^ Majuro, Marshall Islands © ICEM, 2011

CLIMATE CHANGE ADAPTATION AND MITIGATION METHODOLOGY (CAM)

The Asia Pacific region is likely to experience significant adverse impacts from climate change. A wide range of challenges must be met, including urban and infrastructure planning, energy supply, food security, water supply and sanitation, ecological sustainability, and resilience of local communities. In response to these challenges, ICEM - the International Centre for Environmental Management has developed an integrated approach to climate change adaptation and mitigation planning and implementation – the ICEM Climate Change and Adaptation and Mitigation Methodology or CAM.

ICEM's CAM – Climate change adaptation and mitigation methodology has been developed specifically for the Asia Pacific region and has been extensively tested and adjusted in ICEM projects. The methodology combines a range of tools developed by ICEM and based on international and regional best practice, with decades of ICEM experience in integrated environment and socio-economic assessments. CAM addresses the need for a flexible and integrated approach to adaptation and mitigation planning that can be tailored to each situation and projects across all levels and systems.

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INTRODUCTION

The ICEM CAM – Climate change adaptation and mitigation methodology is an integrated approach to climate change mitigation and adaptation planning developed by ICEM. The methodology has and continues to be developed and adapted to project and case specific needs. CAM is an overall conceptual approach that has been designed to integrate a wide range of tools and processes that can be applied at different levels and stages of climate change mitigation and adaptation planning.

The CAM methodology recognises the connection between adaptation and mitigation as two sides of the same coin. Many actions achieve both adaptation and mitigation. For example, making an industry more water, energy and natural resource efficient may be an essential adaptation action that also reduces GHG emissions. ICEM aims to seek these win-win solutions where possible, however there are very distinctive technical and process requirements for adaptation and mitigation. This brief deals with adaptation with reference to mitigation where relevant – another linked ICEM brief addresses the application of CAM to mitigation.

ICEM CAM has been developed and tested in the Asia Pacific region over the past five years. It is applicable to varying assessment scales from project-specific assessments to cities and settlements to larger spatial planning such as provinces and watersheds. ICEM CAM has been applied at difference levels of focus – for example as a local community vulnerability assessment and adaptation planning process, with sector line agencies, and with provincial and district governments. Also, it has been applied to specific natural systems such as wetlands or to major infrastructure developments such as power plant complexes and roads and bridges.[1] The methodology combines international best-practice in climate change science and modelling, with best-practice in a number of rapid assessment methodologies such as Strategic Environmental Assessments, life-cycle analysis, socio-economic analysis, energy efficiency audits, risk management and participatory approaches.

1 At the project level, CAM has been piloted for a rapid climate change vulnerability assessment of the O Mon IV power station for ADB and the Can Tho Power Company. At the city level, CAM was piloted in Ho Chi Minh City with a focus on transport and energy sectors for the ADB, JIBIC and HCMC People's Committee. At larger spatial scales, CAM is currently being piloted in a basin-wide vulnerability assessment of the wetlands in the Mekong Basin for the Mekong River Commission and in five Pacific Islands Countries focusing on transport, water supply and tourism development.

GUIDING PRINCIPLES

The ICEM CAM methodology has been developed based on a series of underlying guiding principles. To ensure an integrated approach to climate change mitigation and adaptation, climate change planning and actions should:

Recognise the fundamental role of natural systems in maintaining and enhancing resilience: Recognise that healthy natural systems are a foundation for the development and wellbeing of socio-economic systems and are essential in building resilience in communities, economic sector and areas. Mitigation and adaptation actions should always contribute to ecological sustainability and social equity as well as reducing climate change vulnerability or emissions. The corollary to this principle is to ensure that adaptation and mitigation actions do not contribute to environmental and biodiversity degradation.

Recognise the cyclical and iterative nature of adaptation and mitigation: There is no permanent "fix" to climate vulnerability and adaptation responses need to be regularly adjusted based on experience and new information. It is not necessary or possible to do everything at once – priorities need to be set with less urgent measures left to later development cycles. Some things need to be done before others are possible. Adaptation is best achieved in phases.

Maximize co-benefits: Pursue synergies and opportunities to integrate adaptation and mitigation. This is not always possible, but all adaptation and mitigation actions should be assessed for their impact on resilience and reducing climate change and for their potential to reinforce each other.

Use spatial planning as the foundation for adaptation: Adaptation is best planned and achieved on an 'area wide' basis which allows for needed integration across sectors and levels of government. The opportunities for adaptation and integration become clearer when considered on a spatial basis. Even adaptation planning for organisations such as line ministries need to consider how their mandate and responses to climate change play out on the ground.

Integrate with development planning: Recognise adaptation and mitigation actions as part of development planning cycles so they become an integral part of sector socio-economic plans, budget allocation and staffing commitments. Climate change impact, vulnerability and adaptation assessments need to lock into sector and area planning steps. Separate adaptation and mitigation plans are important to build capacity and focus attention, but progressively they need to be woven into existing development plans and structures.

APPROACH TO CLIMATE CHANGE ADAPTATION

The aim of climate change adaptation assessment and planning is to reduce the vulnerability of natural, social, economic, built and institutional systems to the risks of climate change. Climate change relates to different systems in different ways. ICEM has tested and adjusted the methodology with a focus on: *natural systems, infrastructure, urban* and *rural areas and for institutions*.

Assessing the vulnerability and adaptive capacity of wetlands, forests or a coral reef complex involves a greater emphasis on the tolerance and ecology of species and habitats – as well as the special needs of local communities dependent on them.

Large infrastructure such as power plants and bridges have economic drivers with immediate cost implications if designs and operations need to be revised to cope with climate change. Developers demand precise information and a strong evidence base for projected climate and hydrological changes.

Box 1: O Mon IV rapid climate change threat and vulnerability assessment

ICEM undertook a rapid assessment of potential climate change threats to the O Mon IV combined cycle gas-fired power plant and of the vulnerability of plant design, infrastructure and operations to these threats for the ADB and Can Tho Power Company. The project tested new modelling and vulnerability analysis methods for CC assessment of large infrastructure.

The ICEM approach included climate downscaling, hydrological and hydrodynamic modelling, plant performance simulation and hydro-economic and life-cycle analyses to assess the impact of climate change on the structural integrity, performance, legal compliance and maintenance scheduling of the plant and provide recommendations on priority adaptation options. The science based approach was necessary to convince power station owners and achieve uptake.

The study found that climate change would not result in significant damage to plant assets, but that the performance and efficiency would be reduced over the economic design life. Increasing air temperature would reduce the efficiency of the gas turbines, while increasing river water temperature would reduce the efficiency of the cooling water cycle and steam turbine.

In *urban areas*, the emphasis needs to be on integrating action across sectors, such as transport, energy, health and industry. It is in *urban areas* that win-win solutions are most often found for adaptation and mitigation responses.

Whatever the focus of the CAM approach to adaptation, ICEM has defined a set of lessons which need to shape the process:

Address the adaptation deficit first (Figure 1) – or what some refer to as "no regrets" options. Addressing many day to day environmental, development and maintenance challenges can enhance resilience to future climate change. Most important it brings climate change to the immediate agenda and budgets of local planners in ways they appreciate and understand.

Box 2: The adaptation deficit

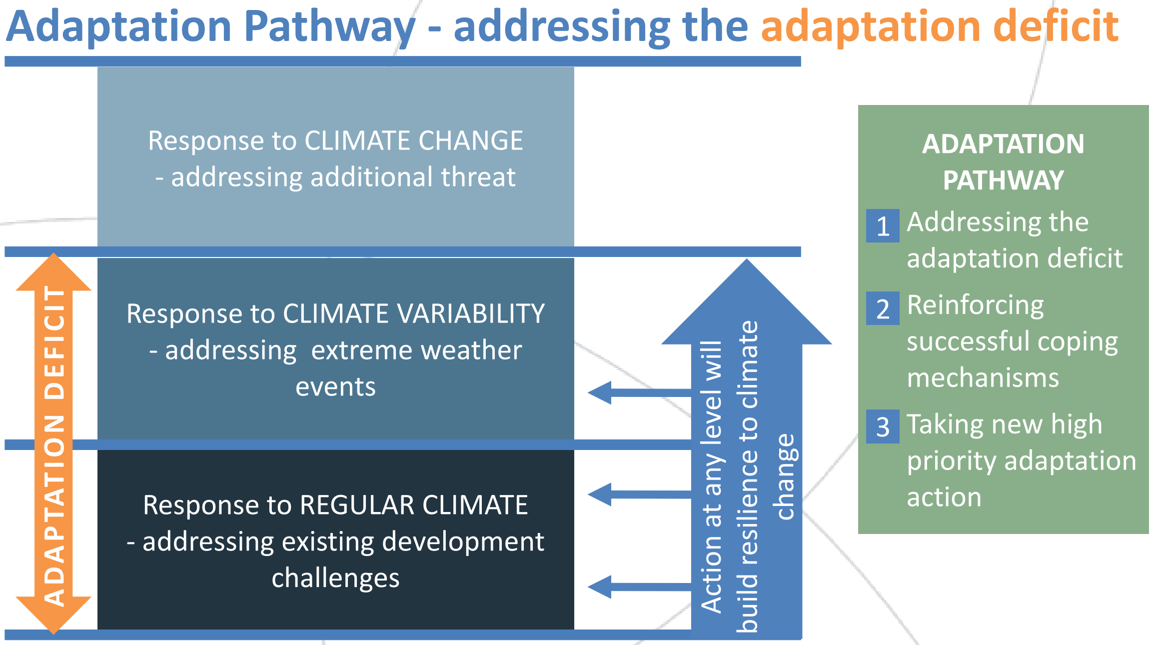
An important part of the approach to developing adaptation priorities through vulnerability assessments is addressing the *adaptation deficit.* The adaptation deficit refers to those things which need to be done to address current development problems such as rehabilitation and maintenance of water drainage systems, forest loss and soil erosion, flooding due to poor development control and land use and coastal protection.

Many actions to address current development problems will build resilience even if not specifically targeting climate change. The importance of addressing the adaptation deficit in the early stages of building resilience to climate changes is illustrated in Figure 1.

Build on understanding and documenting past extremes and trends, based on stakeholder experience, official records and expert judgment. Integrate modelling results and projections as good science evidence becomes available. In many cases available information and capacities do not allow for useful science based projections.

Emphasise adaptation action despite scientific uncertainty: There are high levels of uncertainty and variability in scenarios, models and interpretation of future threats; however, this does not mean we cannot identify trends and directions of change. We live and plan with uncertainty in every facet of human activity and climate change is no different. We need to take action in the face of scientific uncertainty.

Figure 1: Adaptation Pathway - addressing the adaptation deficit



Box 3: Action despite uncertainty

The CAM methodology is a planning response based on the establishment of a credible scientific evidence base, participatory approaches and expert judgment. There are high levels of uncertainty and variability in scenarios, models and interpretation of future threats. In response to the uncertainty, ICEM has learned that it is necessary to:

- Take a precautionary approach in managing risks associated with development.
- Understand past extreme events and trends.
- Understand past vulnerabilities and past adaptation to extreme events and regular climate.
- Concerning the future - talk in terms of trends and ranges rather than precise predictions.
- Supplement the science with expert judgement and local experience in priority setting and action.
- Use technical assessment and modelling methodologies which are consistent with those employed during conventional project design.

Focus on integration across sectors and geographic areas: Adaptation action is best implemented by integrating actions across systems, sectors and geographic areas as adaptation in one area or sector can have unwanted impacts on the resilience of others.

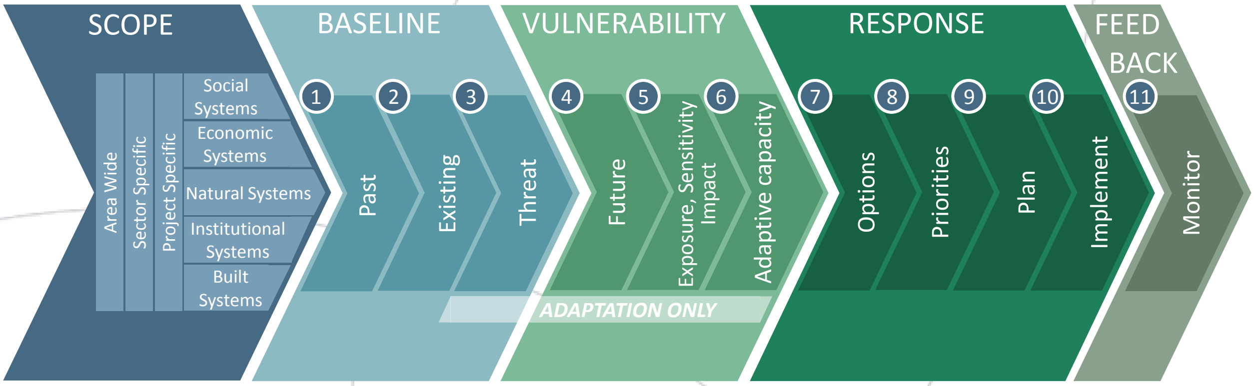
Adapt on a phased basis: Seek to implement adaptation on a phased basis so that lessons can be learned, adjustments made and one step prepares the ground for the next if required.

CAM ADAPTATION PROCESS

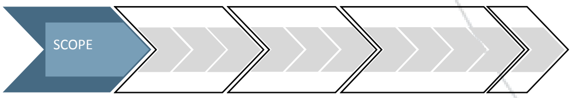
The CAM process illustrated in Figure 2 includes five primary steps for adaptation planning including:

- Determining the project **scope**, by identifying the geographic and sector focus of the assessment and the systems (natural, social, economic, institutional and built) which will be impacted.
- Conducting a **baseline** assessment to describe the past and **existing** situation, trends and drivers across each of the identified systems, projecting the changes to these systems which will occur irrespective of climate change.
- Determining the climate change **threats** through an analysis of past extreme events and trends and through climate modelling and downscaling of future climate and hydrology against various scenarios.
- **An impact and vulnerability assessment**, which includes analysis of the projected climatic threats to the target systems for defined time slices. The impact assessment combines the level of **exposure** of key system components and assets and their relative **sensitivity** to the threats. The **vulnerability** is a measure which considers the impact and the capacity of the component or asset to adapt to it.

Figure 2: ICEM CAM methodology



- **Defining adaptation responses:** this step includes developing a range of **options** for integrated adaptation interventions and then working with stakeholders to determine **priorities** – with limited resources it is not possible or necessary to do everything at once.
- **Providing feedback on the adaptation implementation**. Monitoring implementation and making adjustments and additions based on experience and new information is critical to taking a phased and systematic approach to adaptation.
- These CAM steps are described in more detail in the following sections.



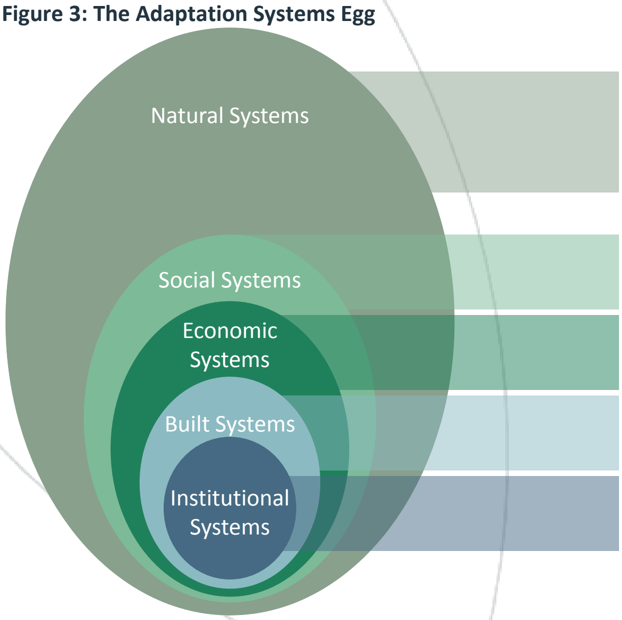
SCOPE

Across systems

ICEM developed CAM to address the effects of climate change on five system: natural, social, economic, built and institutional (Figure 3). Each system has distinct needs, relationships and challenges with respect to climate change. The CAM methodology recognises the importance of distinguishing between these systems and addressing their specific sensitivities, while maintaining a broader integrated ecosystems approach that captures the interactions between them. A range of tools is required in applying CAM to meet area and sector specific needs and for achieving the right balance between local experience, expert knowledge and a science basis for adaptation and mitigation.

Ecological or natural systems sustainability is the foundation for effective adaptation in all other systems as reflected in the adaptation "egg" illustrated in Figure 3. Adaptation action is best implemented by integrating actions across systems. Understanding the characteristics of each system and their interrelationships is a prerequisite for defining an effective adaptation plan.

Figure 3: The Adaptation Systems Egg



Across levels

In the CAM methodology, planning and action is also filtered through **area**, **sector** and **project** levels to sharpen the scope and targets of the vulnerability assessment and adaptation. At each step in the CAM process, the scope can be refined across these levels to apply scarce resources to the most vulnerable and highest priority assets and to help define a phased approach to adaptation (Figure 4).

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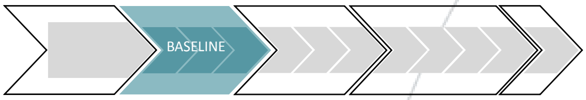
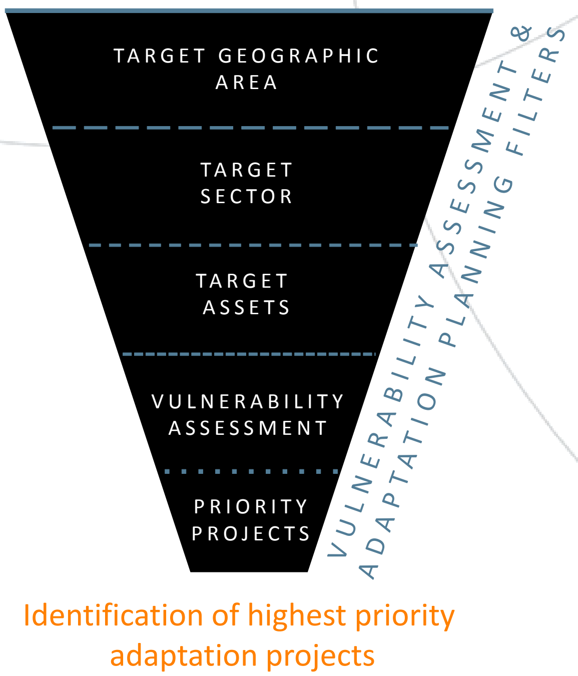


BASELINE ASSESSMENT

The baseline phase of the CAM methodology establishes an understanding of past and present status and trends in natural, social, economic, built and institutional systems linked to the target area, sector or institution. The baseline includes a review of existing management and system initiatives, which may provide the basis for adaptation measures.[2] Climate change response is not starting from scratch – many elements in existing policies, institutional arrangements and programs are consistent with needed adaptation. They may relate, for example, to poverty reduction, disaster management and agricultural cropping innovations addressing existing stresses such as saline intrusion.

Figure 4: Adaptation planning filters



Major challenges at the baseline stage are gaining access to data required on past, existing and future plans and experience and in projecting forward past trends taking key drivers into account.

Carefully documenting and mapping past extreme events and their impacts as well as climate trends is a much neglected but essential part of the baseline assessment. In the absence of systematic official records, this process becomes one of recording stakeholder experiences and anecdotal evidence.

Box 4: Climate change impact assessment and adaptation in Ho Chi Minh City, Vietnam

ICEM completed this study for ADB as part of a collaborative assessment with the WB and JBIC on the impacts of climate change on four major Asian coastal cities – Bangkok, HCMC, Mandalay and Manila. The study – the first of its kind in the region – conducted localised climate and hydrological modelling of IPCC climate change scenarios to estimate the risk and associated social, environmental and economic impacts, as well as assessing possible adaptation options and implementation arrangements. ICEM is conducting a follow up project in HCMC and Danang (2012-2014) to implement key recommendations relating to adaptation in the transport and power supply sectors, and to urban planning.

The information on past extremes and impacts and on projections of future climate and linked hydrological changes need to be expressed in terms which are of practical use to development planners – for example, maps of extent of flooding, saline intrusion and land degradation under difference scenarios (Box 5). ICEM has found that planners have difficulty in using past or downscaled future temperature and rainfall data alone.

Box 5: Definitions of threats by Palau national team in conducting a CAM vulnerability assessment for Melekoek State

These threats are assumed to be accompanied by an extreme high tide:

- **Storm surge** – offshore depression leading to high waves of greater than 1m and an increased sea level
- **High intensity rainfall and flooding** – rainfall of extreme intensity of greater than ?mm/hour. This includes the resulting flash flooding and pooling.
- **Sea level rise (2030)** – incremental increases in sea level of 20-30 cm by 2030-2050 (IPCC, 2007)
- **Typhoon (Tropical Storm)** – a combination of intensive rainfall, storm surge, high winds.
- **Extreme drought** – periods of unusually low rainfall.
- **Temperature increase** – air temperature is projected to increase by 2oC by 2050 and sea temperature

Looking to the future – downscaling climate change and then modelling its implications for hydrology is a specialist field. ICEM provides that service working

2 An example of existing adaptation measures is the MARD policy for the Mekong Delta in Vietnam of "living with floods". This policy informs rural land-use zoning to encourage agricultural practices and flood relief areas which enhance resilience.

with local scientists. The ICEM tool kit for making those projections is introduced later in this brief and detailed in a separate ICEM technical paper. In most countries there are significant capacity limitations in conducting this modelling and projections and in linking it effectively with adaptation and development planning at local and sector level. The ICEM CAM process is flexible – it can be applied relying mostly on past extremes and trends.

Some national teams using CAM prefer to focus on documenting the past in the baseline assessment and leaving modelling and projection of future conditions and trends to the next phase – the vulnerability assessment.

IMPACT AND VULNERABILITY ASSESSMENT

There are two distinctive components in this phase of the CAM method – impact assessment and defining the final level of vulnerability of the target assets and systems to the projected threats.

The potential **impact** (or level of risk) is a function of the level of **exposure** to climate change induced threats, and the **sensitivity** of the target assets or system to that exposure.

Box 6: Strengthening the capacity of Pacific Developing Member Countries to respond to climate change

In this ADB regional project, ICEM developed climate change adaptation investment packages for Fiji, Marshall Islands, Palau, Solomon Islands and Timor L'este. The planning process in each country included a baseline assessment, a climate change impact and vulnerability assessment, and the identification of adaptation options and priorities in line with national strategies.

A key component of the project was the use of a **vulnerability assessment matrix** (Table 1 illustrates the matrix completed for a strategic culvert in Honiara, Solomon Islands). The assessments were informed by the best available knowledge and expert judgements. The depth and coverage of the scientific evidence base for the VA varied for each of the countries and included analysis of past extreme events, GIS mapping and analysis, topographic surveys, biological surveys and community vulnerability assessment. Also, available information on climate change projects was summarised as an input in defining future threats.

Exposure

Exposure is the *degree of climate stress on a particular asset; it is influenced by long-term changes in climate conditions, and by changes in climate variability, including the magnitude and frequency of extreme events*. The nature and extent of the exposure is a key concern. With regard to a flooding event, for example, the exposure of assets may be determined by the depth, duration and speed of floodwaters. For drought, the exposure of a crop will be influenced by duration and severity. The following criteria influence exposure:

- Duration (e.g. hours or days of flooding)
- Location (e.g. distance from flood)
- Intensity (e.g. strength of rainfall, speed of flood)
- Magnitude (e.g. volume, flow or size of event)
- Aspect (orientation to the threat – e.g. wind and waves)

Sensitivity

Sensitivity *is the degree to which a system will be affected by, or responsive to climate change exposure*. With regard to a flood event, for example, sensitivity may be understood in terms of the level of disruption such as the value of the damage and/or length of time it takes to return to the pre-flood state – a wooden house may be more severely damaged by flood exposure than a cement dwelling. For infrastructure, sensitivity is the degree to which the exposure to a threat will negatively affect the integrity or operation of the asset. The following variables affect infrastructure sensitivity:

- Materials
- Construction quality
- Levels of maintenance
- Protective system (e.g. river wall protecting the water transmission pipe)
- Design (including safety margins)

Sensitivity in communities and families is affected by the level of education and income level, access to government support, mobility, health and social networks and support structures. Sensitivity in environmental and natural systems is influenced by, for example, the biological response to temperature change, tolerance of drought conditions, capacity for regeneration, the degree of connectivity and diversity and size of habitats.

Impact

The CAM vulnerability assessment matrix involves stakeholders in: (i) defining the main assets/system components at threat and (ii) the main climate change threats. It then has them using Table 2 as a guide in deciding on: (iii) the level of exposure and (iv) level of sensitivity. The level is set using science-based information and supplemented through expert judgement. Table 2 is also a guide to the final projected impact of a threat on an asset given the assessed levels of exposure and sensitivity.

Adaptive capacity

The next step in applying the CAM methodology is to determine the adaptive capacity of the system or assets to the impact. Adaptive capacity is understood in terms of the ability to prepare for a future threat and in the process increase resilience and the ability to recover from the impact.
Determinants of adaptive capacity include:

Cross cutting factors

- The range of available adaptation technologies
- Availability and distribution of financial resources
- Availability of relevant skills and knowledge
- Management, maintenance and response systems including policies, structures, technical staff and budgets
- Political will and policy commitment

Infrastructure

- Availability of physical resources (e.g. materials and equipment)
- Backup systems (e.g. a plan B)

Social Factors

- Social networks
- Insurance

Natural Systems

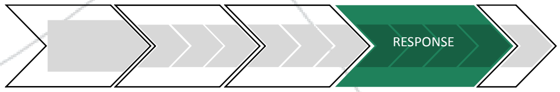
- Species diversity and integrity
- Species and habitat tolerance levels

Table 3 assists in defining the adaptive capacity. For example, a low adaptive capacity would imply a limited institutional capacity and limited access to technical and financial resources.

Determining vulnerability

Table 3 provides the key for combining the impact with adaptive capacity to define vulnerability. .

A vulnerable system is one that is sensitive to changes and extremes in climate and hydrology and one for which the ability to adapt is constrained.



ADAPTATION RESPONSE

The next phase of the CAM process involves: (i) identifying adaptation options to address the vulnerabilities of strategic assets and systems, (ii) choosing between them, and then (iii) drawing up adaptation plans and projects (Figure 5).

Table 1: VA Matrix Lungga River Catchment – Solomon Islands – the example of Burns Creek Culvert

Component or asset	Threat	Exposure	Sensitivity	Impact Level (Exposure & sensitivity)	Impact Summary	Adaptive Capacity *(consultation /expert assessment)*	Vulnerability *(impact and adaptive capacity)*
Burns Creek Culvert/Bridge	High intensity - flash flood	Low	Medium	Medium	Bridge is in a lowland area, flash floods will be dissipated except for when debris blocks the channel	Low	Medium
	Localized flooding/pooling	High	High	High	Pooling occurs on the roads surrounding the culvert, access roads may be flooded, overtopping may occur	Low	High
	Storm surge/coastal flooding/saline intrusion	Low	Low	Low	2 km from the coast, but the land is very flat between the coast and the bridge	Low	Medium
	Large scale extreme flooding	Very High	High	Very High	Flood will block all transport, pavement may be stripped, road washout likely	Low	Very High
	Extreme drought	Very Low	Very Low	Very Low	No significant effects	Low	Low
	Increased temperature (~2°C)	High	High	High	Road pavement sensitive to temperature	Low	High

Table 2: Climate change impacts matrix for climate change threats to a system

Sensitivity of system to climate threat	Exposure of system to climate threat: Very Low	Low	Medium	High	Very High
Very High	Medium	Medium	High	Very High	Very High
High	Low	Medium	Medium	High	Very High
Medium	Low	Medium	Medium	High	Very High
Low	Low	Low	Medium	Medium	High
Very Low	Very Low	Low	Low	Medium	High

Table 3: Determining vulnerability

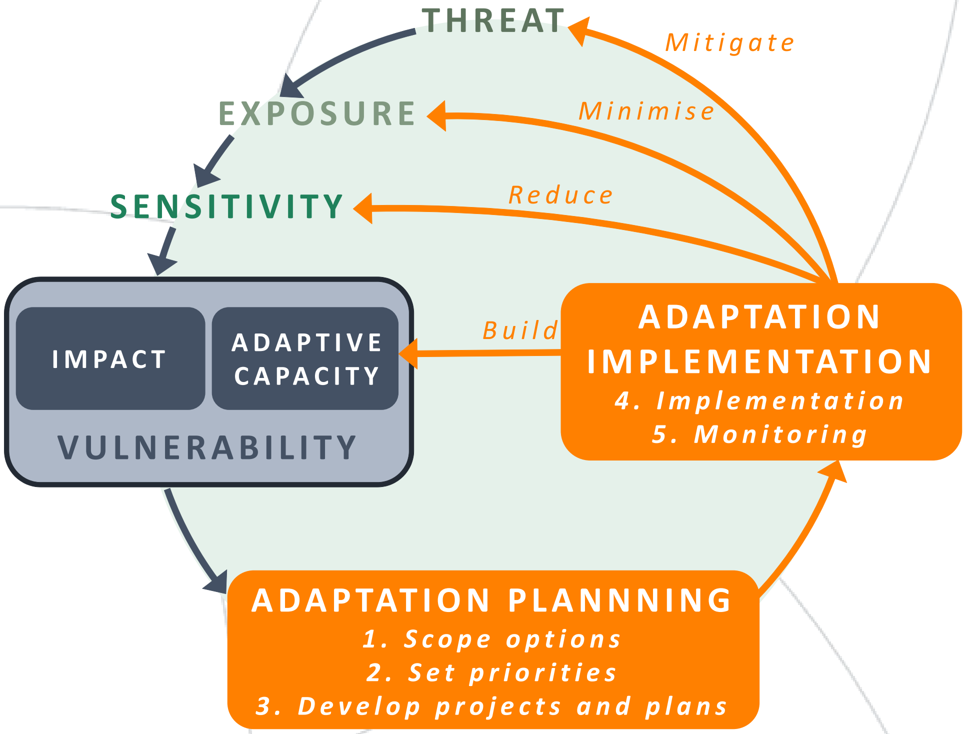
Adaptive Capacity	Impact: **Very Low** Inconvenience (days)	**Low** Short disruption to system function (weeks)	**Medium** Medium term disruption to system function (months)	**High** Long term damage to system property or function (years)	**Very High** Loss of life, livelihood or system integrity
Very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

Defining adaptation options: Adaptation builds climate change resilience in communities, sectors and areas. Opportunities for increasing resilience (i.e. for reducing vulnerability) through adaptation can be found in natural, built, social, economic and institutional systems, for example:

- Engineering options (e.g. flood protection dykes, sea walls and effective drainage systems)
- Traditional local strategies (e.g. terracing and selection of crops)
- Social responses (e.g. resettlement and migration)
- Land use planning (e.g. zoning and development controls)
- Economic instruments (e.g. subsidies and tax incentives)
- Natural systems management (e.g. rehabilitation, conservation, watershed management)
- Sector specific adaptation practices (e.g. agriculture - species, cropping patterns)
- Institutional options: associated policy, institutional and administrative innovations

In most cases, an effective response requires an integrated set of adaptation actions across those fields of management so that one reinforces the other. It is also desirable to analyse how an action will modify vulnerability – either by minimising exposure, reducing sensitivity or by building adaptive capacity, as illustrated in Figure 5.

Figure 5: Adaptation responses and feedback



Listing adaptation options requires the involvement of a cross sectoral group of specialists as well as other affected stakeholders – often it is a matter of identifying what has worked best in the past as well as learning from international experience.

Setting adaptation priorities:

CAM teams need to keep foremost in mind that it is not necessary to do everything at once – some investments need to be made now, leaving others for future financing. Sharp priorities for action are required which are within available funds, and which address vulnerabilities in the assets and systems of strategic importance to the target area, sector or community.

Some measures should lay the foundation for future adaptation investments and facilitate future additions and modifications as climate continues to change.

Phasing of adaptation options

CAM teams should plan to phase adaptation so that funding at each stage is not prohibitive and prove to be an obstacle to action as illustrated in Figure 6. It is best to start by addressing the adaptation deficit. – that is all those things which need to be done to address current development problems such as rehabilitation and maintenance of water drainage systems, forest loss and soil erosion, flooding due to poor development control and land use and coastal protection. Many actions to address current development problems with existing and variable climate will build resilience even if not specifically targeting climate change.

Figure 6: Phasing of adaptation measures

SHORT TERM	MEDIUM-LONG TERM	LONG-TERM
Operational and maintenance responses	Retrofitting and rehabilitation of existing infrastructures	Infrastructures retirement and new development Protective infrastructures Climate-appropriate energy & transport infrastructures

The CAM tool box has various methods for facilitating the identification of sharp priorities for action endorsed by key stakeholders.

A simple method is based on group consensus guided by criteria, expert opinion and the results of the vulnerability assessment. Criteria for priority setting may include:

- Government commitment through:
  - Policy (e.g. national or sector climate change policy)
  - National or local government strategies and plans

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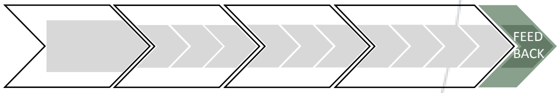
  – Government guidelines and procedures (e.g. road and drainage design code, code of logging practice)
- Effectiveness in addressing the adaptation deficit
- Urgency for action in addressing the impact of climate change
- Number of people benefiting
- Strong community support
- Available resources for implementation
- Commitment of local government and relevant sector agencies

Preparing adaption plans & projects

There are a number of options available for developing climate change adaptation projects:

- Designing now to withstand conditions at a defined future time slice under a projected scenario. This comes with a significant upfront cost but may not require future investment.
- Plan to progressively upgrade the project design throughout its implementation life as climate change occurs. The initial design should be immediately functional and anticipate modifications over its life span. A good example is building a sea wall foundation so that it can support incremental increases in wall height as they become necessary. This approach comes with increased flexibility but requires more substantial upfront costs, ongoing monitoring and capital upgrades at the times designated in the original design.
- Redesign and reconstruct as required in response to threshold events being reached, such as when sea level reaches a pre-determined level. The infrastructure may need to be re-designed to avoid catastrophic failure. This is potentially an expensive approach.
- Accept damage and repair it as it occurs, this approach does not consider climate change at the design phase and reconstruction would be required after a major event. This is the cheapest up-front option but comes with the largest risk and potential cost.

The CAM method advocates the "plan to progressively upgrade" approach, but acknowledges that budget and capacity constraints often makes the upfront investment in preparing for the future a challenge. Adaptation plans should include a framework for monitoring and adjustment against projected climate change.



ADAPTATION FEEDBACK

Figure 7 illustrates the cyclical nature of the adaptation planning process. It needs to be locked into and integrated with normal socio-economic development planning processes so that budgets and staff are committed to adaptation on a regular basis and as a foundation requirement.

The climate change focal point and facilitator in national and local government (usually the environment agencies) has a central responsibility for ensuring adaptation plans are implemented effectively.

Climate change screening procedures need to be introduced at three review levels: (i) as part of the normal review of sector and local government draft development plans, (ii) in the Strategic Environmental Assessment of plans and (iii) in Environmental Impact Assessment of projects. Progressively, the sector and local government implementing agencies need to take on the responsibility for review and adjustment to their own adaptation plans.

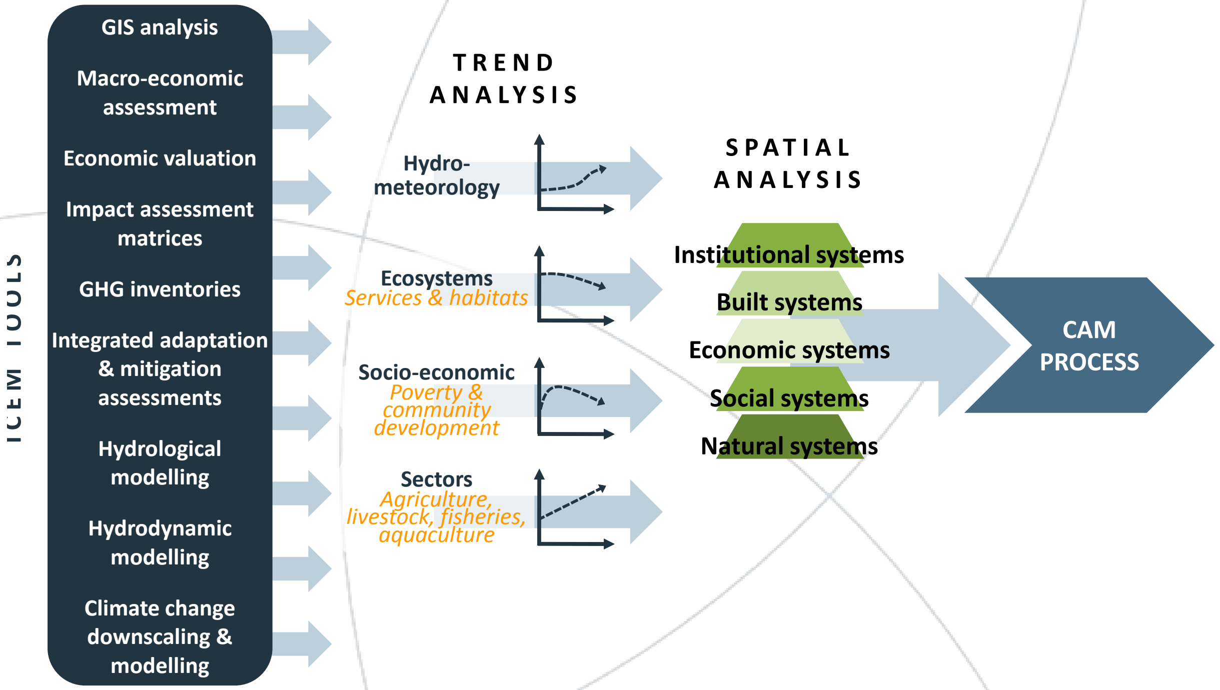
Box 7: Mekong Delta bridges rapid climate change threat and vulnerability assessment

ICEM's assessment for ADB of potential climate change impacts to the Cao Lanh and Vam Cong Bridges and connecting road is the first climate change assessment in the Mekong region to be undertaken concurrent with the detailed design phase of major infrastructure – allowing recommended adaptation options to be integrated into the project life-cycle at the outset.

The study utilises climate data from 6 Global Circulation Models (GCMs) downscaled using statistical techniques to quantify the changes in 14 hydro-physical parameters which have been identified as critical for the project site context. A review of the bridge and road design identified 11 main infrastructure components as being sensitive to climate change and the CAM vulnerability assessment framework was applied to quantify the impact of climate change on each component.

Central to the study was the use of Cost-Benefit Analysis and Cost-Effectiveness analysis as economic tools to quantify the cost of climate change, and the benefits of adaptation over the design life (100 years). Based on this quantification of impact, the study supported the ADB to source funding to cover the cost of adaptation from available funding streams.

Figure 7: Integration of ICEM toolbox and CAM



The CAM method is linked to the ICEM environment assessment tools and approaches to support governments in integrating climate change provisions into the review and monitoring process.

TOOLS SUPPORTING THE CAM PROCESS

A number of tools have been developed by ICEM that are an integral part of the CAM methodology. They are described in a separate ICEM brief. The tools have been developed through specific climate change assessments and are based on international and regional best practice. The integration of these tools with the CAM methodology is illustrated in Figure 7. Key ICEM climate change adaptation tools include:

Climate change downscaling and modelling: The downscaling of predicted climate change and GCMs enable spatial assessment to quantify future climate, using both statistical and dynamic approaches. ICEM uses multiple GCMs and multiples downscaling techniques in all of our assessments so that results reflect the range of impact predicted with climate change and results can be separated from errors and uncertainties inherent with each individual modelling approach.

Hydrological modelling: One of the most important effects of climate change is on hydrological processes and a reason why ICEM links projected climate changes with hydrological analysis. Hydrological modelling is used in developing baselines and assessing changes in basic hydro-physical process of the global water cycle, including precipitation, hill slope run-off sub-surface infiltration and groundwater interactions, stream flow and water levels, and sediment transport. The ICEM–IWRM model is a physical model which provides an advanced GIS-compatible framework for integrated modelling of water resources and water utilisation in both local and basin-wide scales.

Hydrodynamic modelling: Enables threats to be quantified. By running detailed 3-D models of lakes, deltas, river channels, floodplains and coastal areas it is possible to quantify erosion, sediment dynamics, saline intrusion, stratification of the water column, nutrient transport pathways, water quality, and productivity. Hydrodynamic modelling can also be applied to atmospheric environments for 3-D analysis of pollutant dispersion and emissions modelling.

GIS analysis: ICEM has developed GIS techniques for assessing the impacts of climate change and development, including zone of influence mapping, sectoral overlays, hot spot mapping and vegetation/land use identification mapping using satellite imagery. All modelling tool outputs and socio-economic analysis can be linked directly to GIS analysis making it the interpretive core of the

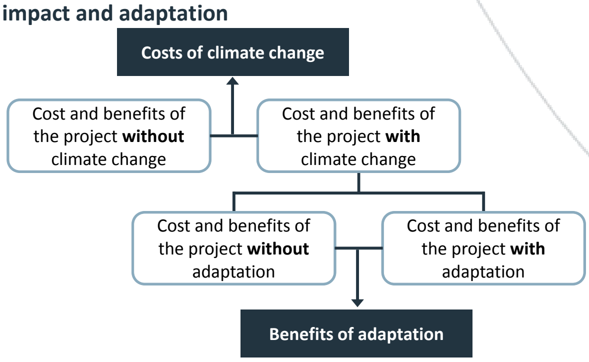
ICEM integrated assessment and visualization methodologies.

Macro-economic assessment and economic valuation: Macro-economic assessment examines the effects of climate change on individual sectors and the economy and cross sector implications of adaptation options. Economic valuation assesses impact costs and compares adaptation options through Cost-Benefit Analysis, Cost-Effectiveness Analysis, sensitivity analysis and trend analysis.

Economic assessments of climate change serve to justify appropriate adaptation response and identify the investment required to make adaptation effective. For built systems and sectors, Economic assessments need to cover two critical steps (Figure 8):

- **Establishes the costs of climate change with respect to the project:** comparison of the net present value (NPV) of the project without climate change to the NPV for the project with climate change, the difference between the former and the latter represent the costs (or benefits) of climate change.
- **Determining the benefits of adaptation:** comparison between the NPV of the project with climate change, but without adaptation, and the NPV of the project with climate change and with adaptation

Figure 8: Economic assessment of climate change impact and adaptation



Integrated spatial assessment: Dyna-CLUE is a practical integrated assessment model, designed for undertaking integrated spatial assessments and suited to focused climate change assessments for specific regions. The central core of the model is spatial land use projections capable of integrating demand for different land uses, location conditions (including climate change) and policy scenarios. The model output can be read directly by various indicator models to assess the environmental consequences of the simulated changes.

Impact assessment matrices: Impact assessment matrices for climate change allow the prioritising and weighting of options and recommendations. They are technical and capacity building tools that promote ownership by stakeholders of process and its results.

Box 8: Basin-wide climate change impact and vulnerability assessment of wetlands in the lower Mekong basin

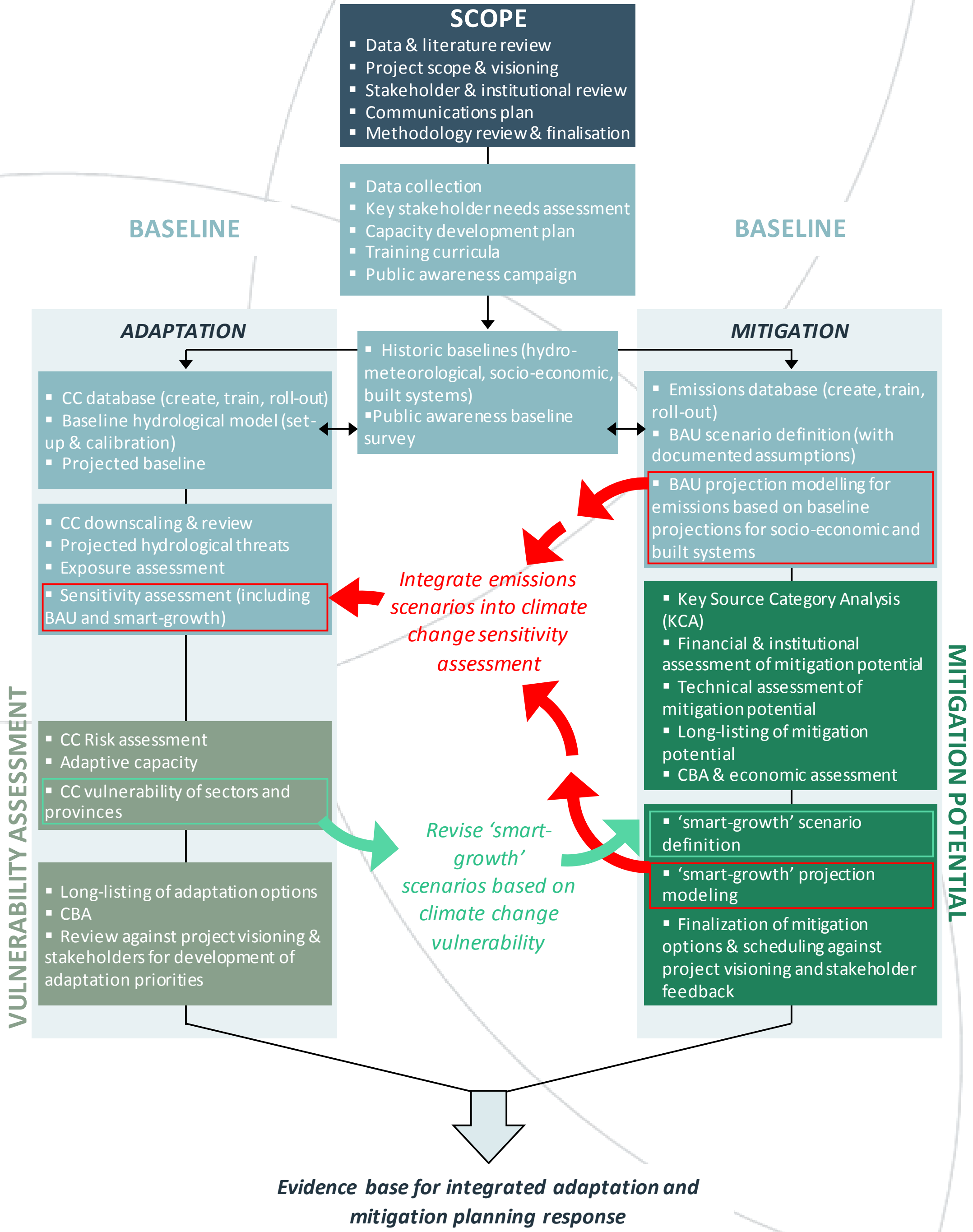
MRC commissioned ICEM to conduct a climate change impact and vulnerability assessment of Lower Mekong Basin wetlands and provide adaptation options and recommendations for their management. The study required developing a scientific evidence base and rapid spatial assessment methods for climate change vulnerability assessments of natural systems. ICEM demonstrated the process and benefits of a geo-spatial analysis, allowing the transfer of scientific findings to basin, sub-basin and local levels.

Integrated adaptation and mitigation assessments: Figure 9 shows how adaptation and mitigation is linked in the CAM process. It is included here as the bridge between this ICEM brief and its twin which focuses on mitigation. ICEM CAM tools which address mitigation include:

GHG inventories: Developing GHG inventories can uncover the most significant emissions sources and trends and allow the development of policies and programs, which can maximise potential GHG reductions while minimising costs. Well-established approaches to emissions inventories at national and sectoral levels are clearly defined in IPCC guidelines and for project and organisational level emissions in ISO14064.

Emissions projections are usually conducted with specially designed software packages. SEI's Long-range Energy Alternatives Planning System (LEAP) is an integrated scenario-based energy and environment-modelling tool. LEAP can account for how energy is consumed, converted and produced in an energy system under a range of assumptions including population, economic development, technology and price. This software is an integral part of developing cost estimates and abatement cost curves for projects as well as performing sensitivity analysis.

Figure 9: Integrating Adaptation and Mitigation Planning – building the scientific evidence base for climate change response and action planning



This ICEM *Climate Change Adaptation and Mitigation Methodology Brief* has been developed and tested in ICEM work in the Asia Pacific region over the past five years. ICEM briefs contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues.

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