Task 3.2 Design a portfolio of interventions

Task 3.2.1 Formulate pathways to climate resilience

What is this task about?

This task involves the formulation of adaptation pathways to help realise your region's climate resilient shared vision (Task 2.3.1). In practice, this consists of sequencing the prioritised adaptation options (Task 3.1.2) over time, before using these sequences to identify the future key adaptation decision moments for your region. Options are sequenced and assessed for their cumulative performance against your primary adaptation objectives (i.e. to manage risks, defined in Task 1.2.1) as conditions continually evolve according to the assumed Theory of Change (Task 2.4.1).

Sequencing is also important to ensure that options match with the available resources in the region. The resulting pathways should inject and illustrate the flexibility present in your adaptation planning. In practice, this means that short-term measures should ideally leave multiple options open to scale up adaptation action in the future as climate and socioeconomic conditions evolve. Engage your stakeholders in the pathway formulation processes as per your stakeholder engagement strategy (Task 2.1.1).

This involves:

- **Selecting promising** – and preferably 'low-regret' – adaptation options (e.g. climate smart decisions, adaptive measures) to implement in the short-term and identifying (and, where possible, quantifying) their adaptation limits (i.e., the conditions under which an option will no longer achieve the primary adaptation objectives).
- **Selecting additional adaptation options** to be implemented when the adaptation limits to the short-term options are reached or when new opportunities emerge (e.g. technological progress, policy change, or shifts in socioeconomic conditions).
- **Continually iterating;** identifying the next options to be implemented and their associated adaptation limits until you also consider options which will be effective under long-term and more extreme scenarios (developed during Task 1.3.1).

The task should be completed in parallel with Task 3.2 of the Adaptation Investment Cycle.

Task 3.2 Design a portfolio of interventions

Task 3.2.1 Formulate pathways to climate resilience

Why is it important?

The formulation of adaptation pathways supports flexible, robust and proactive long-term planning. Adaptation pathways acknowledge that the future is uncertain and allow for strategic adjustments to be made through time as conditions evolve and new information becomes available or as conditions evolve. They progress your region towards realising its vision – regardless of the climate or socioeconomic conditions that emerge – by scaling up adaptation action as needed. They are therefore capable of responding to the assumption present within your Theory of Change (Task 2.4.1).

Adaptation pathways enable more robust decision-making by assessing the ability of pathways to achieve set risk reduction goals across the plausible range of future conditions. This makes investing in adaptation more financially feasible by distributing these investments over time. It also minimises the chances of being 'locked-in' to an adaptation trajectory that is unsuited or otherwise maladaptive to the key drivers of risk. Formulating pathways encourages you to consider which adaptation options are more compatible with each other (and which are not), as well as which options are reversible, easy-to-adjust and/or scalable to the future climate or socio-economic conditions that may emerge.

Explainer: Adaptation pathways

What are they?

Adaptation pathways are sequences of adaptation measures to flexibly address climate risks through time.

Adaptation pathways are flexible, dynamic sequences of options designed to address uncertain climate risks over time. They ensure that planning objectives are met as conditions evolve, making them ideal for decision-making in deeply uncertain environments with potentially significant future climate impacts (Mendoza et al., 2018). Initially developed for water management (Haasnoot et al., 2013), adaptation pathways have since been applied across various sectors, including water resources, coastal and flood management, agriculture, forestry, climate mitigation, natural resource management, sustainable development, transport, and urban planning (Haasnoot et al., in review).

Multiple adaptation pathways can achieve long-term goals, each with distinct benefits and trade-offs. These pathways include short-, medium-, and long-term adaptation options, with the flexibility to switch courses as conditions change. Short-term measures—often low- or no-regret adaptation options—are implemented immediately, while medium- and long-term options are reserved for future risks, deployed

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Design a portfolio of interventions

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as needed based on how conditions unfold. If greater change occurs, more impactful measures may be required; if change is less severe, fewer measures may suffice.

How are they visualised?

Adaptation pathways can be visualised in an adaptation pathways map – a metro-map-inspired infographic that indicates the potential adaptation limits associated with each measure (sequence) as the conditions change. Alternative pathways can be evaluated using a variety of evaluation methods including scorecards, multi-criteria analysis, or cost-benefit analysis. The below figure shows an example pathways map with scorecard.

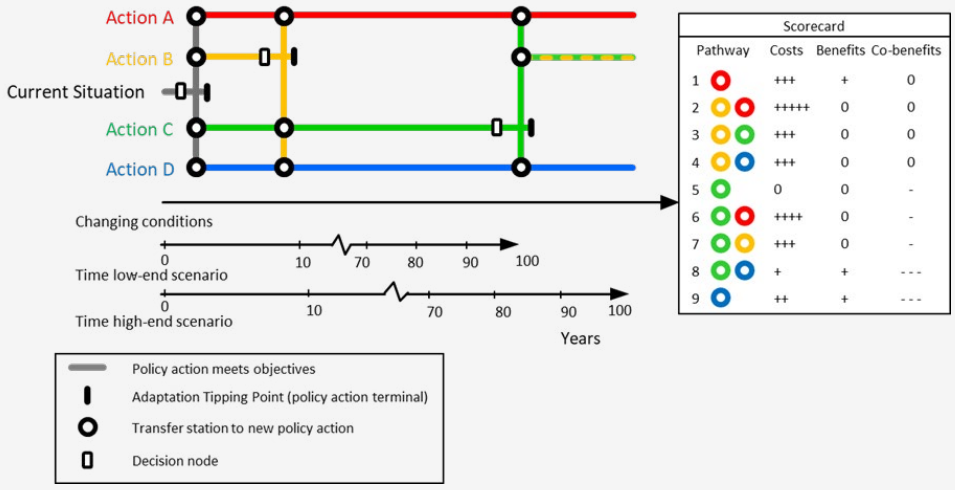

Figure 12: Typical metro-map to visualise adaptation pathways, including symbols to indicate transfer stations from one adaptation measure to another, adaptation limits (or tipping points) or effectiveness of each measure (sequence), and decision nodes to indicate the timing of the associated adaptation decision in recognition of the next measure's lead time (adapted from Haasnoot et al., 2013)

References

Mendoza, G, Jeuken, A, Matthews, J, Kucharski, J, Gilroy, K, Ray, P, Brown, C (2018). Climate Risk Informed Decision Analysis (CRIDA) - Collaborative water resources planning for an uncertain future.

Haasnoot, M, Kwakkel, JH, Walker, WE, ter Maat, J (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world, Global Environmental Change, 23 (2), 485-498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

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Task 3.2 Design a portfolio of interventions

Task 3.2.1 Formulate pathways to climate resilience

How can you complete it?

You can choose to develop qualitative, semi-quantitative or quantitative adaptation pathways. The steps to be followed to develop pathways are similar in all three cases; and are outlined below. Draw your options from which to build your pathways from the list you prioritised in Task 3.1.2 and with reference to both your shared vision (Task 2.3.1) and Theory of Change (Task 2.4.1).

- **Characterise your promising adaptation options** as either short-, medium- or long-term – based on the level of potential regret attached to the option; the timing of the risks (from Task 1.3.1); the effectiveness of the option in reducing risks; the implementation feasibility of the options (from Task 3.1.2); as well as when the costs and benefits will arise (from Adaptation Investment Cycle Task 3.2).
- **Identify potential adaptation limits** for the considered adaptation options. These are points at which further adaptation will be required. Estimate/calculate potential timings for these conditions being reached in the various risk-based scenarios (developed in Task 1.3.1).
- **Explore logical combinations of short-, medium- and long-term options**, thereby building alternative pathways to address risks into the future.
- **Visualise your pathways alternatives** in the form of a table, metro-map, or similar. Use this visualisation to identify those moments in time when key adaptation decisions will need to be taken. That is, when a decision must be made relating to the overarching strategic direction that may lock out other options.

An example characterisation of options (including identification of adaptation limits) is shown overleaf in Table , while example pathways visualisations are provided in ***Appendix D13.***

For the Investment Plan development, Adaptation Investment Cycle Task 3.2 emphasises the economic and financing considerations for prioritising and sequencing options according to their relative benefits, costs and timing for these effects being experienced. The assessment undertaken in Adaptation Investment Cycle Task 3.2 should be completed in parallel with the characterisation activity in this task. Further information on the economic and financing aspects of sequencing options is provided in Task 3.2 of the Adaptation Investment Cycle guidance.

Further detailed technical guidance on completing this task, along with useful tools and methods, can be found in ***Appendix D13.***

Food for thought: Whether you develop qualitative, semi-quantitative or quantitative pathways depends primarily on two factors: (1) availability of data and models to calculate the indicators associated with your primary adaptation objectives for each option (i.e., the extent to which quantification is possible), and (2) the degree of quantification required to take the investment decision to commence implementation of your pathways. Quantitative assessments may help to build confidence in the pathways, but this is not always possible to perform given time, data, capacity and budget constraints.

Consider to what extent will quantifying the effects of your options and pathways change the outcomes of your analysis?

Task 3.2 Design a portfolio of interventions

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What are key inputs for the task?

- Updated problem framing (Task 1.1.2)
- Climate Risk Assessment (Task 1.3.1)
- Shared vision for climate resilience (Task 2.3.1)
- Theory of Change (Task 2.4.1)
- Prioritised list of assessed options (Task 2.3.2)
- The assessment of economic and financing sequencing considerations identified in Task 3.2 of the Adaptation Investment Cycle Guidance (completed in parallel)

What are the expected outputs?

The key outputs from this task are a set of alternative adaptation pathways which could be implemented to reach and/or maintain your adaptation objective(s). We recommend you also visualize all pathways alternatives, to aid in stakeholder communication. The pathways should all perform similarly in terms of your adaptation objective(s) (i.e. they should sufficiently address your climate risks). But they may perform differently in relation to your secondary planning objectives and may even negatively impact some of these. Such trade-offs are explored and evaluated in Task 3.2.2.

Before moving on, have you...

- [ ] Identified key short-, medium- and long-term adaptation options?
- [ ] Assessed the limits of each adaptation option, at least in qualitative terms (relative timing of adaptation limits for all options under increasing climate change)?
- [ ] Developed multiple sequences of adaptation options that address adaptation needs in the short-, medium- and long-term, resulting in a set of alternative pathways to evaluate in the next task?
- [ ] Visualized the pathways alternatives in a comprehensible way, for communication to stakeholders?

Table 5: Example initial (qualitative) sequencing approach to adaptation pathways for flood risk management.

Options		Adaptation criteria					Economic criteria				Pathways Input		
Name	Option type	Potential regret	Adaptation effectiveness*	Timing of adaptation limit*	Indicative co-benefits**	Lead time ***	Urgency of action	Indicative economic benefits	When costs arise	When benefits arise	When should the action happen?		
											Short	Med	Long
Early warning system extension	No regrets	Low	Exposure reduction (casualties): Med	Expected annual casualties > threshold: 2035	Addresses social vulnerabilities: **Low**	1 year	High	High	Now	Now	⊗		
Resettlement with coastal and river planning	Adaptive management	High	Exposure reduction (damages): High	Flooding EAD > threshold: 2100+	Climate smart spatial planning, addresses social vulnerabilities, restores coastal/river biodiversity, etc.: **High**	25+ years	Low	Medium	Future	Future			⊗
Climate proof highways	Climate Smart	Low	Exposure & Vulnerability reduction (damages): High	Flooding EAD > threshold: 2075	Maintains transport corridors and associated economic activities, aids in disaster response/ recovery: **Med**	5 years	High	High	Now	Future	⊗		
NBS in built environment	No regrets	Low	Hazard reduction (runoff, delays flood peaks): Med	Flooding EAD > threshold: 2045	Restores biodiversity, addresses heat stress, provides public recreation areas, etc.: **High**	10 years	Med	Med	Now	Now		⊗	

** Risk reduction impacts and timings can be expressed either quantitatively or qualitatively depending on your selected assessment methodology. Separate impact assessments should be completed for each option against each of the primary adaptation objectives.*

*** Secondary impacts can be expressed either quantitatively or qualitatively depending on your selected assessment methodologies. Separate impact assessments may be completed for each option against each of the secondary resilience objectives.*

**** Lead time refers to the length of time to address any implementation feasibility concerns and/or for the likely emergence of favourable opportunity conditions (based on analyses completed in Task 3.1.2)*

D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

You can choose to develop qualitative, semi-quantitative or quantitative adaptation pathways. The steps to follow when developing pathways are similar in all three cases, however each case typically applies different methods and resources.

The type of analysis you perform largely depends on the availability of data and models to calculate effects of concern for the options and pathways (i.e. the extent to which quantification is possible). For a quantitative analysis to be feasible, you need to be able to model the selected options making up the pathways using the same risk assessment tool you applied in Task 1.3.1. However, your choice also depends on the degree of quantification required for your region to take the investment decision to commence implementation of the pathways. Quantitative assessments may help to build confidence in the pathways, but this is not always possible to perform given time, data, capacity and budget constraints. The key question to consider is: to what degree will quantifying the effects of your pathways change the outcomes of your analysis?

Pathways are developed in the following steps:

Characterise your adaptation options as short-, medium- and long-term:

Commencing with the pre-selected options (Task 3.1.2), characterise every option based on whether these are more useful in the short-, medium- or long-term.

- Short-term options tend to be low-regret, relatively easy to implement and often a continuation or upscaling of already implemented measures. They also often tend to require smaller investments.
- Medium-term options are those to be implemented when the short-term options have reached their adaptation limits. They often have longer implementation lead-times and may not yet have been included in any existing plans.
- Long-term options are those to implement when the medium-term options have reached their adaptation limits. These should be able to cope with any projected extreme climate change impacts.

To inform this characterisation, initially assess the performance of each adaptation option against the prioritised adaptation objectives using your appraisal from Task 3.1.2. To what extent do you think each option will contribute to reaching the objectives and maintain them under growing climate and socioeconomic impacts?

An example characterisation of options is shown in Table presented in the main guidance for Task 3.2.1.

D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

Identify potential adaptation limits:

Identify any limits for your considered adaptation options. These are conditions under which additional adaptation will be required. Identify the conditions under which unacceptable performance will occur, and estimate/calculate potential timings for these conditions being reached according to the risk-based scenarios (developed in Task 1.3.1). The methods with which you complete this activity differ depending on the type of analysis to be undertaken.

Qualitative analyses

In a qualitative analysis, compare how each adaptation option contributes to reaching your prioritised adaptation objectives. Your initial appraisal from Task 3.1.2 can again inform this analysis. Consider whether there are any limits to their effectiveness as climate and socioeconomic conditions change. Under what types of conditions will each option no longer be sufficient to achieve the adaptation objectives? Which options do you expect to reach their limits first? Which options do you expect to be effective for longer? How do the limits of the various options relate to each other? Depending on your specific adaptation objectives, establishing limits to certain options may be straightforward, e.g. a dike will reach its limit when the maximum water level exceeds the protective capacity of the dike. In other cases, it may not be possible to easily assess the limits of specific options. In this case, make a relative assessment of the different options, and determine the order in which you believe each of the short-, medium- and long-term options will reach their limits. Relate these limits back to your future climate risks assessed in the CRA to estimate their approximate timing (range).

Insight: When identifying long-term options, try not to think about whether the extreme scenarios in which they might be needed are realistic in the short-term, or even when these might occur, but instead focus on what you could do if these impacts were experienced in your region. This may lead you to consider larger-scale, more transformational options for inclusion in your pathways. While these may not be feasible in the short term, their suitability in addressing longer-term challenges will have been recognised, such that the necessary time, effort and resources can be placed in overcoming any barriers to their implementation if they are needed in the end. Additionally, the implementation of some measures may be sped up by specific opportunities for adaptation. These are the manifestation of the future conditions under which certain adaptation measures may become more attractive, identified in Task 3.1.2.

D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

Semi-quantitative analyses

As in the CRA, semi-quantitative methods tend to elaborate qualitative assessments by applying a scoring system to assess the relative risk reduction effectiveness of the options. These scores can be informed by either expert judgement, quantitative modelling, or a combination of both if different options demand different assessment methods. Similar to the qualitative analysis above, once the options have been scored, use these to establish corresponding adaptation limit scores for each option. Do so by relating the option scores back to the (scored) magnitude of your future climate risks as per your CRA (Task 1.3.1). Use the climate risk scenarios (Task 1.3.1) to determine an approximate timing (range) for when you expect each of the short-, medium- and long-term options to reach their limits.

Quantitative analyses

Use the same quantitative modelling tools applied in Task 1.3.1 to assess the risk reduction impacts of each of your options according to your assessment metrics. Use the models to calculate the adaptation limits for each option. In instances where you are calculating multiple performance metrics for a given adaptation objective, the adaptation limit corresponds to the metric that breaches its acceptable performance threshold soonest. Note that the governing metric can change under different sets of scenario conditions. As with the CRA, adaptation limits can be established through interpolation, incremental stress-tests, or statistical means as appropriate. Having established the adaptation limit, apply your climate risk scenarios (Task 1.3.1) to determine timing projections for when each limit is reached in each scenario.

Adaptation limits for options are specified in two ways:

1. The conditions under which the limits are reached, and which are closely associated with your key drivers of climate risk (Task 1.2.1). For example:

- When your adaptation objective relates to flood management at the coast, you could express the condition in terms of cm of SLR
- When your adaptation objective relates to managing extreme heat, a useful metric could be average night temperature
- When your adaptation objective relates to drought management, a potential metric could be number of consecutive dry days.

In situations where you cannot identify the specific conditions under which adaptation limits are reached, you may instead choose to identify 'perceived' limits together with relevant stakeholders. Such limits represent what stakeholders perceive as (in)tolerable within the system of interest. For example, in the domain of flood risk management:

- *Number of floods per year*
- *Number of temporary evacuations per year, etc.*

2. The range in time when these will be reached (depending on the different climate and socio-economic scenarios). For example, an existing levee may be able to prevent floods up to a certain water level (condition), but the timing when that specific water level is reached (through a combination of e.g. SLR, increased river discharge, tides, storm surges…) will depend on the specific climate impact scenario that is taken into account, and will occur much sooner in scenarios based on RCP8.5, rather than those based on RCP6.0, RCP4.5 and RCP2.6.

D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

Explore logical combinations of short-, medium- and long-term options:

Build your adaptation pathways by sequencing and/or combining your short-, medium- and long-term options. Your objective is to formulate pathways that are capable of managing your climate risks in line with how you expect these risks to develop over time. This means that (combinations of) your short-term options need to be sufficient to address your current risks in the short-term, (combinations of) your short- and medium-term options need to be sufficient to address your potential risks in the medium-term, and (combinations of) your short-, medium- and long-term options need to be sufficient to address your potential risks in the long-term, even against the most extreme risk projections you are assessing.

When formulating your pathways, consider which sequences of options are most compatible which each other, which options can be implemented in combination with others, as well as which options are mutually exclusive. In some pathways, you may wish to include a single short-, medium- and long-term option, while in others you may wish to combine multiple short-, medium- and/or long-term options together. Let logic and stakeholder preferences dictate your selections, but we do recommend that each pathway also includes longer-term options. This will ensure that the alternative pathways all continue to achieve the adaptation objectives under extreme climate change and help to avoid lock-in situations. Keep in mind the cumulative risk reduction effects of your pathways as you build them. For example,

If short-term option A is extended with option B in the medium-term, will their combined effects be sufficient against the entire medium-term time horizon, or do I need to supplement them further?

To this end, analyse each option combination in terms of its sequential, cumulative risk reduction effects as each new option is added to the pathway. As far as possible, estimate/calculate any new adaptation limits associated with these. For qualitative and semi-quantitative analyses, you will need to estimate these effects via expert judgement. Consider this,

If option A reduces risks by X amount, and option B reduces risks by Y amount, what will be the combined effects of A and B? Is it X+Y, or more/less than this?

For quantitative analyses, one can calculate these effects and estimate any new tipping points directly, given the ability of the applied models to model the adaptation options and pathways being considered. Quantitative analyses also offer the advantage that one can use your models to directly build up your pathways in line with the changing risk projections.

Food for thought: Some quantitative analysis methods can be resource intensive and demand specialised skills and capabilities. Only embark on such analyses if you have the necessary resources available and if this level of detailed analysis is required by your region to be able to take its investment decisions.

Consider to what extent will quantifying the effects of your options and pathways change the outcomes of your analysis?

D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

At this stage, try to build as many logical alternative pathways as possible. When picking 'logical' pathways, you could choose to prioritise different outcomes. For example, you can develop pathways according to:

- the most effective measures in terms of risk reduction
- the cheapest measures
- the least environmentally destructive measures
- the most effective measures in terms of delivering the greatest co-benefits, etc.

Visualise your pathways alternatives:

Visualise your pathways according to whether you have carried out a qualitative, semi-quantitative or quantitative assessment.

Qualitative analyses

Visualise each of the pathway alternatives you developed in the previous step as sequences of options or clusters of options over time. Make sure to distinguish between short-, medium- and long-term options and highlight the points at which one option is no longer sufficient and is thus substituted/supplemented with the next ones. If you have identified any specific adaptation limits to any of the options, add these to your pathways visualisation. An example of how you could visualise your pathways at this level of detail is provided in Figure D13.1.

Semi-quantitative & quantitative analyses

Visualise each of the pathways alternatives you developed in the previous step as a so-called 'pathways map' (Deltares, n.d., see figure in the explainer below). This is a visualisation technique which allows to showcase adaptation pathways in a way that is similar to metro-maps used in large cities. This approach to pathways visualisation permits the inclusion in the map of the timing and/or conditions under which the adaptation limits are reached. These visualisations look the same for both semi-quantitative and quantitative analyses, the only difference being how you determined the adaptation limits for the different options and their combinations in previous steps. You can use the tools mentioned below to guide you in the visualisation. Alternatively, you can also simply sketch the pathways alternatives on paper and/or using digital drawing tools, such as Microsoft Visio, or Miro.

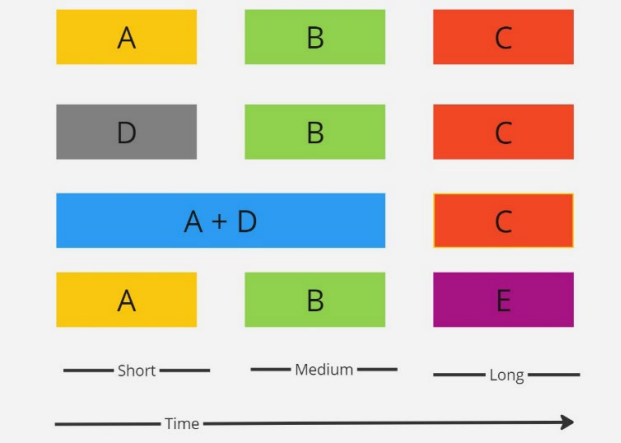


Figure D13.1: Qualitative visual representation of alternative pathways

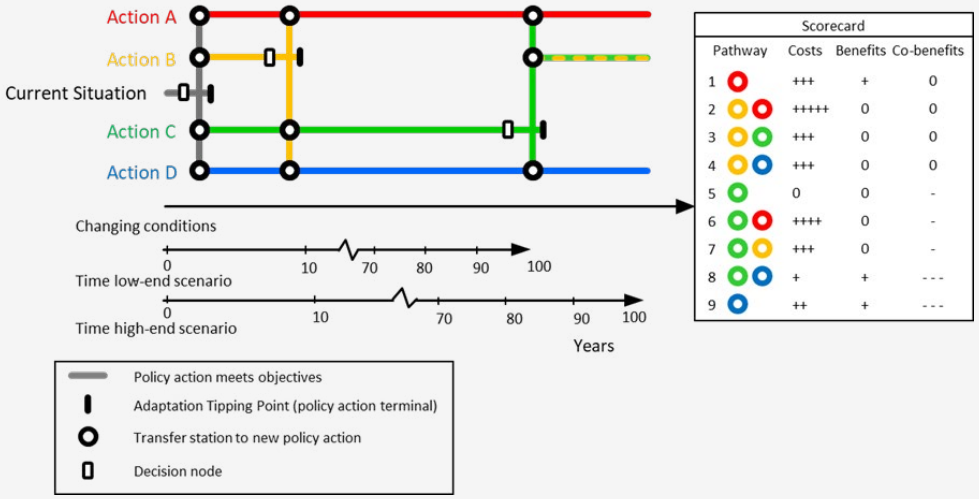
D13. Task 3.2.1 Formulate pathways – Technical guidance on how to complete

Explainer: Reading a pathways map

Consider the below coastal example where Action A involves constructing a sea wall, Action B entails sandbagging vulnerable households during high tides, Action C focuses on beach replenishment, and Action D enforces setback lines. Action A has three possible transfers: one from the current situation (grey line), one from Action B (yellow line) when its adaptation limit is reached, and another from Action C (green line) when it reaches its limit.

There are two types of transfers: one where the subsequent intervention replaces the previous one, and another where it supplements the existing measure. A solid colour transfer on the map indicates a replacement. For instance, the transfer from Action C to Action A (solid red) shows that Action A has replaced Action C. In contrast, the transfer from Action C to Action B (yellow/green) indicates that Action B complements Action C, which remains in effect.

Pathways maps typically includes multiple timing axes below them, reflecting the uncertainty around when specific conditions will arise under different climate risk scenarios. While the conditions requiring action are relatively clear, their timing is uncertain. The map helps clarify what is known and what remains uncertain.



Typical metro-map to visualise adaptation pathways, including symbols to indicate transfer stations from one adaptation measure to another, adaptation limits (or tipping points) or effectiveness of each measure (sequence), and decision nodes to indicate the timing of the associated adaptation decision in recognition of the next measure's lead time (adapted from Haasnoot et al., 2013).

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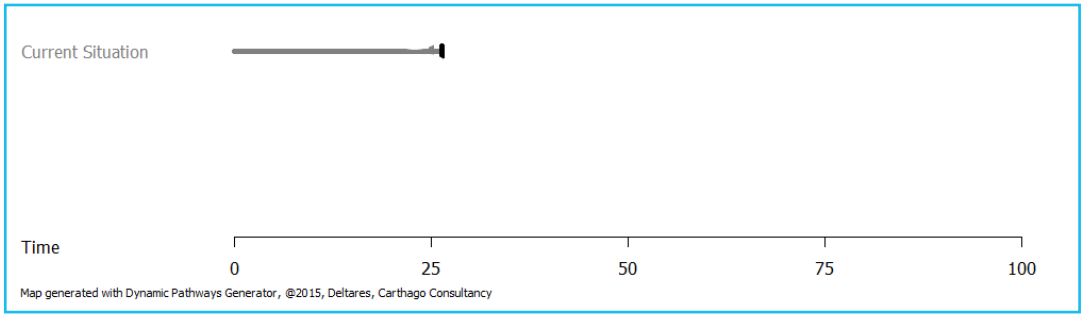
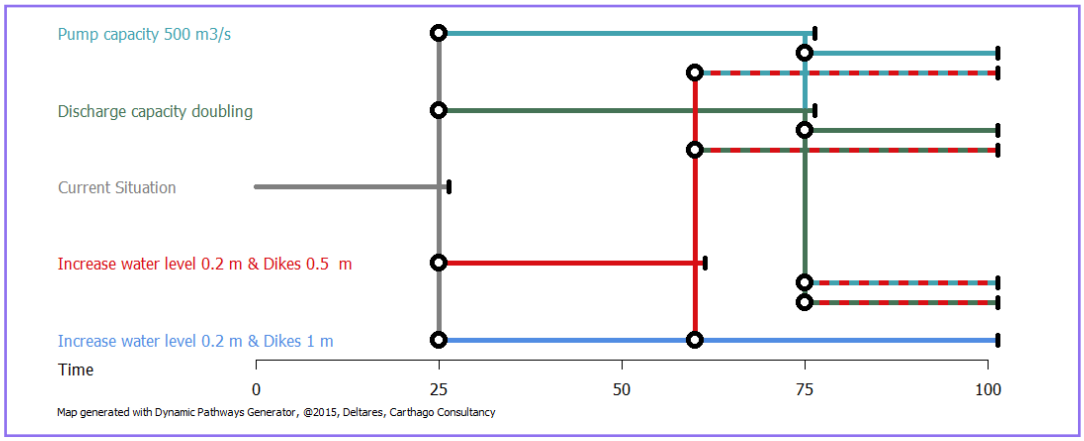
When building a pathways map, commence by drawing your x-axis, which can be described as time, and/or as changing conditions (depending on the manner in which you described you adaptation limits in earlier activities). You will fill in your map from left to right. Start by including one short line at the left border, which will indicate your current situation. Indicate the estimated/calculated adaptation limit of the current system with a short perpendicular line at the end of the line you just traced. The figure below provides an example of this in which the current situation reaches its adaptation limit after 25 years.



Add additional/alternative adaptation options to be implemented when your current system reaches it adaptation limit. The vertical lines connecting two or more measures indicate transfers between measures. Be sure to account for any lead times for any of the options. In the example shown below, there are four alternative options to manage drainage in a polder. For each option, indicate its adaptation limits as you have done before.



For those options which are not effective in the medium- to long-term (in the example, from top to bottom, options 1, 2, and 3), add options to be implemented when these reach their adaptation limits. Continue doing so in steps until all pathways are effective against the entire extent of the x-axis. In the below example, options in two colours indicate the simultaneous combination of two measures, whereas solid lines indicate single options that have replaced their predecessors. You can also choose to visualise your pathways differently if you wish.

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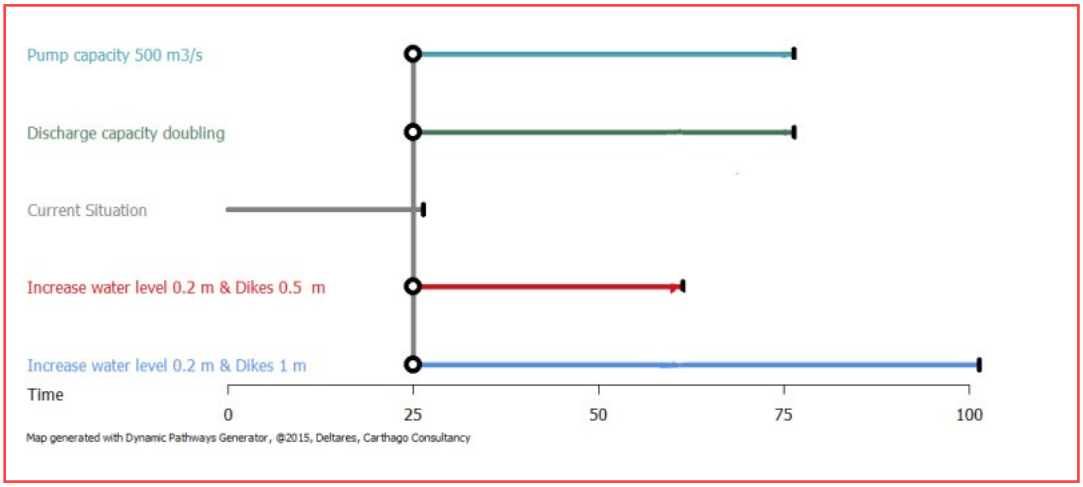

Once you have formulated all your pathway sequences, you are left with a complete pathways map. Your map may be larger or smaller, and more or less complex than the above example, depending on how many different alternative pathways you have identified and from how many individual measures each pathway is comprised.

Once complete, use your visualisation to identify those moments in time when key adaptation decisions will need to be taken. That is, where a decision must be made relating to the overarching strategic direction that may lock out other options. In the above example, we can see the last option (increase water level 0.2m and raise dikes 1m) could be considered a lock-in. Once implemented, there is no option to divert course to another option. Hence, a key decision moment occurs at around T=60, when the decision to implement that option as opposed to others must be made.

Supporting resources:

Useful tools

- Pathways generator
- Resilience pathway visualisation tool

Useful methods

- Stakeholder workshop
- Adaptation tipping point (ATP) analysis
- Literature review