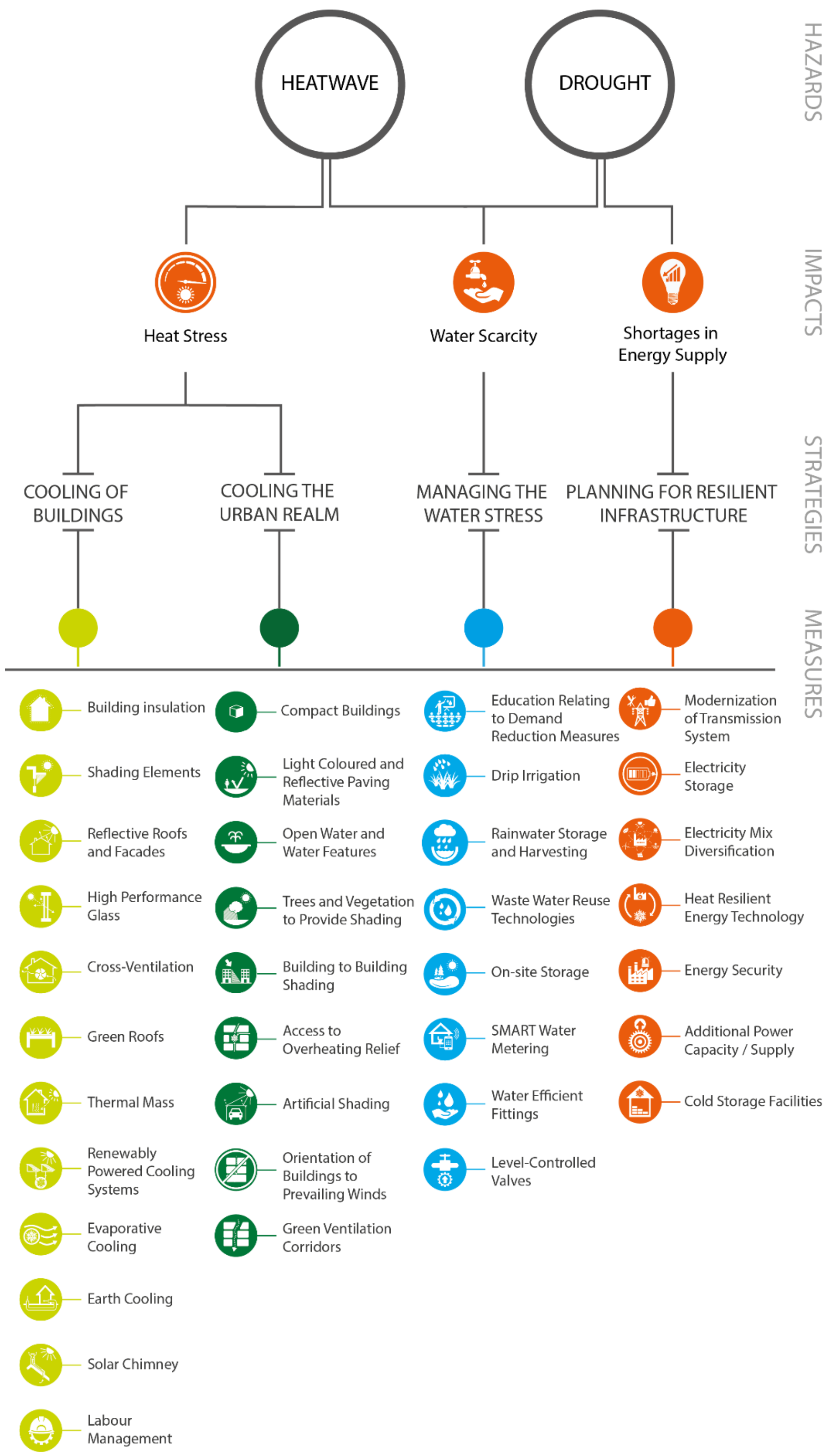


Figure 15: Overview of all related adaptation measures for each impact – heat stress, water scarcity and shortages in energy supply

4.2.1 References to Manuals and Tools

The detailed explanation of the measures with engineering and application details can be seen in the Manual 2 (Chapter 2 for Heavy Rainfall related measures and Chapter 3 for Heat and Drought related measures). In these detailed explanations, there are also particular tools presented to aid the design and implementation process of each measure, as well as a list of reading material for further information.

Most of the measures are appropriate for both existing and newly planned industrial parks, but there are also a few that apply to only one. This feature is indicated for each measure in the Manual 2 (Chapter 2 and 3).

The measures can be selected in terms of their cost and effectiveness in the case of the particular industrial park of interest.

4.3 Price Fixation

The following subchapter provides information which according the planning process of new IPs falls under Phase C Infrastructure and Price Fixation, but includes information also for existing IPs.

4.3.1 Funding of Measures in new IPs

Phase B (I) in Figure 5 of *Climate Risk Analysis for new industrial park* is the phase, where the Price Fixation Committee (PFC) will determine the level of level of infrastructure to be provided in an industrial park. This committee is constituted by MD, APIIC/TSIIC. The members include Executive Director, Chief Engineers, Chief General Manager (CGM) (Finance), CGM (Projects), Zonal Manager. The costing considerations cover an assumption of upfront costs (costs of acquiring land) and infrastructure costs, occurring during construction of the zone.

The following steps are considered to part of the Price Fixation Phase

- Step 8: Convention of the PFC: Committee
- Step 9: Price Fixation Approval
- Step 10: Review and recommend land cost in all the industrial parks periodically and upon the requirement.

4.3.2 Funding of Measures in Existing IPs

If the park is relatively new, then funding is also considered from PF C committee, if available for the older parks, most of the funding comes from tax collection from the respective industrial park. Assessing the costs and benefits together with available finance and funding opportunities are handled in Phase 4 for existing IPs. After clarifying the aspect of finance and funding, the Phase of 5 and 6 will be followed in terms of acquiring the necessary approvals and provision of technical sanctions and finally implementing the selected CCA Measures.

Cost of Development for Climate Change Adaptation

Overall cost of development for climate change adaptation for the Industrial Parks, for its infrastructural development and plotting, as well as development of individual Industrial structures and services, can be attributed to the following.

- Degree of relief requirement based on the level of impact,
- Quality of retrofitting,
- Type of material specifications used in the design,
- Competence of contractor,
- Level of compliance.

Cost of improvement for the IPs could be of two types:

- For new IPs the cost is in-built in the overall design, specification, estimation and construction phases.
- For existing IPs the additional fund has to be allocated depending on the nature of impacts and subsequent relief requirements to improve essentially the operation of the industrial functions as well as peoples' safety and equipment safety.

4.3.3 Estimation of detailed Cost of Adaptation

For the new IPs, additional cost to be estimated for the additional works required as CCA measures implementable during new construction.

For the existing IPs, additional cost to be estimated for the additional works required as CCA measures incurred through mandatory retrofit works through addition / removal / replacement of the vulnerable components in the existing constructed buildings / services to make it CCA compliant over the existing property.

4.3.4 Applicable Standard Scheduled Rates for Cost Estimation

Following working schedule of rates to be used during selection of the items of works and estimating the cost of mitigation.

- Schedule of Rates for Building Works: 2015–16 (effective from 1st June 2015), Government of Andhra Pradesh and Government of Telangana Part - I Building Items
    - Part - II Water Supply & Sanitary Items
    - Part - III Electrical Items
    - Part - IV Public Health Items
- Common Schedule of Rates as per A.P. revised standard data for the year 2014-15, Government of Andhra Pradesh
    - Irrigation and CAD Works
- Common Schedule of Rates as per A.P. revised standard data for the year 2015-16, Government of Andhra Pradesh
    - Part - I Water Resources Department Work Items

- o Part - II Roads & Bridge Works

In the absence of the items of works, which are very essential for adaptation purpose but not covered in the above SoR, the following approaches are to be adopted.

- Adopt the items of works mentioned in the DSR (Delhi Schedule of Rates) published by CPWD.

or

- Draft the items of works, as special items (commonly termed as non-schedule items) with appropriate specifications of components, such as materials, Labour, equipment etc., arriving at the unit rate (supported with rate analysis based on the current market rates). Obtain the approval of the execution authority designated by APIIC / TSIIC / IALA.

4.3.5 Economic Analysis of Adaptation Measures

Once the costs are defined and fixed, the benefits of the measured must be determined in order to prioritise measures and to allocate resources. Since adaptation costs are often project or site-specific, this can be a complex process. Identifying benefits of adaption measures is also often associated with a large amount of uncertainty.

According to IPCC, adaptation costs are “the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs”[21]. Benefits are defined as “the avoided damage costs following the adoption and implementation of adaptation measures”[22].

In order to estimate the benefits of the respective adaption measure (compared to or business as usual scenario), the impacts of climate change and the costs to mitigate these must be determined. This analysis can be a complex endeavour and many tools have been developed assisting planners and official to assess the benefits. Generally, the availability of data (such as cost and benefit information) required to conduct the assessment will determine which tool to apply.

A cost based prioritisation of the engineering measures would help in analysing the benefit based adaptation of measures. The figure 16 below gives a qualitative insight to the cost of the measures applicable for CCA of the IPs.

[21] http://www.climateready.com.au/cb_pages/glossary_bak.php
[22] http://www.climateready.com.au/cb_pages/glossary_bak.php

	Impacts							
Measures	**High Winds**	**Lightning**	**Storm surge And Coastal inundation**	**Soil Erosion**	**Flood**	**Heat Stress**	**Water Scarcity**	**Shortages in Energy Supply**
Measure 1	Low Cost	Low Cost	Low Cost	Low Cost	Low Cost	Medium Cost	Medium Cost	High Cost
Measure 2	Low Cost	Low Cost	Medium Cost	Medium Cost	Medium Cost	Low Cost	Medium Cost	High Cost
Measure 3	Low Cost	Medium Cost	Low Cost	Low Cost	Medium Cost	Low Cost	High Cost	High Cost
Measure 4	Low Cost	Medium Cost	Low Cost	Medium Cost	Low Cost	High Cost	Medium Cost	High Cost
Measure 5	Medium Cost	High Cost	Low Cost	Low Cost	Low Cost	Low Cost	Medium Cost	Medium Cost
Measure 6	Low Cost	Medium Cost	Medium Cost	Low Cost	Low Cost	Medium Cost	Medium Cost	High Cost
Measure 7	Medium Cost	High Cost	Medium Cost	Low Cost	Medium Cost	Low Cost	Low Cost	High Cost
Measure 8	Low Cost	Low Cost	Medium Cost		Low Cost	High Cost	Low Cost	
Measure 9	Medium Cost				Low Cost	Medium Cost		
Measure 10	Medium Cost				Medium Cost	Medium Cost		
Measure 11					Low Cost	Medium Cost		
Measure 12					Medium Cost	Low Cost		
Measure 13					Medium Cost	Low Cost		
Measure 14					Medium Cost	Low Cost		
Measure 15					Low Cost	Medium Cost		
Measure 16						Low Cost		
Measure 17						Low Cost		
Measure 18						Medium Cost		
Measure 19						Medium Cost		
Measure 20						Medium Cost		
Measure 21						Low Cost		

(green)	Low Cost
(yellow)	Medium Cost
(red)	High Cost

Figure 16: Cost based prioritisation matrices

The following section proves an orientation for the user on how to assess the benefits and the effectiveness of measures. For details on the respective analytical methods and steps it is recommended to refer to the guidelines “Assessing the Costs And Benefits of Adaptation Options” by the United Nations Framework Convention on Climate Change:[23] This document provides details for each step as outlines below and gives best practice examples.

4.3.6 Cost-Benefit-Analysis (CBA)

A CBA is often used to assess adaptation options when efficiency is the most important decision making criteria. This approach involves calculating and comparing all the costs and benefits of a measure, expressing all variables in monetary terms. Since no revenue can be expected from the investment on the CCA actions, it is wiser to estimate the benefits in terms of lesser direct cost / property and human loss involvement during / post disaster occurrence. Hence cost and benefits for CCA actions could be a subject of brainstorming, and subsequently the outcome of the level concerns of loss viewed by the investor.

A simplified step of CBA has been suggested below to arrive at a fair judgement on the Cost vis-à-vis benefit for CCA at IP / industry levels.

Step 1: Conduct an in-house brainstorming session with all the persons concerned on the hazards, degree of impacts, degree of expected losses, various items of costs, and perceivable benefits.

Step 2: List all the anticipated items of physical losses (intangible) and items of costs.

Step 3: Assign monetary value to all the losses and costs.

Step 4: Visualise all the probable benefits discreetly.

The components of benefits can be estimated in terms of Economic or Moral terms.

Economic terms (tangible): safe property, safe equipment remaining worthy of operation continuity, tax exemption, low-interest or soft loans, interest-free grants, regulatory exemptions, additional building permit, low land price.

Moral terms (intangible): no human loss, brand identity, award winning, wide publicity (No human loss can be viewed as benefit in terms of moral terms).

Step 5: Assign monetary value to all the benefits.

Step 6: Compare Costs and Benefits (Total computed monetary value of Cost and Total monetary value Bf benefits

Step 7: Estimate the Payback period where benefits are received over time.

(In other words, Payback period in terms of Length of time = Total computed monetary value of Cost / Total monetary value of Benefits)

CBA approach may pose some problems, especially in the cases where cash flows and returns vary from time to time. In such cases adopt **NPV (Net Present Value)** together with **IRR (Internal Rate of Return)** to arrive at the understanding of cost and benefit, as in this process ‘time value for money’ is inbuilt in the calculation.

- The net present value (NPV) describes the difference between the present value of the benefits and the present value of the costs.

[23] http://unfccc.int/resource/docs/publications/pub_nwp_costs_benefits_adaptation.pdf

- The benefit-cost ratio (BCR) describes the ratio of the present value of the benefits to the present value of the costs. Benefits and costs are each discounted at a chosen discount rate.
- The internal rate of return (IRR), i.e. the discount rate that makes the NPV equal to zero. The higher an option's IRR, the more desirable it is.

4.3.7 Cost-Effectiveness Analysis (CEA)

Cost effectiveness analysis (CEA) is often used to identify the CCA option with the lowest costs if several options are available to meet a certain adaptation objective.

Step 1: As with the CBA, the adaptation objective must be defined with its accomplishment being quantifiable in monetary terms. In a CEA several alternatives to achieve this objective should be defined.

Step 2: In a second step, the current situation in a baseline scenario and the future situation with the successful implementation of the adaptation measures will be defined. Defining and comparing the two scenarios will allow determining the costs and benefits.

Step 3: In a third step the effectiveness of a measure need to be defined, depending on the adaptation objective and the baseline.

Step 4: In a fourth step, the cost-effectiveness of different options is assessed either overall or in incremental terms. An overall analysis compares the cost per unit of effectiveness for each adaptation option (e.g. USD per 1 litre of water). An incremental cost effectiveness analysis considers the difference in costs divided by the difference in effectiveness that result from comparing one adaptation option to the next most effective policy measure (or a baseline situation).

The challenge of a CEA is that it assesses only the effectiveness of a measure and other important dimensions are not included.

4.3.8 Alternative Approaches

Besides CBA and CEA a number of other approaches can be used to support adaptation planning. These include, but are not limited to, multiple criteria analysis or expert panels. For more information on multiple criteria analysis it is recommended to refer to:

- USAID, Analysing Climate Change Adaptation Options Using Multi-Criteria Analysis, January 2013[24].

[24] http://community.eldis.org/.5b9bfce3/Multi-Criteria%20Analysis_CLEARED.pdf

4.4 Management of Plot Allotment Mechanism

The allotment process must be based on the applicant's willingness to incorporate climate change adaptation measures that have been initiated by the IP and potentially refer to the plot considered for allotment. The allotment of plots to bidders should be decided on the basis of the commitment of the bidders to adaptation measures. Following steps may be undertaken by the APIIC/TSIIC

Steps for the Plot Allotment Guidelines

Step 1 Invite applications from the potential industrial organisation through aggressive marketing and publicity to attract investment in the IPs

Step 2 On receiving applications, review the climate risk sensitivity /resilience of the applicant industries

Step 3 Stratify the applicant industries based on the review through Step 2 and allocate them in the different IPs on the suitability of the sites

Step 4 Adopt available APIIC / TSIIC industrial plot allotment guidelines

Step 5 Priority to be given to the industry owners who are ready to adopt CCA mitigation measures

The stakeholders' willingness to comply with the mandatory incorporation of CCA measures through execution of the detail engineering to be given priority during plot allotment process.

4.5 Environmental Clearance

Execution of EIA, documents required for Environmental Clearance

In terms of adapting to Climate Change, planning approaches need to have measurable outcomes to ensure that the risk-management activities being undertaken are effective.

APIIC / TSIIC / IALA, in collaboration with research consultants should attempt to measure and monitor how Climate Change hazard risk is changing.

The common indicators for monitoring risk need to:

- be CCA and Industry policy-relevant
- be based on data that are obtained in periodic regular intervals
- provide regularly interpreted information on which decisions can be made
- be simple and easily understood
- be readily collected without significant additional cost
- be comparable over the area under study

formation of environment management plan as per EC conditions and regular monitoring of IP as per EC condition for every 6 months needs to be considered. Budget allocation should be done for EMP monitoring by considering 5% of total budget collected during land sale.

The core hazard risk indicators that may be adopted are:

- Identifiable and/or identified hazard zones that are included on regional level planning maps
- National / district regulations rules that support those hazard zones aimed at not reducing the physical risk of hazards (e.g. Coastal Zone Regulation)
- District plan policies, prepared by District Plan Committee, to ensure that any IP within the hazard zones is subject to Climate Change Adaptation to mitigate risk, rehabilitation / relocation management plans
- Average building setback for the most seaward residential dwellings on residential lots in coastal hazard zones from the year 2000 datum for toe of fore dune survey line
- Number of existing IPs within the hazard zones as per latest RS (Remotely Sensed) maps
- Number of existing IPs within the hazard zones as recorded in the latest BLRO (Block Land Record Office) cadastral database (Maps and documented land records)
- Percentage of existing IPs within hazard zones with consent for CC adaptation to mitigate risks
- Percentage of existing IPs within hazard zones with financial constraints for CC adaptation to mitigate risks

4.6 Implementation, Construction, & Monitoring

Following are various stages of implementation process for successful realization of the CCA measures.

4.6.1 Expert Review of the Hazard Impacts

The design team shall undertake evaluation of meteorological inputs prior start of the planning and design at IP or individual industry level. If necessary, analytical input should be sought from a qualified external expert / organisation.

The design input or expert review may be arranged for the entire IP, individual building, or for specific components such subjected to hazard risks that are critical and beyond the design team's expertise.

A second opinion should be sought from the experts irrespective of the design team's competence, expertise and experience for the cases where the CCA measures are likely to be cost-intensive.

4.6.2 Implementation of construction works

Planning / Design: It is recommended that the design team analyses the design to determine which elements are critical to ensure appropriate performance on high-hazard situation.

The analysis should include necessary details and analysis (such as structural system, mounting of exterior components / equipment) in conjunction with reference to relevant codes in the BIS (India).

For New IP

IP level

- Procurement (land Acquisition, registration, mutation)
- Site Planning (layout planning, plot allotment, Trunk infrastructure planning e.g. roads, water supply, drainage, sanitation, landscape, grading, construction scheduling)
- Approval (submittal review, regulatory compliance)
- Site Accessibility (material transport/availability, restoration of access areas)
- Site Development (clearing, grading, levelling, mobilisation of machineries and labour)
- Execution (construction, inspection, compliance, completion certificate)

Industry Level

- Procurement (receiving allotment, registration, mutation)
- Building Design (Layout, industrial structure, plot level services e.g. roads, parking, water supply, drainage, sanitation, solid waste disposal, landscape etc.)
- Approval (submittal review, regulatory compliance)
- Execution (construction, inspection, compliance, completion certificate)
- Materials of construction
- Installation

For Existing IP

IP level

- IP-specific Climate change risk analysis (hazard-wise evaluation of the vulnerability of plots, Trunk infrastructure)
- Site Planning (rezoning, layout planning, augmenting existing trunk infrastructure e.g. roads, water supply, drainage, sanitation, landscape, grading, construction scheduling)
- Approval (submittal review, regulatory compliance)
- Site Accessibility (emergency egress, access to the emergency vehicles)
- Site Development (clearing, grading, levelling, mobilisation of machineries and labour)
- Execution (construction, inspection, compliance, completion certificate)

Industry level

- Plot-specific Climate change risk analysis (hazard-wise evaluation of the vulnerability of the plot, site infrastructure)
- Building Design (augmenting existing buildings and services e.g. road, water supply, drainage, sanitation, digital communication networks, landscape, grading, construction scheduling)
- Approval (submittal review, regulatory compliance)
- Retrofitting measures (component-wise actions, site grading)

- Execution (site and building construction, inspection, compliance, completion certificate)

4.6.3 Execution: Selection of Execution Agency

Construction Contract Administration

After a suitable design is complete, the design team should endeavour to ensure that the design intent is achieved during construction.

It is important for IP / individual industry owners in hazard-prone regions to obtain the services of a professional contractor who will execute the work described in the contract documents in a diligent and technically proficient manner. The frequency of field observations and extent of special inspections and testing should be greater than those employed on critical facilities that are not in hurricane-prone regions.

The key elements of construction contract administration are submittal reviews and appropriate field inspections by IALA / appointed expert agencies.

4.6.4 Execution Process

Handover of the working site to the Contractor

On completion of the proposed plans, specification, provision of the regulatory approval, selection of the contractor the site has to be handed over formally to the contractor with the rights of use and protection liability.

Construction Process

Construction process to be undertaken with diligence and compliance as per the conditions of contract by the Contractor and subcontractors till the construction is completed and the project site is handed over back to the APIIC / TSIIC / IALA by the contractor with the undertaking of completion.

4.6.5 Emergency Response Plan

- Creating government organizations responsible for emergency management
- Elaborating plans to manage emergencies and local mitigation policies
- Identifying the measures to implement in case of emergencies and the resources needed to respond to extreme weather; planning for evacuations
- Identifying emergency shelters in case of floods
- Planning a space to where floodwater can be directed and stored
- Planning methods to deviate the flow of floodwater away from vulnerable areas
- Planning an alternative source of energy for times of crisis
- Building a recovery plan that is part of the emergency measures
- Implementing warning systems in case of extreme weather events and making sure that the entire population in Industrial park is warned

4.6.6 Regulatory Compliance for Planning and Buildings

Review of Plan Submittals

The specifications need to stipulate the submittal requirements. This includes specifying what systems require submittals (e.g., windows) and test data (where appropriate).

Each submittal should demonstrate the development of a load path through the system and into its supporting element.

During submittal review, it is important for the designer of record to be diligent in ensuring that all required documents are submitted and that they include the necessary information.

The submittal information needs to be thoroughly checked to ensure its validity. For example, if an approved method used to demonstrate compliance with the design load has been altered or incorrectly applied, the test data should be rejected, unless the contractor can demonstrate the test method was suitable.

Similarly, if a new test method has been developed by a manufacturer or the contractor, the contractor should demonstrate its suitability.

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INTEGRATION Environment & Energy
Climate Change Adaptation Project (CCA), 1st Floor, Parisrama Bhavan
Fateh Maidan Rd, Basheerabagh, Hyderabad – 04, Telangana, India
www.integration.org, Tel. +91 (0)40 66184019,

Responsible
Dieter Brulez, Director, CCA