Climate change REsilience framework for health SYStems and hospiTALs

DA2.3 - [Guidelines to Develop Adaptation Pathways]	
Contractual Delivery Date: 30/06/2022	**Actual Delivery Date**: 02/09/2022
Type: Report	**Version**: v1
Dissemination Level: Public Deliverable	

LIFE RESYSTAL is a project that has received funding from the LIFE programme, the EU's funding instrument for the environment and climate action, under grant agreement LIFE20 CCA/GR/001787.

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Document Log			
Issue	**Date**	**Comment**	**Author / Organization**
V0.0	18/08/2022	Draft version submitted for review to all partners	ACTERRA
V1.0	02/09/2022	Final version	ACTERRA

Executive summary

This deliverable lays out a methodology to develop and envision adaptation pathways relevant for healthcare facilities and health systems, which will be used for the development of an adaptation planning web-based decision-making support system[1] (DC1.4). The methodology and the decision support system should support hospitals and other healthcare facilities elaborate and operationalize their climate adaptation strategy.

6 steps to elaborate an adaptation strategy are proposed:

- Step 0: Mobilize stakeholders and advance a roadmap
- Step 1: Identify the main climate-related risks, the risk levels, and associated thresholds
- Step 2: Set the adaptation objectives/desired vision
- Step 3: List and assess adaptation measures (including through a cost-benefit analysis)
- Step 4: Co-construct the adaptation pathway map
- Step 5: Climate adaptation plan and next steps for implementation.

These methodological steps proposed will probably need to be adjusted in order to reflect the specificities of healthcare facilities and of the healthcare sector at large which will be considered after the testing phase of the tool is completed. Nonetheless, the methodology proposed is conceived as being adaptable to any context, sector, or scale of implementation.

[1] For a brief description of the decision support system, we refer to deliverables A3.1 “Design of the local toolbox” as well as to the specification document included as annex of the present report.

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Table of abbreviations	
Abbreviations	**Meaning**
CCA	Climate Change Adaptation
CoP	Community of Practice
HCWHE	Healthcare Without Harm Europe
NCSRD	National Center for Scientific Research Demokritos
RCP	Representative Concentration Pathways
SSP	Shared Socioeconomic Pathways
UCAM	University of Cambridge

Introduction

This deliverable lays out a methodology to develop and envision adaptation pathways relevant for healthcare facilities and health systems, which will be used for the development of an adaptation planning web-based decision-making support system[2] (DC1.4). The methodology and the decision support system should support hospitals and other healthcare facilities elaborate and operationalize their climate adaptation strategy.

This deliverable draws on past experience of ACTERRA in developing adaptation pathways in other sectors – including water management and agriculture – as well as for the advancement of climate adaptation territorial strategies[3]. It relied also a literature review (see annex for more information) of other adaptation pathway methodologies, including the ADEME[4] TACCT Methodology (Climate Adaptation Pathways for Territories) and the Climate Risk Ready Guide for the New South Wales Government, Australia. No methodology to develop adaptation pathways specifically targeting healthcare facilities was identified.

During and after the testing phase of the methodology (after 02/2023) the methodological steps proposed will probably need to be adjusted in order to reflect the specificities of healthcare facilities and of the healthcare sector at large that have not been considered – or to a limited extent – at this stage. Nonetheless, the methodology proposed is conceived as being adaptable to any context, sector, or scale of implementation.

Adaptation and adaptation pathways

In its Special Report on the impacts of Global Warming of 1.5°C above pre-industrial levels[5], the IPCC defines adaptation as follows:

"In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects."

In climate science, adaptation aims therefore to **anticipate** climate change effects to reduce their impact on natural systems and society. Adaptation is not just a series of measures implemented over time once we observe the impacts of climate change (which refers more to increasing **coping capacity**). The objective

[2] For a brief description of the decision support system, we refer to deliverables A3.1 "Design of the local toolbox" as well as to the specification document included as annex of the present report.
[3] Including the methodology produced by ACTERRA for the EU/LIFE-funded project "LIFE Eau&Climat - Supporting long-term local decision-making for climate-adapted Water Management (LIFE19 GIC/FR/001259)" and EU/H2020-funded project "TransformAr - Accelerating and upscaling transformational adaptation in Europe: demonstration of water-related innovation packages" (H2020 grant no. 101036683).
[4] French National Agency for Ecological Transition
[5] IPCC, 2018: Annex I: Glossary, p. 542 [Matthews, J.B.R. (ed.)]. In: Global warming of 1.5 °C: an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor and T. Waterfield (eds)]. In Press. Link: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf

is in fact to avoid going from an emergency management decision to another. Adaptation is about **planning upstream**, through an identification of the main climate risks on a given system – in our case, a healthcare facility –as well as of actions needed to limit the exposure and the vulnerability of this system to increase its climate resilience.

To increase the climate resilience of a system, a two-phased approach can be considered, including the development of:

- A **climate risk assessment** which makes it possible to assess the consequences of climate change considering the characteristics of the system in question and climate change projections. The methodology for the climate risk assessment is presented in **Deliverable A2.2 "Guidelines to develop vulnerability and risk assessment"** (drafted by NCSRD).
- An **adaptation strategy and action plan** to limit the negative impacts of climate change and profit from opportunities that may arise, while increasing the robustness of the studied system, on **which this deliverable focuses.**

Types of adaptation

The IPCC (IPCC, 2018) distinguishes two climate adaptation approaches:

- **Incremental adaptation which secures the continuity of the system in question** in the face of changing contexts and uncertainty[6] by anticipating climate change impacts. Applied to healthcare facilities, incremental adaptation means focusing on maintaining and increasing the capacity of a given facility, to deliver quality healthcare for everyone as well as to reduce the vulnerability of its community by dealing with other determinants of health (see figure below).

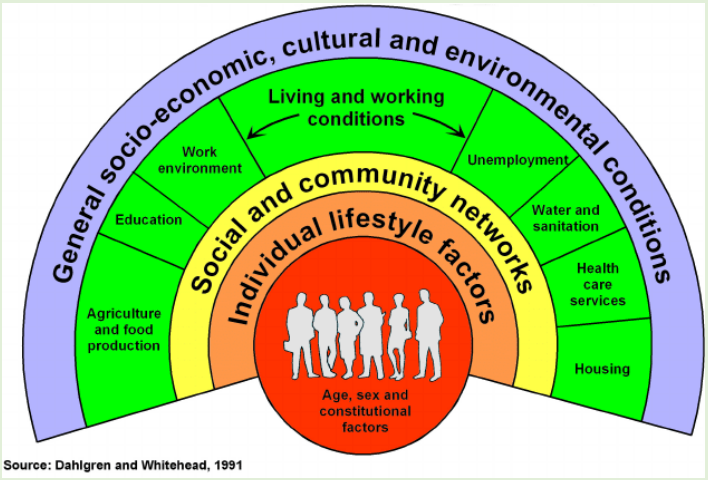


Figure 1 Rainbow model of the determinants of health

- **Transformative or transformational adaptation** encompasses actions that alter the fundamental attributes of a socio-ecological system while anticipating climate change. Transformative adaptation may be an appropriate response to climate change when the severity of climate change impacts is expected to considerably increase, when current

[6] Loginova, J., & Batterbury, S. (2019). Incremental, transitional and transformational adaptation to climate change in resource extraction regions. Global Sustainability, 2, E17. doi:10.1017/sus.2019.14

adaptations are reaching limits, or when radical climate-driven changes have already happened, hence it refers usually to actions to be implemented in the medium to long run. Applied to healthcare facilities, the concept of transformative adaptation may suggest that the hospital would need to be relocated to an area less exposed to climate risks, that new approaches to healthcare provision (such as teleconsultation) could be proposed to patients, or that other healthcare service providers may be more relevant in some cases (such as primary care services).

Anticipating the impacts of climate change is not an easy task. Indeed, the notion of uncertainty is inherent in the effort of climate modeling and therefore in the field of climate change. Uncertainties of climate projections are of three types:

- **Linked to interannual climate variability and exceptional events** (such as volcanism): these uncertainties are predominant in the short term (difficulty predicting the exact climate for next year); their influence is relatively weak in the medium and long term (horizon 2050 and 2100).
- **Linked to the models:** these are the main uncertainties in the medium term (the 2050 horizon which has been retained in the context of this study). They are due to the differences between the different sets of existing models: the models are probabilistic representations of possible futures and may diverge on certain points.
- **Related to prospective scenarios (Representative Concentration Pathways – RCP / Shared Socioeconomic Pathways – SSP):** these are the main long-term uncertainties (horizon 2100). The future consequences of climate change will depend on the choices that humanity makes today: the rapid implementation of ambitious climate policies could limit the impacts of climate change while the laissez-faire scenario would exacerbate them. In the medium term (horizon 2050), the differences between these different scenarios are relatively limited. However, the decision made now will effect what pathways remain feasible in 2050.

The challenge of an adaptation strategy is therefore to be able to integrate flexibility into the way of choosing and sequencing adaptation actions over time, which offers the notion of “adaptation pathways”.

The notion of “adaptation pathways”

Adaptation pathways can be described as “sequences of actions, which can be implemented progressively depending on how the future unfolds and the development of knowledge” (Werners et. al, 2021). Adaptation trajectories can be likened to a **roadmap**, representing several possible routes for adapting the system in question – the healthcare facility in our case – in the short, medium, and long run.

Adaptation pathways is an emerging concept, which started to be conceptualized in the 2010s (Werners, et al., 2021). Its main interests are that (i) it addresses one of the major issues faced by decisionmakers when it comes to climate change, namely uncertainty; (ii) it accounts for long term change and prevent decisionmakers from taking decisions now which could potentially have lock-in or maladaptive consequences, while making them consider the potential need for transformational actions (Werners, et al., 2021). As such it represents **a shift in the understanding of climate change**

adaptation from predicting impacts to understanding dynamic decision processes and adaptive management.

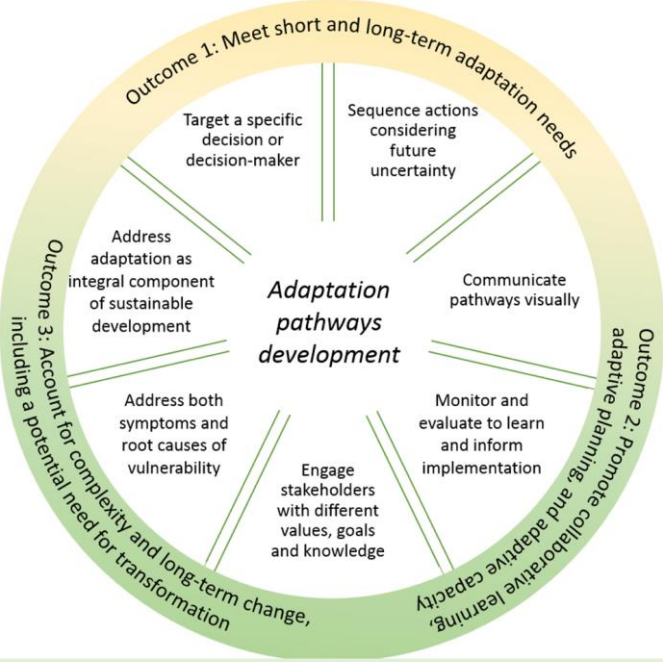


Figure 2 Adaptation pathways development (Source: Saskia E. Werners et. al. (2021) Adaptation pathways: A review of approaches and a learning framework, Environmental Science and Policy 116 (2017), 266-275)

Requirements: the development of climate adaptation pathways is context specific. Depending on the context, it would require a strong engagement and mobilization of stakeholders and/or a solid **monitoring / data collection system** in place.

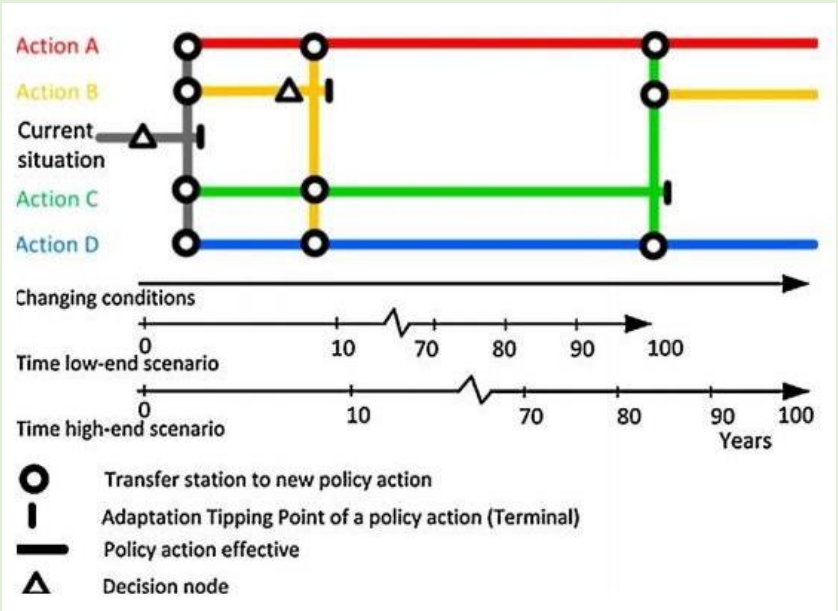


Figure 3 Typical adaptation pathways map (Source: Adapted from Zandvoort et al. (2017): Adaptation pathways in planning for uncertain climate change: Applications in Portugal, the Czech Republic and the Netherlands. Environmental Science and Policy 78 (2017) 18–26.)

Graphic display: Adaptation pathways can be presented in the form of an "adaptation pathway map" (see figure 3). Each adaptative pathway specifies which measure(s) are to be taken right away **('no or low regrets'** interventions) and which are planned to be implemented once certain conditions occur (i.e., once specific adaptation **decision nodes** are reached). It also visually presents when the measures are no longer valid (i.e., when they have reached their "**tipping point**").

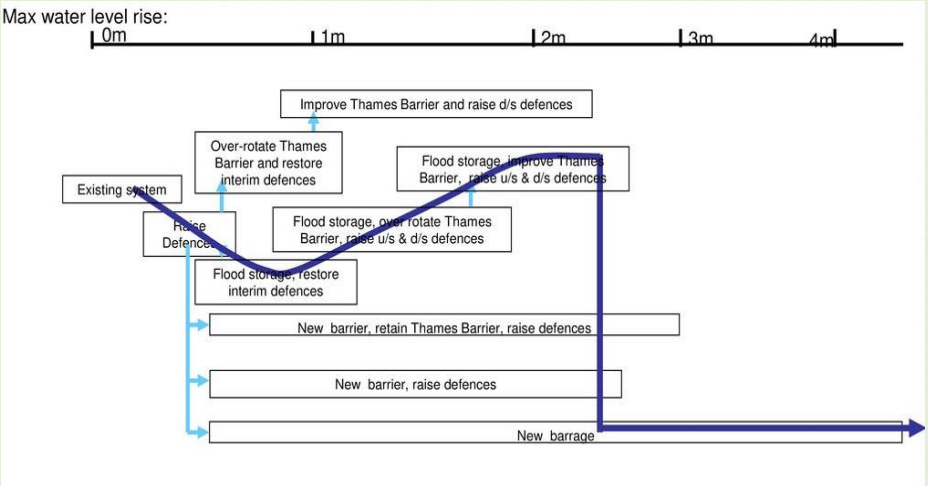


Figure 4 Example of an adaptation pathway from the adaptation scenarios of the Thames Estuary in the United Kingdom. From "Rethinking adaptation for a 4°C world" M.S.Smith, L Horrocks, A. Harvey, C. Hamilton, 2011.

A seminal study: In the example from the UK Thames Estuary adaptation scenarios, actions are placed on the map according to the sea level for which they are relevant (figure 4). The light blue arrows show the sequencing possibilities between actions. The navy-blue arrow represents a possible path, i.e. a succession of 4 actions to be triggered in respect to the observed rise in sea level. what is notable here is the mapping emphasizing the water level condition, rather than time, given the uncertainty surrounding the timing (and extent) of possible sea level rise.

This deliverable comprises six sections which correspond each to a **methodological step to construct adaptation pathways** (see also figure 5).

Figure 5 Methodological steps to develop climate adaptation pathways

In addition, the annexes include, among others, a list of references of academic and grey literature on adaptation pathways, and adaptation approaches conducted by hospitals, including a preliminary assessment of their interest to develop the adaptation pathway methodology[7]

Nota bene

In this deliverable, we chose to use the terms “adaptation”, “adaptation pathway” and not “resilience” and “resilience pathways”, which appears to be more restricted, as they do not account for transformational change.

[7] A full desktop review could not be conducted by UCAM as initially planned due to its difficulty with hiring a research associate. Nevertheless, UCAM contributed and presented several academic documents in the list of reference.

Step 0: Mobilization of stakeholders and roadmap advancements

Developing a well-rounded climate adaptation strategy requires a strong participatory process engage all relevant stakeholders contributing to the healthcare facility's resilience, including external critical infrastructure and utility network providers (roads, water, wastewater, sewage, power, etc.). In fact, this participatory process allows to address key challenges faced by relevant stakeholders and increases their acceptability of adaptation measures. This process can build on a local scale "Community of Practice" (CoP)[8], within which a working group of dedicated members can be leading the adaptation process. **Deliverable C5.8 "Community Approach Replication Guide"** describes the methodology to establish and sustain such communities.

At the inception of the adaptation pathway process, it is recommended to discuss key aspects of a **roadmap** which will be established upfront:

- The **objective of the adaptation approach, which must be clearly defined and formulated.** The approach may aim at updating the **hospital's strategy document**[9] so that it accounts for climate change impacts and includes climate adaptation actions in future investment budget.
- The **governance** set up (including a community of practice, a hospital's climate adaptation strategy team, a steering committee, etc.) and the **mobilization plan**
- The **partners that can support technically** the project team.

It is nevertheless important to keep in mind that engaging stakeholders on climate change adaptation in healthcare facilities can be challenging for several reasons:

- Hospitals do not perceive the integration of climate change actions as a priority, given that their role is to respond first to the short-term health needs of their community, and that climate adaptation requires to plan for the medium and long term.
- Lack of funding, which make hospital prioritize short-term needs over long-term, capital-intensive adjustment process to climate change and/or have the hospital only achieve adaptation by "stealth" (i.e. by showing it also delivers on other needs)
- Adaptation is a process of continuous adjustment to climate change, so the benefits of adaptation may be not immediately visible. Not to mention, it may be difficult to assess the results of adaptation actions right away.

This stresses the importance of finding creative ways to keep the stakeholders interested and engaged through organizing informative and engaging roundtable exchanges and workshops.

[8] The definition given in DA1.3 is the following: "A Community of Practice is a place of actionable knowledge and solutions regarding the climate resilience of healthcare facilities where contributors i.e. members of the CoP are free to share their knowledge as well as their personal and professional experience. The CoP's overarching goal is to build a collective climate-resilient pathway among hospitals and dependent critical infrastructures".

[9] Called "projet médical d'établissement" in French hospital, "plan estratégico" or "proyecto estrategico" in the case of Galician hospitals (SERGAS), etc.

Step 1: Identify the main climate-related risks, the risk levels, and associated thresholds

List the most prominent risks

The CoP working group is first invited to brainstorm and then select the most prominent risks presented by climate change that their healthcare facility is facing (select 5 at most), to propose adequate and specific adaptation measures in response). These risks will have been identified during a preliminary climate risk and vulnerability assessment phase[10].

Examples of climate-related risks that healthcare facilities may face

- Risk of damage to hospital assets – such as the A/C or heating systems – due to climate-driven intensification of extreme weather (heavy precipitation, heatwaves, etc.). Ultimately, such damage may increase the discomfort of patients or even disrupt healthcare delivery.
- Risk of high influx of patients during extreme weather events which are stressing the emergency department (floods, forest fires, heat waves)
- Risk of disruption of critical infrastructure on which the hospital relies to operate (access roads, electricity, water, sewage, etc.)
- Risk of increased demand for healthcare due to an amplification of climate-related disease patterns within the community served by the hospital[11]

Define the magnitude of the risk

For each risk, it is proposed to categorize its magnitude (i.e., the likelihood and the intensity of the risk) according to a low-very high ranking (low, medium, high, very high risk). For each rank, the CoP working group would indicate the potential damage / adverse effect of climate change. To conduct this step, it should rely on the **result of the climate risk assessment**.

Determine risk indicators

The CoP working group should determine one or more relevant and indicative indicator(s) to monitor the transition from one level of risk to another. There can be an indicator for each risk, or a common indicator to monitor several risks.

It is advisable to choose an already existing monitoring indicator to be able to use data that is available, easy to access and whose monitoring will be sustainable. The indicator can be very generic and must remain relevant for all the impacts defined in the project. It can be quantitative or qualitative.

Depending on the risk studied, several types of indicators can be identified:

- **Climate indicators**, which reflect the evolution of the climate and therefore indirectly the potential impact of climate change on the healthcare facility. Example: number of days with heavy rainfall, sea level rise, average annual temperature, number of tropical days/nights, etc.

[10] We refer to Deliverable A2.2 "Guidelines to develop vulnerability and risk assessment" (drafted by NCSRD).

[11] Sorensen CJ, Salas RN, Rublee C, Hill K, Bartlett ES, Charlton P, Dyamond C, Fockele C, Harper R, Barot S, Calvello-Hynes E, Hess J, Lemery J. Clinical Implications of Climate Change on US Emergency Medicine: Challenges and Opportunities. Ann Emerg Med. 2020 Aug;76(2):168-178. doi: 10.1016/j.annemergmed.2020.03.010. Epub 2020 Jun 2. PMID: 32507491.

- **Indicators which reflect the tangible impact** of climate change on the healthcare facility, which can be of two types: (i) biophysical indicators – such as the instance the percentage of the buildings exposed to the risk of landslides, or flooding; (ii) socio-economic indicators: monetized amount of flood damage, the number of people seeking health services following the occurrence of extreme weather events, etc.

Climate indicators are often easier to access, however they reflect more indirectly the potential climate-related risk studied, and therefore their interpretation can be more complex. It is therefore preferable to choose an indicator that is as representative as possible of the risk studied.

Determine critical thresholds

Based on the indicator chosen, the CoP working group determines the thresholds that indicates the passage from one risk level to another and the need for additional measures to adapt to climate change. For example, 3-5 days per year with temperatures exceeding 35 degrees Celsius indicate the margin between low and medium risk, a 5-10 days per year with extreme temperatures indicate the margin between medium and high risk and more than 10-15 days per year with record high temperatures indicate that the risk has gone from high to very high (figure 6). The purpose of determining critical threshold is to know at which point do we go from implementing 1 measure to needing to implement others.

Step 2: Set the adaptation objectives and develop a vision for the desired future

The CoP working group defines adaptation objective for each risk level. Such objectives should help develop the overall vision for the desired future of the hospital. It will be the basis for the development of adaptation pathways and therefore for the identification of adaptation measures. The objectives can be of two types:

- To maintain the nature and integrity of the current system (incremental adaptation[12]). This is generally associated with low or moderate risk levels.
- Initiating and accompanying a more fundamental evolution of the system to adapt to the climate and its effects (transformative adaptation[13]). While such objectives are generally associated with high risk levels, and often over a longer time horizon, planning for them involves considering them immediately to ensure that the decisions taken in the short term do not compromise their achievement if and when needed.

NB 1: One objective can apply for several risk levels

NB 2: The vision / adaptation objectives (step 2) are not to be confused with the objective of the adaptation approach which describe the strategic results targeted by the strategy (step 0).

[12] See definition on p. 5
[13] See definition on p. 6

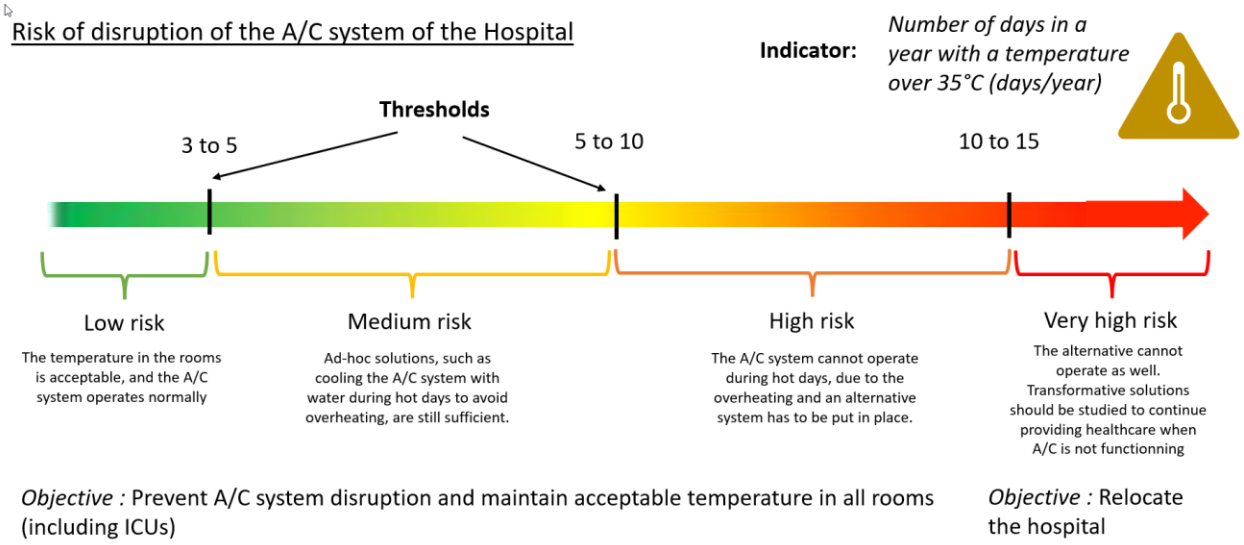


Figure 6 Example of risk levels, indicators, thresholds, and objectives for the risk of disruption of the A/C system

Step 3 List and assess adaptation measures

This step aims to identify and characterize the measures that meet the adaptation objectives defined in the previous step.

List the adaptation measures

First, the CoP working group is invited to list a wide range of measures and **link them with the risk levels** to which they respond. To support this task, it would be given access to an initial database list of measures a preliminary list is in table 1) **and should rely on the results of the climate risk assessment** (they should reduce exposure and/or reduce vulnerability).

Table 1 Preliminary list of adaptation measures for healthcare facilities (with reference to inspiring practices)

Adaptation measure	Hazard type	Adaptive capacity dimension	Measure Type	Inspiring practices of hospital experience
Build community preparedness (awareness raising on climate impacts on health, etc.)	All	Crisis Management	Soft	
Promote and enable action on climate change and environmental sustainability among hospital staff through awareness raising trainings / workshops	All	Crisis Management	Soft	Australian Nursing & Midwifery Federation, Victorian Branch, Australia[14] Complejo Asistencial Dr. Sótero del Río, Chile[15]
Map and surveil the probability of the spread of vector-borne, waterborne, and infectious diseases	All	Crisis Management	Soft	
Develop technology/install sensors to monitor heat-sensible areas in hospitals, health facility services and elderly cares.	Heatwaves	Buildings & Infrastructure	Grey	
Build flood protection systems to protect hospitals and keep them functioning in times of floods	Floods	Buildings & Infrastructure	Grey	Ascension's Our Lady of Lourdes Memorial Hospital, Binghamton, New York, USA
Use water-resistant construction methods and materials (dry proof).	Floods	Buildings & Infrastructure	Grey	Meander Medical Centre, Amersfoort, The Netherlands[16]
Develop bioswales to manage stormwater runoff, for protection against flooding, for erosion control, and to improve water quality in an adjacent body of water while supporting aquifer recharge.	Floods	Buildings & Infrastructure	Green	Kiowa County Memorial Hospital, USA[17] Wexner Medical Center, University of Ohio, USA[18]
Plant trees, install green roofs to cope with the heat island effect for hospitals located in dense urban environment. Species can be resilient to climate change.	Heatwaves	Buildings & Infrastructure	Green	Khoo Teck Puat Hospital[19]

[14] https://www.greenhospitals.net/wp-content/uploads/2019/01/Case-Study-ANMF-Climate-Action.pdf
[15] https://www.hospitalesporlasaludambiental.net/wp-content/uploads/2018/02/Sensibilizaci%C3%B3n-al-Cambio-Clim%C3%A1tico.pdf
[16] https://www.urbangreenbluegrids.com/measures/measures-for-separate-buildings/water-resistant-construction-methods-and-materials-dry-proof/
[17] https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf (p. 63)
[18] https://essentialhospitals.org/wp-content/uploads/2019/11/EHI-Climate-Resiliency-Report-November-2019.pdf
[19] https://blog.interface.com/khoo-teck-puat-hospital-singapore-biophilic-design/

Use a passive downdraught evaporative cooling (PDEC) technique (which, by reflecting the solar radiation and creating ventilation spaces, help to decrease the internal temperature and air-conditioning costs in hot weather).	Heatwaves	Buildings & Infrastructure	Grey	Adamant Hospital Barge in Paris, France[20] Rosie Maternity Hospital, Cambridge, UK[21]
Retrofit the buildings located in a flood-prone area and move vital functions to upper floors, if having access to water activities is important.	Floods	Buildings & Infrastructure	Grey	Spaulding Rehabilitation Hospital, Boston, USA NYU Langone Medical Center, USA[22]
Develop a campus that is self-sufficient, i.e., that can operate for several days even if all of the utility and infrastructure services are lost (supply of food and water, in addition to generators)	Floods	Governance	Soft/Grey	Southeast Louisiana Veterans Health Care Center (SLVHCS)[23], USA Christus Spohn Hospital, Texas, USA[24] Texas Medical Center[25]
Encapsulating a building in pre-molded panels of glass fiber reinforced concrete (GFRC).	Hurricane	Buildings & Infrastructure	Grey	Miami Children's Hospital (MCH), USA
Create safe paths (elevated walkways) to travel between buildings above ground rather than underground	All	Crisis Management	Grey	Tampa General Hospital's emergency department; Texas Medical Center, USA
Develop a climate risk assessment matrix to identify potentially vulnerable infrastructure systems, determine the possible effects of climate change on relevant climate parameters, and develop a risk classification for each possible interaction.	All	Governance	Soft	Nanaimo Regional General Hospital, British Columbia, Canada[26]
Use a passive downdraught evaporative cooling (PDEC) technique –a passive and low energy technique for cooling and ventilating spaces in hot, dry climates	Heatwaves	Buildings & Infrastructure	Grey	
Develop a heatwave plan	Heatwaves	Governance	Soft	

[20] https://www.coolroof-france.com/fr/realisation/peniche-hopital-paris-75-300-m%c2%b2/
[21] https://journals.sagepub.com/doi/pdf/10.1177/0143624414567544
[22] https://drive.google.com/file/d/1Vbr-AUfh8GiyEhdSyv1Ep9qYPAQ_WFL-/view
[23] https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf (p. 61)
[24] https://act-adapt.org/wp-content/uploads/2018/12/2.5.2._lcr_best_practices_web-1.pdf
[25] https://noharm-uscanada.org/sites/default/files/documents-files/5146/Safe%20Haven.pdf
[26] https://climatedata.ca/case-study/the-effects-of-climate-change-on-hospitals/; https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/resources/case-studies/casestudy_nanaimo-gen-hospital.pdf

Assess the relevance of adaptation measures

The **ex-ante multi-criteria analysis** can help the CoP working group assess if a measure is adequate, in relation to the objectives set, the context of the hospital and available financial and technical resources. Eight assessment criteria are proposed (see table below).

The multi-criteria analysis can be done based on knowledge of the CoP working group by **giving a score for each criterion from 1 star (unsatisfactory) to 4 stars (very satisfactory – see table below)** or rely on the results of a quantitative assessment. This is especially the case for the analysis of the cost-effectiveness of the action, which can be assessed through a cost-benefit analysis[27].

At the end of the analysis, if too few measures are assessed as "satisfactory", the CoP working group can add more adaptation measures to be assessed.

Table 2 Assessment criteria for the multi-criteria analysis

Assessment criteria	Guiding questions	Scoring grid	
Efficiency	What kind and level of climate-related risks does the healthcare facility has to deal with?	★☆☆☆	This action is not relevant to deal with the risk.
		★★☆☆	This action is only marginally to deal with the risk.
		★★★☆	This action is quite relevant.
		★★★★	This action is very relevant.
Feasibility	To what extent can its implementation be hampered by technical, regulatory or institutional barriers?	★☆☆☆	This action faces major implementation constraints.
		★★☆☆	Implementation constraints exist but can be overcome.
		★★★☆	There a limited implementation constraints
		★★★★	This is an easy to implement action, with very limited implementation constraints
Flexibility	To what extent can this measure be adjusted if the conditions change or if the changes are different from those envisaged?	★☆☆☆	This action cannot be readjusted.
		★★☆☆	Marginal adjustments are possible
		★★★☆	Flexible action
		★★★★	Totally reversible action and at low cost
Synergy	To what extent does this action improve the adaptive capacity of other sectors / critical infrastructures?	★☆☆☆	This action can increase the vulnerability of other sectors.
		★★☆☆	This action has no impact on other sectors.
		★★★☆	This action can reduce the vulnerability and increase the resilience of other sectors
		★★★★	This action greatly improves the resilience of one or more other sectors
Environmental co-benefit	To what extent does this action bring additional environmental benefits?	★☆☆☆	This action does not bring any environmental benefits.
		★★☆☆	This action brings marginal environmental benefits.
		★★★☆	This action brings some environmental benefits.
		★★★★	This action brings large-scale environmental benefits
Social acceptability	To what extent is this action socially acceptable?	★☆☆☆	This action would not be accepted by the community of patients and staff of the hospital.
		★★☆☆	

[27] A cost-benefit analysis tool will be developed by RINA as part of the adaptation planning decision support system of the LIFE RESYSTAL project.

		★★★☆	This action would only be accepted under specific circumstances.
			There is not issue of social acceptability.
		★★★★	This action can strengthen cohesion of among hospital staff and/or patients.
Cost-benefit analysis	Are the costs generated higher/lower than the avoid cost of potential damage?	★☆☆☆	This action is very costly, compared to the expected damage in case no action is taken
		★★☆☆	This action is quite costly compared to the benefits
		★★★☆	This action is not very costly, but the benefits are not very high
		★★★★	This action is inexpensive compared to expected high benefits
Contribution to mitigation	To what extent does this action contribute to climate mitigation?	★☆☆☆	This action would lead to an increase in GHG emissions.
		★★☆☆	This action has no impact on mitigation
		★★★☆	This action contributes little contributes to mitigation
		★★★★	This action greatly contributes to mitigation

Highlight possible incompatibilities between measures

The last step is to identify if some measures are incompatible (the selection of one adaptation measure may compromise the implementation of other measures). Incompatibilities between measures can be due to technical, financial, time constraints, or other.

Workshop to support the definition of risk levels, adaptation objectives and assessment of adaptation measures

The climate adaptation pathway approach requires to involve a wide range of stakeholders. To cover steps 2, 3 and part of step 4, a 1-day workshop can be organized with them (see below a draft agenda)[28]. Following this workshop, the CoP working group can meet to consolidate the results by conducting the multi-criteria analysis and assessing incompatibilities between measures.

Duration	Content	Facilitation tool
		Morning session
30 minutes	Icebreaker	The facilitator asks 2-3 questions to the participants such as: “how do you perceive climate impacts in your hospital?”; “do you believe that your hospital has the resources to adapt to climate change right now?”; “do you feel able to act at your own scale?”
30 minutes	Validation of the list of risks	The facilitator presents and justify the selection of risks based on the climate risk assessment. The list can be reviewed and amended with the participants.
1 hour	Definition of risk levels	For each risk, the participants propose a gradation in 3 or 4 increasing levels of risk by defining the state of the risk for each level, as well as an indicator to measures them. It is recommended to conduct this session in small groups.

[28] For step 1, we refer to Deliverable A2.2 “Guidelines to develop vulnerability and risk assessment” (drafted by NCSRD).

1 hour	Definition of adaptation objectives	For each level of risk, an adaptation objective is defined by risk level. It is recommended to conduct this session in small groups.
	Afternoon session	
1 hour	Validation of adaptation objectives	One rapporteur per risk presents the adaptation objectives. These objectives can be reformulated.
1 hour	Identification of adaptation measures	From the list of risks, the assessment of vulnerability and exposure factors conducted during the climate risk assessment phase, and the list of adaptation objectives, the participants can list the possible adaptation actions. It is recommended to conduct this session in small groups.
30 minutes	Wrap-up	Conclusion from the sessions, feedback from participants and ways forward

Step 4 Elaborate the adaptation pathways map

This step aims to develop an **adaptation pathways map for each risk considered**, which helps to assess what solutions needs to be implemented now (no or low-regret interventions) and which one should be implemented in the future, in accordance with the adaptation objectives / adopted vision of the hospital. Information about incompatibilities between measures makes it possible to visualize the adaptation tipping point of a path (the point where it is no longer “valid/viable”).

Overall, multiple paths can be defined, helping the CoP working group to consider multiple ways to achieve their adaptation goal.

Workshop to co-construct adaptation pathways

This workshop will produce the content expected to finalize step 4 (assessment of adaptation measures) and to carry out step 5 (adaptation pathways map). All identified stakeholders are invited to participate. Prior to this meeting, the impact levels for each issue and the associated adaptation objectives will have been defined. Adaptation measures will have been listed and assessed. The objective of the workshop is to arrange the actions between them and to define one or more path(s). A draft agenda is shown below:

Duration	Content	Facilitation tool
	Morning session	
1 hour	Icebreaker	Each participant writes on a sheet its vision of the desirable future for the hospital in one sentence. The facilitator presents the mains visions shared by the stakeholders. The participants are invited to provide feedback.
45 minutes	Presentation of the results of the previous steps	The facilitator presents the results of previous steps. For each risk, it recalls the risk levels identified, the adaptation objectives and the proposed adaptation measures with the risk levels to which they respond. The summary of the results of the multi-criteria analysis is presented.
1.5 hour	Development of the paths	Each group works on a risk and, in accordance with the adaptation objectives / vision defined above, selected the relevant measures to imagine desirable pathways for the hospital. Measures may be added if needed.

		A rotation of the groups by mixing them will make it possible to reformulate the title of the trajectory if necessary and to complete the work of the previous group.
1 hour	Pathway prioritization	The pathways identified for each risk are presented by a rapporteur from each group. Each pathway can be quickly assessed through guide questions such as "are the implementation costs greater than the overall benefits created?". Participants may also rely on a more quantitative assessment (cost-benefit analysis). A vote may be carried out to prioritize the pathways for each risk.
15 minutes	Conclusion	The facilitator presents the results of the pathway assessment, then updates participants on the next steps

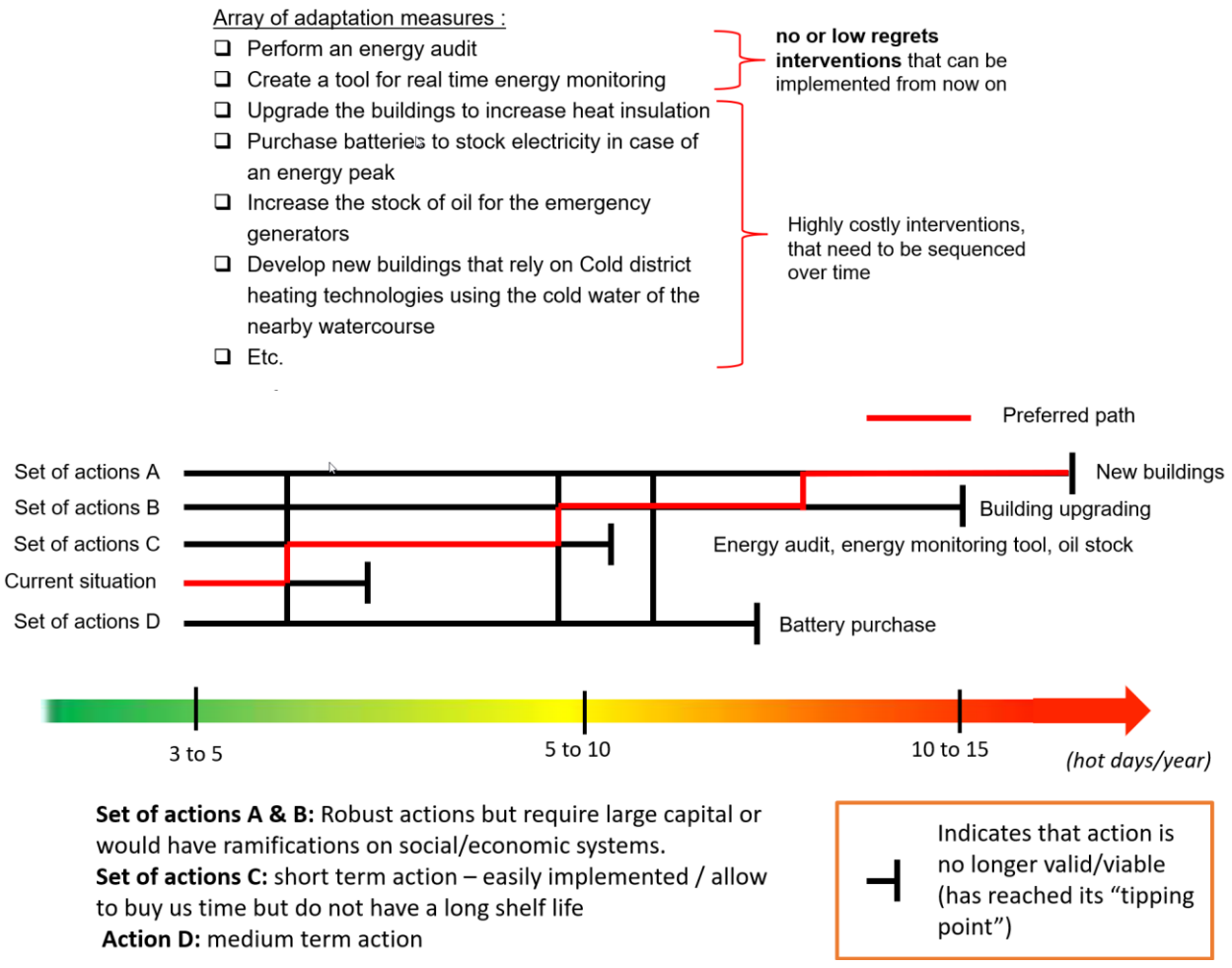


Figure 7 Example of adaptation pathways map for the risk of disruption of the A/C system of a hospital, including preferred path

Step 5 Climate adaptation plan and next steps for implementation

To develop a full climate adaptation action plan, one or more workshops aimed at detailing the adaptation measures selected can be carried out. This will involve, for example, filling out measure sheets in subgroups indicating:

- The owner of the action
- Technical partners
- The objective of the action
- The description of the action
- The implementation timeline
- An estimate of the cost if possible
- The possible funder(s)
- A monitoring indicator

Once this step is performed, the adaptation pathway maps, and adaptation plan should be presented to decisionmakers (hospital management) to ensure their inclusion in future investment budgeting.

Next steps

This deliverable will support the drafting of three future activities of the LIFE RESYSTAL project led by ACTERRA:

- Development of the test version of web-based tool for adaptation planning (DC1.4 & DC1.6, due for 02/2023)
- Methodological guide explaining the web-based tool (DC1.5, due for 02/2023)
- Training material for the sessions on the use of the web-based tool to be organized with pilot hospitals starting from 02/2023 (DC1.1)

Some activities that were outlined in this deliverable may also be further developed, especially the preliminary list of adaptation measures. Based on the workshops to be organized with hospital to test the adaptation planning tool but also a more rigorous desktop review (see list of reference as annex), the objective will be to propose to pilot hospitals (and replicators) a comprehensive catalog of adaptation measures. UCAM may support this task.

Annexes

- PPT presented during the 4th technical meeting
- Technical specification document for modules 4 & 5
- List of references relevant of relevant grey and academic literature on adaptation pathways, as well as on healthcare facilities' climate resilience issues
- Summary table on adaptation planning models

Annex 1: List of references relevant of relevant grey and academic literature on adaptation pathways, as well as on healthcare facilities' climate resilience issues

To support the development of a relevant adaptation pathway methodology for healthcare facilities, ACTERRA conducted a desktop review of the grey and academic literature on adaptation pathways, as well as on healthcare facilities' climate resilience. A list of additional academic references was also provided by UCAM[29]. ACTERRA relied on search tools as well as some documents shared by HCWHE while UCAM focused on academic literature using a dedicated search engine (Scopus[30]). The terms used for this search are listed in the column "keywords" in the tables below. Three categories of documents were collected:

- Methodological guides and tools on adaptation (pathways)
- Case studies of application of adaptation pathway methodologies or at least climate resilience strategies
- Feedback on adaptation pathway methodologies
- Documents that help to assess the determinants of hospital resilience or adaptive capacity

[29] A "resilient pathway analysis" was initially to be conducted by UCAM, with ACTERRA's support. Due to the difficulty of hiring a research assistant to perform this task, limited input had been provided by UCAM, at the time of drafting this deliverable (Q2 & Q3 2022). Additional inputs may be provided later on (starting Q4 2022)

[30] https://www.scopus.com/home.uri

Partner	Type of resource	Author, date	Title	Contents (in brief)	Target audience	Keywords	Area of application ? / to which cases can it be applied ?	What is the relevance of the document to the study?	Score	Open access
	Methodological guides and tools on adaptation (pathways)									
ACTERRA	Guide	World Health Organization, 2017	Climate Change Adaptation in the Health Sector Using Integrated Water Resources Management Tools	Chapter 4 : Identification of Adaptation Measures and Options (IWRM Tools) for the Health Sector Based on the Impact and Vulnerability Assessment Results --> Stocktaking for available adaptation measures. There are recommendations into the development, implementation, and verification of adaptation to climate change programmes in the health sector with the emphasis on the IWRM tools.	Planners, policymakers, water and health dimension of climate change, adaptation experts and stakeholder	Adaptation, climate change, resilient, health systems, who	An exemple of a tool to construct adaptation pathways for a Health Sector	Tools and tables are provided as examples, which can be used to implement our adaptation pathway methodology. The key areas are identified to carry it out.	★★	Yes
ACTERRA	Guide	NSW Government, derpartment of planning industry & environment, march 2021	Climate Risk Ready NSW Guide - Practical guidance for the NSW Government sector to assess and manage climate change risks	The Guide outlines steps to consider the potential climate risks to an enterprise, program or project and encourages integration of these risks into enterprise risk management frameworks and procedures. This will support agencies to holistically and systematically address significant risks to objectives and financial management. This Guide outlines foundational activities and a four-step process for climate change risk assessment and management that can be adapted to suit your organisation (8 months to do all the step)	Planners, policymakers, adaptation experts	Climate risk management, adaptation, guide, government, australia	Methodology for Adaptation Pathways	Exemple of adaptation pathways for heatwave hazard on which we could rely to develop adaptation pathways at the hospitals level facing the risk of a heat wave.	★	Yes
ACTERRA	Pathway tool	ADEME, TACCT, 2018	Climate target - Pathway module - excel	The TACCT (Trajectoires d'Adaptation au Changement Climatique des Territoires or Adaptation Pathway to Climate Change in English) approach enables the development of a climate change adaptation policy from "A to Z", from vulnerability diagnosis to the monitoring of measures and the evaluation of the strategy. The approach comprises three stages, each with a methodological guide and an IT tool made available by ADEME. This excel is the step 2 TACCT Building strategies where adaptation pathways are built. 5 phases built this strategy which has a pre-setting stage as an introduction to the tool: 1 - Definition of aims 2 - Identification of actions 3 - Evaluation of actions	Planners, policymakers, adaptation experts	Local authority, climate change, adaptation pathway, tool	An exemple of a tool to construct adaptation pathways for a company	Understand the logic and try to apply it to hospital level. Inspiration of the tool construction.	★	Yes

				4 - Development of trajectories 5 - Action plan						
ACTERRA	Pathway tool software	Created by Andrew Warren, last modified on 30-11-2017	Pathways Generator	The Pathways Generator helps to explore policy pathways in an interactive way, for example, together with stakeholders. The results are shown in a pathways map. Pathways are sequences (or portfolios) of actions over time to achieve a set of pre-defined objectives under uncertain and changing future conditions.	Adaptation experts	Adaptation pathways, generator	Methodology for Adaptation Pathways	A tool that will help us build the adaptation trajectories of hospitals if we follow the DAPP approach.	★★★	Yes
ACTERRA	Guide	GIZ, April 2019	Methodological Guide for the Adaptation to Climate Change of Industrial Zones	The main objective of the guide is to support a better integration of climate risk into the management of industrial areas. It has the following objectives: - Provide an introduction to Adaptation to Climate Change (ACC) in the context of IZs - Provide an approach and assessment tools on climate risk and opportunity management for IZs - Provide recommendations on the main steps to initiate an ACC process for an existing IZ Chapter 4.3 Adapting: An overview of adaptation strategies and measures. --> example of measures in this area, actors, steps ect..	Companies and industrial zone	Methodology, guide, company, adaptation, strategy	An exemple of implementation of adaptation strategy in industrial zone	Understand the logic of adaptation strategy in industrial zone to try to apply it to health system level. Cf. Schems, tool box and steps to frame the study case.	★	Yes
ACTERRA	Guide	ADEME, Acterra, TEC, Climate adaptation consulting, october 2019	Build adaptation pathways to climate change climate in the territory - Methodology guide TACCT	Build flexibility into the long-term planning of adaptation actions, particularly in light of the changing climate context; Identify the actions to be implemented now, while ensuring that they do not compromise the future; Maintain the flexibility to adjust the strategy and make changes by adopting an agile approach to the evolution of climate change and its impacts.	Planners, policymakers, adaptation experts	Local authority, climate change, adaptation pathway, tool	An example of a guide to construct adaptation pathways for a territory	Understand the logic and try to apply it to hospital level.	★★	Yes
	Application of adaptation pathways in various contexts									
ACTERRA	Research article	Rahaman, Muhammad & Rahman, Mohammad & Rahman, Syed. (2019)	Pathways of Climate-Resilient Health Systems in Bangladesh: Policy Strategies for Adaptation	This document provides a foundation for studying the relationship between the climatic characteristics of the study area, climate-sensitive diseases and other anthropogenic phenomena. It demonstrates the pathways of climate-resilient health systems in Bangladesh. **In the chapter 9.4 Pathways of a Climate-Resilient Health System**, the paper focuses on the actors to be coordinated in a climate change adaptation pathway strategy in the health system. Climate-Resilent health policy and	Adaptation experts	Climate change, Climate extremes, Climate-resilient, Health system, Bangladesh	Climate change resilience policy for a health system.	Key actors in building hospital resilience > summary tables of actors, their roles and links.	★	Yes

			and Resilience	facilities are also highlighted in the next paragraphs of this document.						
ACTERRA	Case study	Edmond Totin, Mary Thompson-Hall, Carla Roncoli, Amadou Sidibé, Laura Schmitt Olabisi, Robert B. Zougmoré, Environmental Science & Policy, Volume 116, february 2021, Pages 196-203,	Achieving sustainable future objectives under uncertain conditions: Application of a learning framework to adaptation pathways in rural Mali	This study elaborates on how pathway approaches operate in practice by applying a learning framework that identifies guiding propositions for successful adaptation pathways. The framework is used to analyze a transformative scenario planning case study from rural Mali. Findings confirm that adaptation pathways are highly context-specific, grounded in local institutions. The study also emphasizes that the adaptation pathways process requires a sufficient timeframe to allow for cross-level interactions and institutional changes to unfold as needed. The case demonstrates that the framework can be a useful tool for reflexive learning and identifying gaps in a structured way during pathway development. However, it needs to be adjusted to specific contexts to better capture the influence of and implications for power relations and social inequality in future adaptation plans.	Adaptation experts	Climate change; Adaptation pathways, Scenario planning, Social learning	Methodology for Adaptation Pathways	A good methodology proposition with clear steps, see fig 1 schematic representation of three phase of adaptation planning	★★	Yes
ACTERRA		Maddalen Mendizabal, Nieves Peña, Hans Hooyberghs, Griet Lambrechts, Joel Sepúlveda and Saioa Zorita, october 2021	Lessons Learned from Applying Adaptation Pathways in Heatwave Risk Management in Antwerp and Key Challenges for Further Development	This paper is focused on one of the dynamic adaptive policy planning approaches: the adaptation pathway. This approach allows designing alternative feasible plans that are flexible and can respond when new information appears or when conditions in the environment change. This paper presents a structured methodology for designing adaptation pathways. The work describes a high-level adaptation pathway covering heatwave impacts on productivity and health at city level in Antwerp to ensure the city adapts to future conditions. Lastly, a summary is provided of the lessons learned and the challenges of this approach are discussed.	Adaptation experts	effectiveness, alternatives, heatwaves, planning, decision making, uncertainty, dynamic adaptative policy	Methodology for Adaptation Pathways	Clear steps and explanations to construct adaptation pathways that we could apply to hospital and health systems.	★★★	Yes

UCAM	Review article	Nieto-Cerezo, O. (2016). Refining NHS Climate Change Adaptation Plans: Central Manchester University Hospitals Foundation Trust (CMFT) Case Study. In Climate Change Management (pp. 225–245). Springer. https://doi.org/10.1007/978-3-319-25814-0_16	Refining NHS Climate Change Adaptation Plans: Central Manchester University Hospitals Foundation Trust (CMFT) Case Study.	The abstract suggests that the paper presents an "innovative climate change adaptation plan for Central Manchester Unviersity Hospitals". It suggests that this is done in four blocks: (1) stakeholder engagement (2) information gathering on local climatechange impacts, local health inequalities spatial planning and attitudes to more sustainable mode of transport of patients, visitors and staff, (3) decision making and implementation, and (4) monitoring. However, the whole case is predominantly focused on understanding travel patterns of staff/patients and how to influence travel behaviour (e.g. provide better cycle routes). This is essentially the extent of the case (as well as a calculation of a carbon footprint). It's not clear how information gathering on local climate change impacts is put to any use. Comments that senior decision-makers need to be engaged for a plan to have any chance of successful adoption - which is clearly sensible. Overall though, a disappointing paper given the title (and I do not come away with the impression of high quality).	? Hospital managers	Travel behaviour, active travel		n/a	0	No
UCAM	Review article	O'Neill, M. S., Carter, R., Kish, J. K., Gronlund, C. J., White-Newsome, J. L., Manarolla, X., Zanobetti, A., & Schwartz, J. D. (2009). Preventing heat-related morbidity and mortality: New approaches in a changing climate. In Maturitas (Vol. 64, Issue 2, pp. 98–103). https://doi.org/10.1016/j.maturitas.2009.08.005	Preventing heat-related morbidity and mortality: New approaches in a changing climate.	Relatively dated paper in a strange journal given the topic, but essentially advocating for the type of tool that the Reystal project intends to create, albeit with more of a focus on local government planning rather than directly for the health sector. References various initiatives at the time of publication. Table 1 outlines ICLEI USA's five milestones for adaptations as described in "preparing for cliamte change : a guidebook for local, regional and state governments." Milestone 1: Initiate your climate resiliency effortScope the climate change impacts expected in your regionPass a resolution or administrative order directing your government toprepare for climate changeBuild and maintain support to prepare for climate changeBuild your climate change preparedness teamIdentify your planning areas relevant to climate change impactsMilestone 2: Conduct a climate resiliency studyAnalyze the change climate impacts to your major sectorsConduct a climate change vulnerability assessmentConduct a climate change risk	?	Adaptation decision-tools, local planning		Paper from >10 years ago calling for online tools that help stakeholders assess risk information and make decisions. A bit dated now, and of limited direct use, other than loose support for the principles of the RESYSTAL project. The reference to ICLEI's five milestones for adaptation (see contents (in brief) for the milestones) have alignment with RESYSTAL's modules.	★	No

				assessmentPrioritize planning areas for actionMilestone 3: Prioritize adaptation actions and develop implementation planDevelop, select and prioritize your preparedness actionsCreate a plan to fund and carry out actionsMilestone 4: Implement your preparedness planEnsure that you have the right implementation toolsMilestone 5: Measure your progress and update your planTrack progress towards meeting implementation goalsUpdate your plan to reflect experience and new information						
	Documents that provide feedback on adaptation pathway methodologies									
ACTERRA	Review article	Saskia E. Werners, Russell M. Wise, James R.A. Butler, Edmond Totin, Katharine Vincent, Environmental Science & Policy, Volume 116, (2021) Pages 266-275, ISSN 1462-9011,	Adaptation pathways: A review of approaches and a learning framework	Sequences of actions, which can be implemented progressively, depending on how the future unfolds and the development of knowledge. A difference between scholars is whether pathways are understood as alternative sequences of measures to realise a well -defined adaptation objective, or as broad directions of change for different strategic aims or outcomes. - Performance threshold oriented, - Multi-stakeholder oriented, - Transformation oriented approaches Three desired outcomes of pathways development: - Meeting short and long term adaptation needs, - Promoting collaborative learning, adaptive planning and adaptive capacity, - Accounting for complexity and long term change, including a potential need for transformation Specifying which measure(s) are to be taken now and which are planned to be implemented once certain conditions occur. Ability to identify 'no or low regrets' interventions and to avoid lock in, threshold effects, and maladaptive consequences.	Adaptation experts	Adaptation, Uncertainty, Decision-making, Climate change, Adaptation pathways, Learning framework	Methodology for Adaptation Pathways	This document helps us to frame our thinking in order to build adaptation pathways according to the context, the actors involved, the objectives and expected results and the type of data available	★★★	Yes

ACTERRA	Report	ADEME, Acterra, TEC, Climate adaptation consulting, january 2018	"Adapting to climate change Strengthening of the " Climate Target" on the part devoted to the selection of actions"	Identification and key principals of approaches to adaptive planning/management. 2 key concepts on which adaptive management is based: robustness and flexibility. In the robustness approach, two procedures are retained: Robust decision making (RDM) and Adaptive policy-making (APM). In the flexibility approach two procedures are retained: Adaptation pathways (AP) and Dynamic adaptive policy pathways (DAPP)	Adaptation experts	Adaptation, Adaptation pathways, adaptative management	Methodology for Adaptation Pathways	Take ownership of the different possible adaptation pathway approaches to choose which type is appropriate for our case, hospitals and health systems.	★★★	Yes
ACTERRA	Research article	Mark Zandvoort, Inês S. Campos, André Vizinho, Gil Penha-Lopes, Eliška Krkoška Lorencová, Rutger van der Brugge, Maarten J. van der Vlist, Adri van den Brink, Ad B.M. Jeuken, Volume 78,2017,Pages 18-26,	Adaptation pathways in planning for uncertain climate change: Applications in Portugal, the Czech Republic and the Netherlands	A compared study of 4 initiatives with regard to design choices made. It founds six design choices which need to be considered when adjusting adaptation pathways :- geographic scale- inclusion of sectors- generation and delineation of adaptation options- specification of possible pathways- related performance metrics - type of assessment = interdependent, but they are also influenced by contextual aspects. Analysis of the institutional diversity, planning culture and framing shows that the use of adaptation pathways is flexible enough to be adjusted for diverging planning practices. However, the tool is best suited to deliver local adaptation solutions, and adequate use depends on consensus about the adaptation problem, setting objective thresholds and determining uncertainty about future change. Principal conclusion is that understanding the customised use of tools for local planning practices is essential for adaptive policy design.Planners need to take 4 steps to create an adaptation pathways map.	Planners, policymakers, adaptation experts	Planning tools, Policy-making, Design choices, Climate adaptation, Uncertainty, Adaptation pathways	Methodology for Adaptation Pathways	Identify (table1) and apply design choice to the study case of hospital and then follow the 4 steps to construct adaptation pathways. --> GIS mapping, urban heat tool for example in Island	★★	Yes
	Documents that help better assess the determinants of hospital resilience or adaptive capacity									
ACTERRA	Research article	Carthey, Jane & Chandra, Venny & Loosemore, Martin. (2008) Association of Researchers in Construction Management, ARCOM 2008 - Proceedings of the 24th Annual Conference. 2.	Assessing the adaptive capacity of hospital facilities to cope with climate-related extreme weather events: A risk	This paper focuses on adaptation strategies required to safeguard essential healthcare infrastructure. It reports the findings of the research which highlight the need for further investigation of the likely increase in healthcare demand due to extreme weather events and the need to investigate further the adaptive capacity of existing health infrastructure. It also highlights the importance of working within existing asset and disaster management frameworks in doing this.	Health and hospital director and manager, decision maker, local and regional government, adaptation expert	Asset management, climate change, extreme weather events, hospitals, risk management	Healthcare building	Potential data: Asset condition Patient demand Climate variables	★★★	Yes

			management approach	The study recommends : - the need to use a systems approach for understanding the vulnerability and need for adaptive capacity that will ensure that healthcare infrastructure can cope with climate change. - the requirement to determine not only the impact of increasing incidences of extreme weather events on the health of the community that may increase the demand for healthcare services, but also to consider how to prevent health facilities failing under the loads placed on the building fabric due to these same events. - the relevance of working with existing systems to achieve both these aims. - It is essential to integrate responses with existing asset and disaster management frameworks and to involve clinicians, health service and facility managers in decision-making processes to ensure more effective community responses and greater pressure for the development of adaptive capacity for healthcare infrastructure. This approach will thus also be more responsive to the existing political, social, technological and institutional capacity, wherever the healthcare system may be located.						
UCAM	Analysis article	Contessa, G. M., Guardati, M., D'Arienzo, M., Poggi, C., Sandri, S., D'Auria, M. C., Genovese, E., & Cannatà, V. (2018). The impact of climate change on radiological practices in Italy: Safety implications and preventive measures. European Physical Journal Plus, 133(9). https://doi.org/10.11	The impact of climate change on radiological practices in Italy: Safety implications and preventive measures.	Reviews the possible risks that extreme weather events (EWE) pose where radioactive materials are used and stored. Explores the possible implications of radioactive contamination as the result of flooding, and provides general guidance on how the risk should be assessed. This is very specific to a particular service within a hospital - but helpful in pointing towards the need to inventory various specialisms/proceedures of a hospital and their vulnerability to EWEs. The paper is focused on Italy, and highlights the accessible information available for people to look up climate risk in their location. While relatively technical, it stood out given the application in Italy, which is within RESYSTAL's direct remit and network. On	Hospital operators	Risk planning, emergency management, radiology, extreme weather, flooding, risk parametization		Highlights what needs to be considered in a resilience assessment (specifcially - the need to understand the characteristics of each hospital). The specific detail of the paper is less relevant.Demonstrates signifcant technical, detailed input to determine	★★	No

		40/epjp/i2018-12243-3		the one hand a narrow analysis given the focus just on radiologiy - but on the other hand demonstrates a very detailed consideration of the risk and possible actions. More generally, relevant points to note: (1) It references the MEd-CORDEX climate model (which I believe Dimokritos have access to/use). (2) It proposes a general criterai for the paramterization of risk into categories. I don't know how standard this would be across hosptials but in terms of "scaling up" this project do we make recommendations for risk parametization or allow flexibility for local COPS to adapt the guidance (I anticipate it being the latter). The paper makes a brief reference to Italian hospitals not being equipped with an emergency team 24/7.				risk for one type of hospital service provision. Raises the question for me regarding how RESYSTAL parametises risk across different hospital services (e.g. how are services defined, how is the aggregate hospital risk exposure determined)? What level of detail is sufficient for the risk analysis to be robust, manageable and informative?		
UCAM	Review/ case study article (academic)	Achour, N., & Price, A. D. f. (2010). Resilience strategies of healthcare facilities: Present and future. International Journal of Disaster Resilience in the Built Environment, 1(3), 264–276. https://doi.org/10.1108/17595901011080869	Resilience strategies of healthcare facilities: Present and future.	Review article, mainly focused on the state of play of healthcare resilience in the UK. Now a little dated - but pointed torwards the US being more open in sharing guidelines and standards, with the UK more recently following suit as a result of European Commission rules. While some references might be dated now, the current version of the codes/guidelines will be relevant. The paper references the fragmented nature of managing infrastructure that is relevant to healthcare resilience (i.e. estate managers not responsible for roads connecting the surrounding area to the hospital). Figure 1 is a good diagram for covering the various pieces of information required for developing an adaptation strategy.	General audience	Contigency planning, governance, guidelines, resilience strategies		Background information for the development of resilience strategies in healthcare sectors - particurlarly relevant to the UK. Helpful for overall conceptualisation	★★	No

UCAM	Case study	Jorge, C. (2021). Landscape intervention in the Hospital for Covid-19 pandemic in Madrid. Landscape Architecture and Art, 18(18), 39–48. https://doi.org/10.22616/J.LANDARCHART.2021.18.04	Landscape intervention in the Hospital for Covid-19 pandemic in Madrid.	Reviews the landscape design for an emergency hospital built in 100 days to manage Covid response. Outlines landscape design considerations to help support well-being of patients and climate-related consdierations in terms of choices of planting. Possible case study that could be investigated further - e.g. have they been able to measure the claim that the landscaping delivers on the design principle that it was intended "to be a part of the machine to heal and to provide relief from the stress and emotional trauma of the Covid-19 hospital environment."?	Hospital estate managers / designers	Landscape design		Could be the focus of a case study, but mostly specific to landscape design. There may be wider hospital design considerations that are relevant but just not covered in this paper (which was written by someone who did the landscape design I believe, or at least was very involved).	★★	Yes
UCAM	Review article (academic)	Lenzer, B., Rupprecht, M., Hoffmann, C., Hoffmann, P., & Liebers, U. (2020). Health effects of heating, ventilation and air conditioning on hospital patients: A scoping review. BMC Public Health, 20(1). https://doi.org/10.1186/s12889-020-09358-1	Health effects of heating, ventilation and air conditioning on hospital patients: A scoping review	A systematic review of literature on the effects of HVAC on inpatient recovery. Highlights very fragmented knowledge on this. The authors suggest HVAC could be a promising adaptation measure to mitigate the adverse effects of climate change on health and healthcare systems. But, despite "abundant epidemiological findings confirming adverse effects of heat on health, this scoping review shows that research on hospital adaptation and the individual treatment of patients is lacking".	Hospital estate managers / designers	Hospital design, HVAC		Background evidence for adaptation interventions. This is very specific to looking at HVAC impacts, I suspect there is better evidence for supporting HVAC via the need to avoid high temperatures which risk being at dangerous levels for patients and staff.	★	Yes
UCAM	Review/ case study article (academic)	Rychetnik, L., Sainsbury, P., & Stewart, G. (2019). How Local Health Districts can prepare for the effects of climate change: an adaptation model applied to metropolitan Sydney. Australian Health Review, 43(6), 601–610.	How Local Health Districts can prepare for the effects of climate change: an adaptation model applied to metropolitan Sydney.	Outlines current approaches and policies in Australia towards Local Health District planning for climate risks. It highlights sources of information for undersatnding climate change risks, outlines policies and governance of the risk and how LHDs might respond (it does not go as far as showing how they are responding in detail, but it does point towards how many Austrlaian health services have "robust disaster plans and management frameworks" but suggests "These could be expanded to incorproate local climate adaptation plans (i.e. makes suggestions on how existing mechanisms	LIFE RESYSTAL network (tool development and evidence)	Climate change adaptation, risk management, case study		Highly relevant case for comparison for the LIFE RESYSTAL toolbox. Provides an excellent outline of a case study at a local district level	★★★	Yes?

		https://doi.org/10.1071/AH18153		may be used to adavnce the adaptation agenda).						
UCAM	Review article (academic)	Sorensen, C. J., Salas, R. N., Rublee, C., Hill, K., Bartlett, E. S., Charlton, P., Dyamond, C., Fockele, C., Harper, R., Barot, S., Calvello-Hynes, E., Hess, J., & Lemery, J. (2020). Clinical Implications of Climate Change on US Emergency Medicine: Challenges and Opportunities. Annals of Emergency Medicine, 76(2), 168–178. https://doi.org/10.1016/j.annemergmed.2020.03.010	Clinical Implications of Climate Change on US Emergency Medicine: Challenges and Opportunities.	An excellent review article that captures the clinical implications of climate change for emergency medicine (focused on the US context - but likely more broadly applicable for Western developed countries). The categorisation and summary of evidence associated with climate-sensitive diseases and outlining different vulnerabilities of members of the population are potentially helpful resourses for the development of LIFE RESYSTAL tools, Makes reference to the US Department of Health and Human Services, which developed the Sustainable and ClimateResilient Health Care Facilities Toolkit. They suggest that this was "partially in response to hospitals forced to close and evacuate during disasters, with devastating losses in infrastructure assets and negative effects on patient."	LIFE RESYSTAL network (tool development and evidence)	Clinical implications, climate change, emergency medicine		Helpful concepualisation to reflect on for developing the LIFE RESYSTAL toolbox	★★★	Yes?
UCAM	Review article (academic)	Tonmoy, F. N., Cooke, S. M., Armstrong, F., & Rissik, D. (2020). From science to policy: Development of a climate change adaptation plan for the health and wellbeing sector in Queensland, Australia. Environmental Science and Policy, 108, 1–13. https://doi.org/10.1016/j.envsci.2020.03.005	From science to policy: Development of a climate change adaptation plan for the health and wellbeing sector in Queensland, Australia.	Another excellent article, it outlines the stakeholder engagement process undertaken to develop priority focus areas for Queensland's health sector climate strategy. The authors of this paper are key authors of the official Queensland government strategy. I see many parallels in the engagement principles of the approach described and the efforts of LIFE RESYSTAL, albeit the scope set in a different way (focus is development of a sector-level strategy for one region).	Policy-makers/those facilitating policy development	Stakeholder engagement, Queensland, regional policy		Good compartive point for RESYSTAL's stakeholder engagement and management processes. Key point this paper makes is the need for stakeholder buy-in and active participation.	★★★	No

UCAM	Analysis article (academic)	TONG, M. X., WONDMAGEGN, B. Y., WILLIAMS, S., HANSEN, A., DEAR, K., PISANIELLO, D., XIANG, J., XIAO, J., JIAN, L., SCALLEY, B., NITSCHKE, M., NAIRN, J., BAMBRICK, H., KARNON, J., & BI, P. (2021). Hospital healthcare costs attributable to heat and future estimations in the context of climate change in Perth, Western Australia. Advances in Climate Change Research, 12(5), 638–648. https://doi.org/10.1016/j.accre.2021.07.008	Hospital healthcare costs attributable to heat and future estimations in the context of climate change in Perth, Western Australia.	An analysis of the economic burden of future climate change on hospital costs in Perth. Baseline data from 2006-12 is used alongside climate data to determine the influence on changing temperatures on hospital admissisions for various illnesses. The temperature is then extrapolated based on IPCC pathway scenarios and future economic burden calculated. The paper gets very technical in describing the economics/mathematics behind the analysis - which is generally beyond the scope this review. However, the discussion is helpful in terms of framing the assumptions/knowledge gained which should be reflected upon when Rina is doing the risk modelling.	Climate change researchers	Australia, economic burden, heat-related disease, cost analysis		Risk modelling/quantification	★★	Yes
UCAM	Research article (academic)	Short, C. A., Renganathan, G., & Lomas, K. J. (2015). A medium-rise 1970s maternity hospital in the east of England: Resilience and adaptation to climate change. Building Services Engineering Research and Technology, 36(2), 247–274. https://doi.org/10.1177/0143624414567544	A medium-rise 1970s maternity hospital in the east of England: Resilience and adaptation to climate change.	A quantitative (building modelling) study of the Rosie Maternity Hospital in Cambridge, UK (representing a recurring building type across the UK's National Health Service. A model was developed and calibrated against observed data an dused to predict future likely temperature in the 2030s. The paper also reports on testing on various adaptive intervention schemes. Among the key findings are the "existing building enjoys a relatively low energy and low carbon performance against the DH [Department for Health] guidance benchmarks but at the cost of comfort, it is unable shed heat so that internal temperatures reach 28C in relatively mild conditions. Night tempreature are consistently uncomfortable.... It also highlights that business case requirements for funding (e.g. Treasury requirement ROI of 2.4 within five years) is not supportive of climate adaptation efforst)	Poilcy, building model experts	Resilience, adaptation, building modelling, overheating		Detailed evidence (for a particular case in England) on changing probability of overheating as a result of climate change. Relevant for how the risk assessment tool of Resystal is developed (although the detailed modelling would not be replicable in the project)	★★	Yes
UCAM	Analysis article (academic)	Biddle, L., Wahedi, K., & Bozorgmehr, K. (2020). Health system resilience: A	Health system resilience: A literature	This is an excellent review paper, covering how healthcare system resilience has been covered conceptually in literature. It is published in 2020, while it will not cover publications over	Healthcare / health system researchers	Research review, helath system		The paper adopts Blanchet et al (2017)'s conceptulaisation	★★★	

		literature review of empirical research. In Health Policy and Planning (Vol. 35, Issue 8, pp. 1084–1109). Oxford University Press. https://doi.org/10.1093/heapol/czaa032	review of empirical research.	the past couple of years it remains relatively recent. Key finding: "Despite extensive theoretical work on the domains which constitute health system resilience, we found that most of the empirical literature only addressed particular aspects related to absorptive and adaptive capacities,with legitimacy of institutions and transformative resilience seldom addressed. Qualitative and mixed methods research captured a broader range of resilience domains than quantitative research." With regards to the final statement, about qualitative vs quantitative research, this is because quantative research is often delving into detailed technical analysis to provide robust insight into an impact of climate change for healthcare (e.g. overheating of hospital buildings). It is not that the qualitative reseach is BETTER, it is just conceptually broader. The paper adopts Blanchet et al (2017)'s conceptulaisation of resilience domains for conceptual analysis studies. This captures resilience in terms of 4 management capacities and 3 levels of resilience. These are more about describing capacity to act and the level of action rather than providing a "pathway". However, the language/terminology could be directly adopted by RESYSTAL: Management capacities:Knowledge—'Capacity to collect, integrate and analysedifferent forms of knowledge and information'Uncertainties—'Ability to anticipate and cope with uncer-tainties and surprises'Interdependence—'Capacity to manage interdependence:to engage effectively with and handle multiple-andcross-scale dynamics' Legitimacy—'Capacity to build or develop legitimateinstitutions that are socially accepted and contextuallyadapted'Three levels of resilience:Absorptive capacity—'capacity of a health system to con-tinue to deliver the same level (quantity, quality andequity) of basic healthcare services and protection topopulations despite the shock using the same level ofresources and capacities'Adaptive capacity—'capacity of the health system actorsto deliver the same level of healthcare		resilience, concepts		of resilience domains for conceptual analysis studies. This captures resilience in terms of 4 management capacities and 3 levels of resilience. These are more about describing capacity to act and the level of action rather than providing a "pathway". However, the language/terminology could be directly adopted by RESYSTAL		

				services withfewer and/ or different resources, which requires mak-ing organisational adaptations'Transformative capacity—'the ability of health systemactors to transform the functions and structure of thehealth system to respond to a changing environment'						
ACTERRA	Seminar	CleanMed, 2021	''Designing Tomorrow's Healthcare'' Building into the Future	Example to frame and develop hospital buildings adapted to the impacts of climate change but also to reduce its effects.	Planners, policymakers, adaptation experts	Future Healthcare, future proofing, Healthcare Architecture, healthcare design, presentation	Healthcare building	Example of Health care architecture and plan adapted to climate change risk.	★	Yes

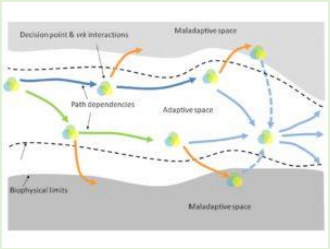
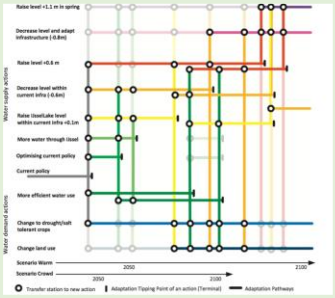
Scoring grid:

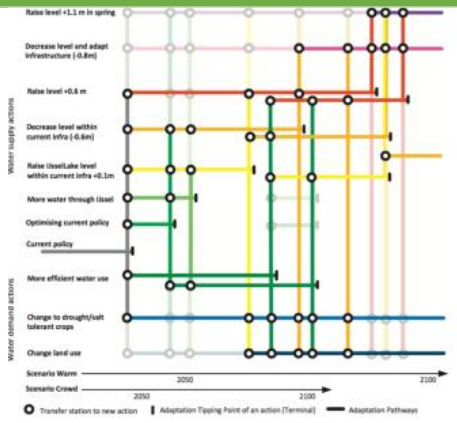
★★★ The document is very relevant for the objective of designing a methodology on adaptation pathways of hospitals and health systems. The document can be a direct source of support for drafting the methodology.

★★ This document is relevant because it provides ideas for building the methodology of adaptation pathways through similar themes or examples.

★ Document opening the reflection with examples a little more distant from our theme from which it is possible to draw a parallel with our project for hospitals and health systems.

Annex 2: Summary table on adaptive planning models & methodologies

A) Models of adaptive planning		
Approach 1 : Develop a simple action plan or start from a pre-existing action plan and increase its robustness by confronting it with possible futures and/or by setting up a contingency plan to be activated if / when the context changes.  ***Figure 8 Broad directions of change for different strategic aims and outcomes (Mendizabal et al., 2021)***	**<u>Robust decision making (RDM)</u>:** Confront a plan of action with a multitude of possible futures. - Identify the scenarios in which the plan works or fails. - Increase its robustness in an iterative way. The plan is implemented once it is judged to perform well in a satisfactory number of scenarios. (Computer modeling, thousands of possible futures to test plan performance) →static plan (does not evolve during plan implementation	**<u>Adaptive policy-making (APM)</u>:** Address a future project by tracking the evolution of the current context. Emphasis on monitoring the context, with **indicators that give an alert on the obsolescence of the action plan and pre-identified corrective actions** to be implemented if necessary. A signpost is associated with each vulnerability point in the plan, and critical values (triggers) are identified beyond which the plan must be adjusted.
Authors & Sources	USA, 80s by the RAND Corporation	RAND Europe in the Netherlands, early 2000s (Walker et al., 2001)
Approach 2 : Define a clear long-term vision that then guides the entire definition of the action plan, and identify alternative paths to get there. The focus is on decision making and flexibility in the decision making process.  ***Figure 98 Alternative Sequences of measures to realize a well-defined***	**<u>Adaptation pathways (AP) :</u>** Combination and sequencing of short/medium and long term adaptation actions to meet a given objective. Definition of **an objective** and then selection of **a set of actions** on the one hand, and on the other hand, the definition of **decision points from which a reorientation of the action** must be discussed. Use of **tipping points** and exploration of the different possible sequences of actions after this threshold as a decision tree.	**<u>Dynamic adaptive policy pathways (DAPP):</u>** Definition of the objective of the action plan & development of several alternative trajectories to achieve it. Trajectories evaluated in multi-criteria and the preferred one is selected. Implementation phase, setting up a double monitoring system: 1-Monitor the **occurrence of a threshold or tipping point** that leads to switch from one action to another on the selected trajectory (#AP) 2-Monitoring that the **selected trajectory remains relevant with regard to the evolution of the context** and adjusting it / correcting it or even changing the trajectory if the context requires it. (#APM) **→ Combination APM and AP**

adaptation objective (Mendizabal et al., 2021)		
Authors & Sources	**Thames Estuary 2100** as **"routemaps"** (Ranger, Reeder, 2011), and then conceptualized as **"pathways"** by researchers at the **University of Delft and Deltares** in the Netherlands for adaptation of the Rhine Delta to climate change (Haasnoot et al., 2012).	University of Delft and Deltares, Netherlands (Haasnoot et al., 2013)
B) Methodology for pathway development		
	 **9**	
	Process	**Method & Assessment**
Approach 1 : Performance-threshold oriented. **Outcome desired : Meeting short and long-term adaptation needs.** **Examples :** **- Thames estuary flood risk management planning (Ranger et al., 2013; Reeder and Ranger, 2011).** **- Adaptation planning for London's water supply system (Kingsborough et al., 2016).** **- Adaptation to sea level rise in Los Angeles (Aerts et al.,2018; de Ruig et al., 2019).**	Informs adaptation planning by providing **alternative sequences** of discrete adaptation measures in response to **different future scenarios.** Context : It is designed to address future adaptation needs in a **well-defined system of interest**: - Data rich context : where the goals can be quantified, and are little contested. - Clear mandate and agency of the decision makers -Adaptation goal is clearly defined. -Results are policy and government-actor oriented Assumption of satisfactory current system . -Adaptation is motivated by system performance dropping below a decisive level. This condition is called an adaptation **tipping point.** -Measures are organised incrementally into pathways to maintain performance	Tipping points and related actions are assessed with **respect to a specific performance metric** (mainly scientific knowledge regarding change in environmental/climate conditions). Typical iterative assessment steps: (i) Decision context. (ii) Vulnerabilities and opportunities. (iii) Identification and analysis of actions. (iv) Development and evaluation of pathways. (v) Design of an adaptive plan. The additional steps (vi) implementation and (vii) monitoring are usually outside research lifetime and not reported in case papers. In the final representation of pathways, **the decision context is reduced to a single climate metric against which the**

	under different climate scenarios. Pathways : - Evaluated quantitatively - Represented in a "route-map" : exemplifies the necessary actions for sustaining system performance. - Expert-driven	**performances of clearly identified** (controlling) measures are quantified.
Authors & Sources	Dutch Rhine Delta (Haasnoot et al., 2013), and London, United Kingdom (Kingsborough et al., 2016).	Kwakkel et al. (2016)
Approach 2 : Multi-stakeholder oriented. **→ Promoting collaborative learning, adaptive planning and adaptive capacity.** **Examples :** **-The Cauvery River Basin in Karnataka (India) Bhave et al. (2018)**	Focus on the social and institutional components of pathways development. It starts by acknowledging that adaptation plays out in a multi-stakeholder setting. Context : Instead of using hanges in environmental conditions as thresholds, they **identify thresholds that are important for local people.** Pathways : - Include multiple drivers and multiple stakeholders with conflicting goals, interests, and contested values. - Framed as the necessary management of risks for achieving societal goals and collective values. -Pathways maps reflect the output of a stakeholder process and qualitatively visualise selected pathways	Tipping points and related actions are assessed through a **stakeholder's engagement process to build consensus** while providing space for the recognition and inclusion of non-scientific knowledge Method to deal with different stakeholder opinions : - Each pathway represents the preferences of a particular stakeholder group. - Use of participatory methods. - Attention to multi-stakeholder interests, ambiguity and to the process. - Knowledge development designed to provide space for recognition and inclusion of non-scientific knowledge. - Promote collaborative learning and to build capacity for adaptive planning.
Authors & Sources	Barnett et al. (2014)	Bhave et al. (2018) ; Bosomworth and Gaillard, 2019

Approach 3 : Transformation oriented approaches. **→ Accounting for complexity and long-term change, including a potential need for transformation**	Broad directions of change that represent different strategic aims. Context : - **Multi-divers contexts** where an implementation deficit and the potential n**eed for transformational change** have been identified. -Still in support of the existing value set. -Do not assume current system performance to be satisfactory. Pathways: -Intentionally address a potential need to transform values and governance arrangements to enable adaptation. - Visualised as broad transformational directions of change.	Back-casting method : 3 steps - Identification of drivers of change - Participatory development of an aspirational vision and future scenarios of what could be - A normative back-casting process to identify and explore no-regrets strategies. Or Values-rules-knowledge framework: -Assess the multiple-drivers -Identify potential constraints to implementing pathways. Or Maru et al 2014, combine : -Short-term measures that address current disadvantages reflecting the vulnerability of communities - Long-term responses that focus on the resilience of the community
Authors & Sources	(Wise et al., 2014).	Butler et al. (2016a) ; Gorddard et al. (2016)
C) On steps to construct adaptation pathways		
4-step approach	Zandvoort et al., 2017	
4-step approach	Climate Risk Ready NSW Guide	
5-step approach	ADEME Guide méthodologique et outil TACCT : construire des trajectoires d'adaptation au changement climatique	

Annex 3: PPT presented by ACTERRA during the 4th technical meeting (March 31, 2022)

LIFE
RESYSTAL

CLIMATE CHANGE RESILIENCE FRAMEWORK FOR HEALTH SYSTEMS AND HOSPITALS

4th TECHNICAL MEETING

MARCH 31, 2022

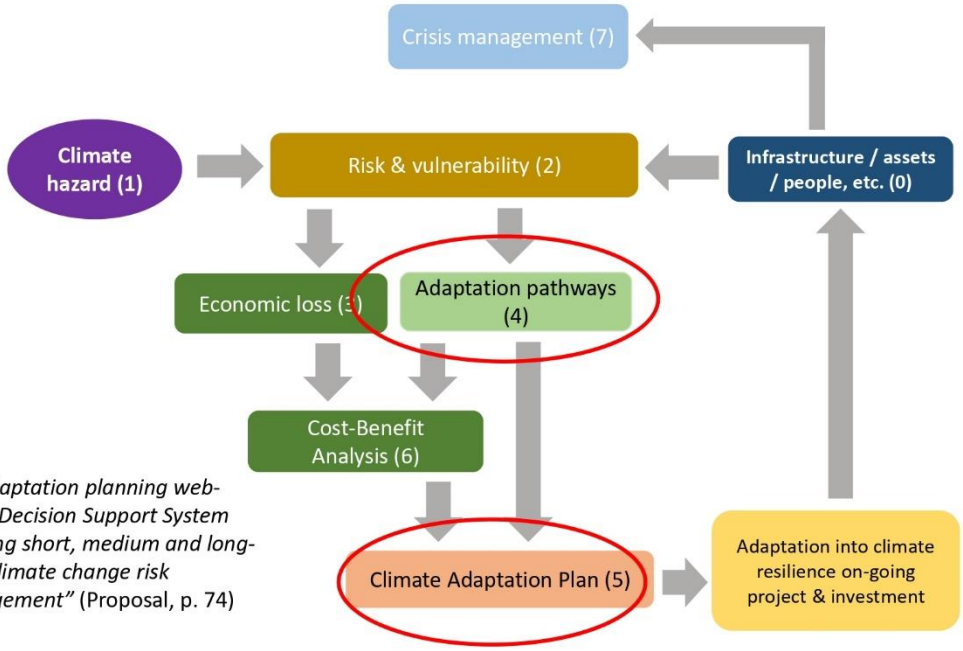
acterra
ENVIRONMENT CLIMATE CHANGE

Meeting objectives

1. Present and discuss the adaptation methodology for healthcare facilities that could be applied
2. Clarify the links between the modules and the input data needed
3. Agree on a timeline for the preparation of deliverable DA3.2

Confidential working document – Not for external distribution

Architecture of the toolkit (adapted from DA3.1)



"An adaptation planning web-based Decision Support System covering short, medium and long-term climate change risk management" (Proposal, p. 74)

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Overview of modules 4 & 5

Adaptation pathways (4)

"Using the data developed through the RV module, the AP module will enable dynamic and flexible adaptation planning accounting for the uncertainty of climate change scenarios. The proposed method is based on the principle of "adaptation pathways".

Climate Adaptation Plan (5)

"This module will produce an adaptation action plan sequenced over time. It will be derived from the adaptation pathway analysis (AP module) as well as the estimated avoided economic loss of adaptation measures (CBA module)".

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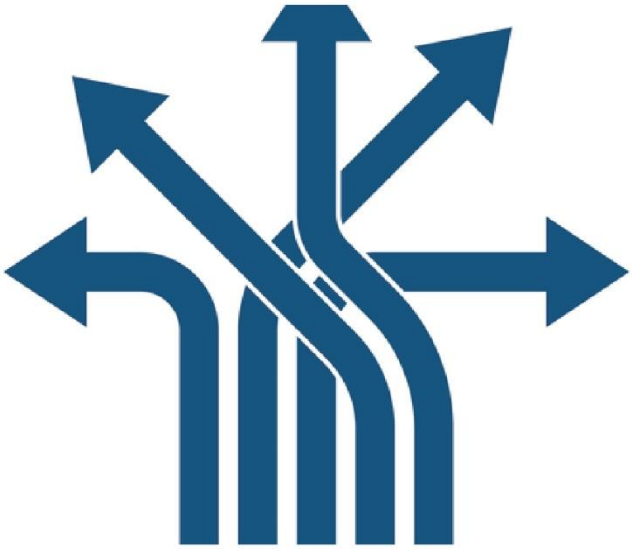
Adaptation pathways

Definition: "Sequences of actions, which can be implemented progressively depending on how the future unfolds and the development of knowledge."

Interest: Address one of the major issues faced by decision-makers → Climate change **Uncertainty. It represents a shift in the understanding of climate change adaptation from predicting impacts to understanding dynamic decision processes.**

Requirements: There is no common approach to the development of climate adaptation pathways → **It is a context and stakeholder-driven process.**



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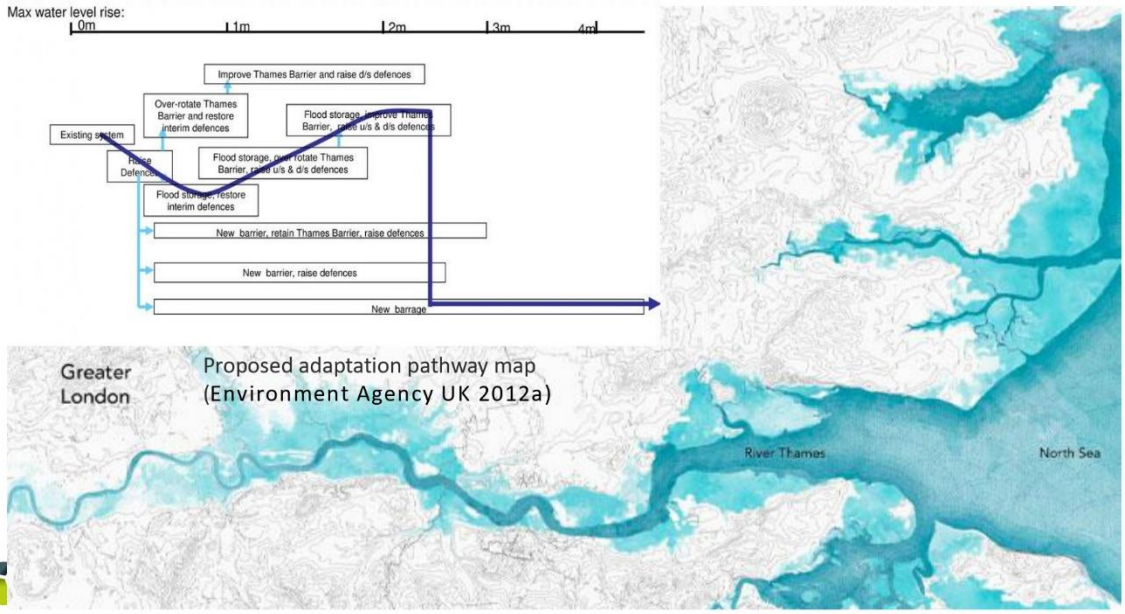
A seminal study on adaptation pathways: Thames Estuary



Overview of the methodology

OBJECTIVE: To identify and prioritize the adaptation measures by distinguishing the ones to be taken now (called 'no or low regrets interventions') and the ones which should be implemented once certain conditions occur.

7 steps:

Step 1: Identify the **climate-related risks faced by the healthcare facility(ies)**

Step 2: Assess the **current and projected levels of these risks**

} Interconnection with modules 0, 1 and 2 (NCSRD)

Step 3: Choose (a) relevant **indicator(s)** to measure and monitor this or these risks?

} There could be links with the monitoring activities (RINA)

Step 4: Identify qualitative and/or quantitative **thresholds** that indicate a change in conditions

Step 5: Set one or several **objective(s)**

Step 6: Identify **relevant solutions** (adaptation measures) to reach the objective(s)

Step 7: Assess the relevant of **each option** and prioritize them

} Interconnection with module 6 « Cost-Benefit Analysis » (RINA)

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Step 1 & 2: Identify & Assess the Risks

What is a Risk?

Possibility of adverse consequences for something of value. In the context of climate change impact assessments, the term risk refers to the **potential for adverse consequences of a climate-related hazard on livelihoods, assets, services, infrastructure, etc.** (IPCC, 5th Assessment Report – AR5, 2014)

Risk Factors:

Risk results from the interaction between:

- The **VULNERABILITY** of a given system (it encompasses two main elements: the **sensitivity** to harm and the **lack of capacity** to cope or adapt)
- Its **EXPOSURE** overtime to the hazard (i.e. the presence of people, species, infrastructure and critical assets in settings that could be adversely affected)
- The **HAZARD** i.e. climate-related physical events or their physical impacts

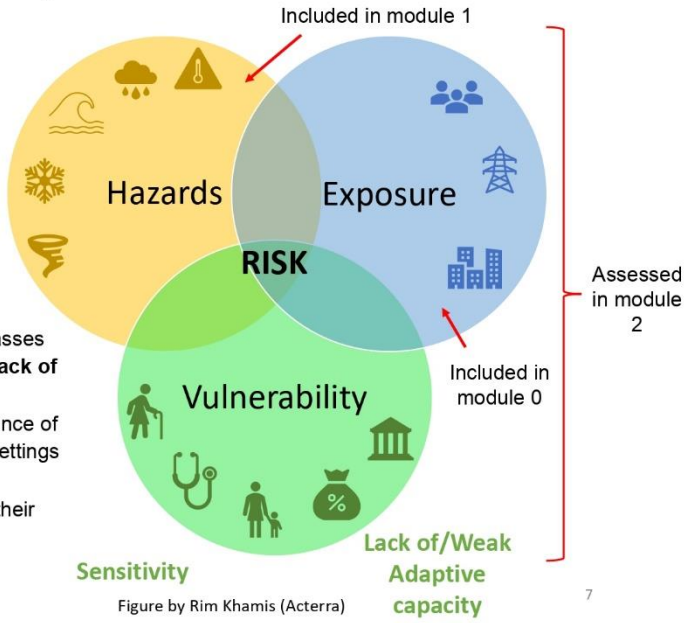

Figure by Rim Khamis (Acterra)

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Step 1 & 2: Identify & Assess the Risks

An <u>example</u> of climate-related risk for the General State Hospital of Nikaia, Greece (based on preliminary discussions)

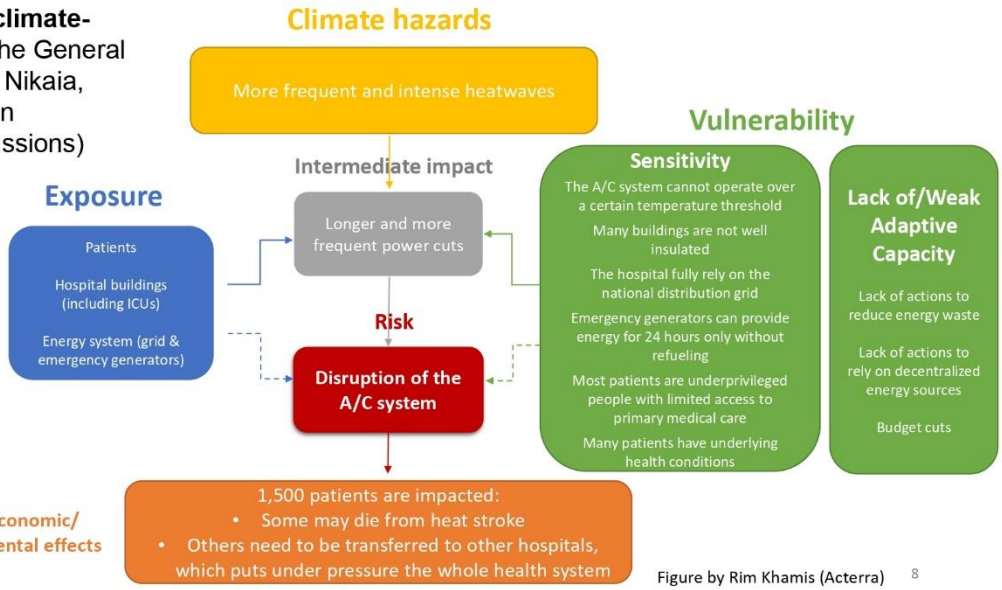

Figure by Rim Khamis (Acterra)

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Step 1 & 2: Identify & Assess the Risks

The risk assessment should provide information on:

- The current level of risk
- The future level of risk for different scenarios e.g.:
  - 2050 - **RCP 4.5** (Strong mitigation),
  - 2050 - **RCP 8.5** (Business as usual, etc.)

Climate-related risks could be identified using the distinction made in the survey questionnaire on hospital's resilience capacity:

- **Governance and leadership capacity**
- **Infrastructure capacity**
- **Crisis preparedness and management capacity**

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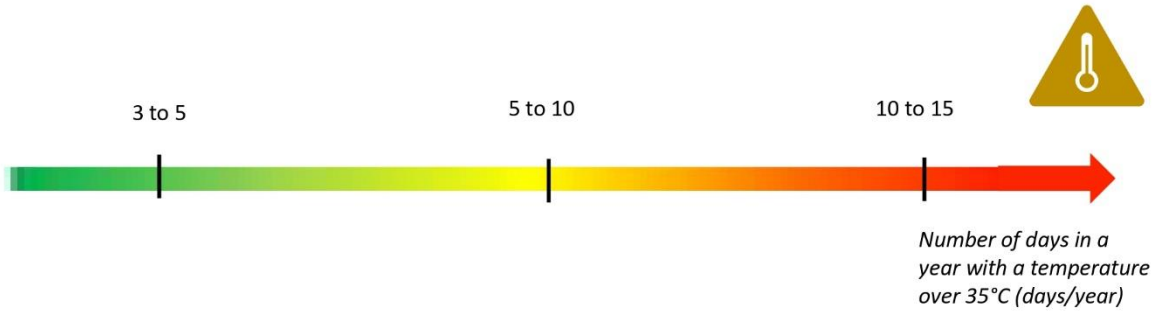
Step 3, 4 & 5: Indicators, Thresholds & Objectives

Risk of disruption of the A/C system of the Nikaia Hospital

Possible indicator: **Frequency heatwaves** => Number of days in a year where the temperature in the campus is > 35°C

Alternative indicator: Electricity consumption (KWh) / patients?

Alternative indicator: Temperature in the rooms during hot days?



Objective : Prevent A/C system disruption and maintain acceptable temperature in all rooms (including ICUs)

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Step 6 & 7: Assess Solutions and Prioritize Them

Adaptation measures can be identified through a climate risk assessment. They are are the ones that:

- Reduce exposure
- Reduce sensitivity and increase adaptive capacity (reduce vulnerability)

Array of adaptation measures :

- ❑ Perform an energy audit
- ❑ Create a tool for real time energy monitoring
- ❑ Upgrade the buildings to increase heat insulation
- ❑ Purchase batteries to stock electricity in case of an energy peak
- ❑ Increase the stock of oil for the emergency generators
- ❑ Develop new buildings that rely on Cold district heating technologies using the cold water of the nearby watercourse
- ❑ Etc.

no or low regrets interventions that can be implemented from now on

Highly costly interventions, that need to be sequenced over time

More work (desk review, benchmark, discussions with hospitals) needed to identify relevant adaptation actions and assess their implementing condition.

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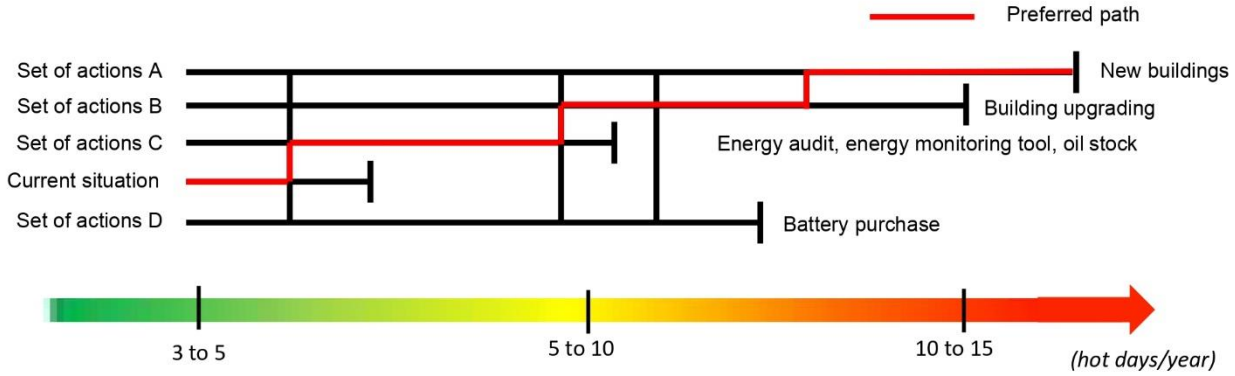
Step 6 & 7: Assess Solutions and Prioritize Them



Set of actions A & B: Robust actions but require large capital or would have ramifications on social/economic systems.
Set of actions C: short term action – easily implemented / allow to buy us time but do not have a long shelf life
Action D: medium term action

⊣ Indicates that action is no longer valid/viable (has reached its "tipping point")

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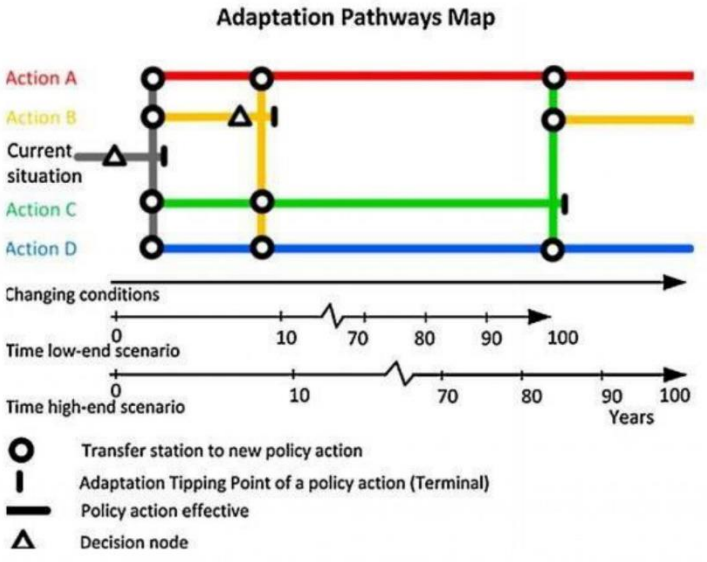
Step 6 & 7: Assess Solutions and Prioritize Them

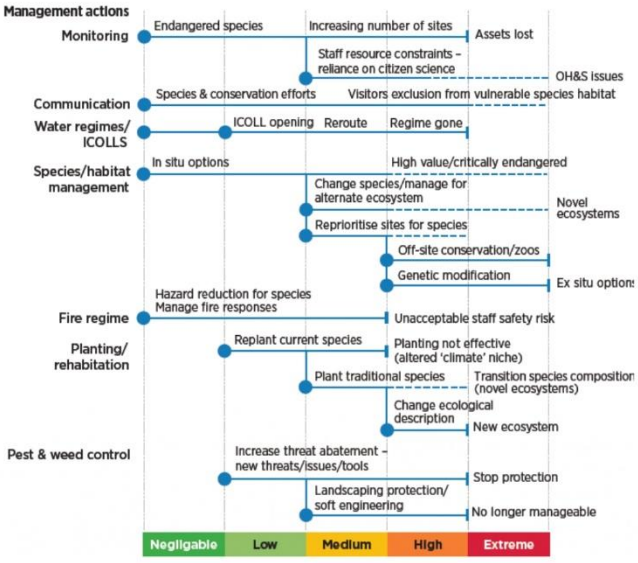
Typical adaptation pathway map



Example of adaptation pathway map with several indicators and objectives

Biodiversity conservation pathway in the New South Wales reserve (Australia)

(Jacobs et al., 2018)



Step 6 & 7: Assess Solutions and Prioritize Them

Each pathways / set of actions would need to be assessed based on several criteria :

- *Effectiveness:* how much can this action reduce the risk? This can be assessed by **measuring the avoided economic loss of the adaptation measures**
- *Feasibility:* to what extent can its implementation be hampered by technical, regulatory, or institutional barriers?
- *Flexibility:* to what extent can this action be adjusted in the event of changing conditions?
- *Synergy* with other actions
- *Cost* of the actions
- Etc.

} Performed by RINA (Module 6)

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Next steps

To be clarified:

- With NCSRD:
  - Interconnection between modules 2 and 4 (input data…)
  - Format of deliverable DA3.2 led by NCSRD
- With RINA: Interconnection between module 3, 4, 5 and 6 (input data…)
- With UCAM: Support to (i) further elaborate the adaptation pathway methodology for healthcare facilities and (ii) identify relevant adaptation actions, building on hospital experience (benchmark)
- With CRISISOFT: Support to identify actions to enhance the crisis management capacity of hospitals

Proposed timeline:

- April 30th: First draft of the specification document for modules 4 & 5 (as part of DA3.2)
- Between April and June: Final version of the specification document for modules 4 & 5
- June 30th: DA2.2 “Guidelines to develop adaptation pathways” that will include a list of adaptation measures

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Annex 4: Technical specification document for the web-based adaptation planning tool