



Regional Resilience Framework Tools

DECEMBER 2023

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sandag.org/LanguageAssistance | 619.699.1900

Prepared by
DUDEK
605 Third Street
Encinitas, California 92024

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An aerial photograph of a coastal city, likely San Diego, featuring a multi-lane highway with traffic, a residential area with many houses, and a body of water in the background. The sky is dramatic with purple and blue hues. A large white number '1' is inside a dark blue circle in the top left corner.

1

Adaptation Pathways

CONTEXT

Using the California Adaptation Planning Guide (APG), many jurisdictions have developed climate adaptation plans with strategies to build resilience and adapt to climate change. However, the uncertainty around when climate change impacts may occur can make it difficult to determine when to implement strategies, and which strategies to prioritize given limited funding and staff time. To address this challenge, this Adaptation Pathways Guide shows how to use climate change impacts (such as the number of heat waves or flooding frequency) to guide when strategies should be initiated. This tool is part of the San Diego Association of Governments (SANDAG) Regional Resilience Framework (Framework), which provides guidance and best practices to member agencies to promote holistic regional climate adaptation planning and tools for multiple climate hazards.

The concept of adaptation pathways has been widely used to support sea level rise adaptation, but it has not often been applied to address other hazards, such as inland flooding, wildfire, and extreme heat. This guide takes the example of extreme heat in a hypothetical city where extreme heat days are projected to increase substantially due to global greenhouse gas emissions, particularly threatening vulnerable populations. The example city has created plans with goals and policies to adapt to and mitigate the risk of extreme heat impacts, but it does not yet have a tool to guide when to implement strategies in the short-, mid-, and long-term. In a

simplified format, this Guide demonstrates how to prioritize and sequence adaptation actions, using the Adaptation Pathways tool, to more effectively mitigate the risks associated with climate hazards.

WHAT ARE ADAPTATION PATHWAYS?

In contrast to traditional time-based planning¹, the Adaptation Pathways tool utilizes observable conditions to represent a point in time when action must be taken to address hazard-related vulnerabilities (i.e., a trigger point). An appropriate trigger point provides enough notice and lead time to plan for and implement an adaptation strategy before vulnerabilities become severe.

WHEN SHOULD ADAPTATION PATHWAYS BE DEVELOPED?

Developing adaptation pathways should occur at the end of APG Phase 3 (Define Adaptation Framework and Strategies). After a jurisdiction summarizes vulnerability (Step 3.1) and confirms its vision and goals (Step 3.2), it must prepare adaptation strategies (Step 3.3) and prioritize strategies (Step 3.4). Throughout Phase 3, public meetings and outreach events should be organized to engage community members, community organizations, and other interested parties to identify vulnerable areas or populations, identify co-benefits and specific community challenges, and select appropriate

¹ Resilient CA, 2023. Adaptation Pathways, <https://resilientca.org/apg/adaptationpathways/>

strategies (Step 3.5)². Creating adaptation pathways involves the additional step of strategically sequencing strategies to enhance resilience.

WHO SHOULD USE ADAPTATION PATHWAYS?

Planning department staff will mostly likely take the lead on developing adaptation pathways. However, coordination with key departments, such as Public Works or Finance, is vital. Planners should also work closely with community members and organizations to translate the vision and goals to trigger points.

LIMITATIONS

The adaptation pathways approach is most useful for situations in which monitoring data of the hazard of concern is available and areas with higher vulnerability and/or exposure to the hazard are identifiable.

An adaptation pathways approach is not always possible or appropriate. Limitations in data availability – such as lack of monitoring data – can make Pathways infeasible. An example of this is wildfire: since local governments are only required to determine the high fire hazard severity zones within their local responsibility area, many cities do not have data on other hazard severity levels within its boundary. It may be impractical to base trigger points off a binary measure of “high fire hazard severity” and no fire hazard.

An adaptation pathways model is not a comprehensive tool for adaptation planning. Timelines for securing funding, construction, maintenance, community engagement, City Council approval, etc. are not embedded directly in the tool. However, these considerations should be part of determining the lead time needed for strategies.

2 Resilient CA. 2020. Phase 3: Define Adaptation Framework and Strategies. In the Adaptation Planning Guide. <https://resilientca.org/apg/phase-3/>



STEP 1: ESTABLISHING MEASURABLE INDICATORS

Trigger points are based on measurable indicators that must be monitored to initiate planning, permitting, and/or the implementation process for adaptation strategies. Therefore, a monitoring program plays a key role in the implementation of adaptation pathways and should be developed in conjunction with other departments (e.g., Public Works) to leverage ongoing surveys and inspections. For instance, if Public Works collects data on inland flooding frequency and location, the data could serve as a basis to determine what level or frequency of future flooding should trigger which actions. It may also be appropriate to use publicly available data as a basis for trigger points.

In many cases, guiding principles for developing, evaluating, and analyzing adaptation measures are translated to trigger points and associated monitoring. For example, if a jurisdiction has a goal of maintaining a walkable beach in both summer and winter, then the goals can be translated into summer and winter beach width thresholds. These beach width thresholds can serve to trigger certain actions that maintain or expand, as needed, the beach width. To track when thresholds are reached, the jurisdiction must monitor the beach profile on an ongoing and regular basis.

The chosen indicator is displayed as a scale along the X-axis of the adaptation pathways canvas (see the hypothetical example to the right) and will serve as the basis triggering adaptation actions.

3 Cal-Adapt. 2023. Extreme Heat Days & Warm Nights. <https://cal-adapt.org/tools/extreme-heat>.

EXAMPLE CASE

In this example, the city considered several potential measures to use as a basis for adaptation pathway trigger points for extreme heat, including average temperature, the frequency of extreme heat days, and frequency of heat waves. In this example, the city selected frequency of heat waves because the city determined heat waves to be a particularly direct public health risk.

The city is interested in a long-term planning horizon, so the city used a scale of 2 to 17 for the annual number of heat waves along the x-axis indicated below. This scale represents the number of heat waves the city expects to experience under a high-emissions scenario by 2100. The city obtained this data from Cal-Adapt extreme heat projections of RCP 8.5 and RCP 4.5 emissions scenarios³, which can be found here: <https://cal-adapt.org/tools/extreme-heat>



Importantly, strategies are not triggered on certain years; rather, the number of heat waves recorded annually is the basis for all adaptation strategies’ trigger points. The year in which a trigger point occurs is merely for reference to climate projections. This method enables the Adaptation Pathways tool to be dynamic in response to uncertainties: if climate effects happen faster or slower than anticipated, the timing of strategy implementation shifts.

STEP 2: SPECIFYING ADAPTATION STRATEGIES

Agencies usually have established adaptation or resilience goals, policies, and strategies or actions; however, sometimes these lack information such as quantitative end-points, funding, and responsible parties. Adaptation pathways can be used for any type of adaptation strategy (e.g., programs, infrastructure improvements, or development standards), but strategies that have measurable endpoints are best suited for this approach. For example, if a city has set a goal of increasing tree canopy, the city should identify specific targets, such as 20% tree canopy coverage city-wide, or for specific areas, such as safe routes to school. Targets such as these aid in the process of determining trigger points for strategies.

Furthermore, some strategies are foundational, while others are supporting. Foundational strategies enable or ‘unlock’ other strategies. Foundational strategies are generally high priority for implementation as they are often the foundation on which other strategies depend. For example, a strategy foundational to reducing urban heat island effect is increasing the urban tree canopy. Supporting strategies include urban forest maintenance, new funding source identification, and a design standards ordinance requiring natural shade, among others.

For each strategy, funding should be specified. Strategies can be categorized by those that require no new funding source (i.e., available), those that can be funded with a known source (i.e., existing), and those that require a significant new funding source (i.e., needed). If no new funding is required, the strategy can be completed without capital expenditure but require staff

time or other non-budgetary resources. If the funding source is known, budget has already been identified for the strategy and can be expended as needed. If the strategy requires a significant new funding source, then a new budget allocation, whether from the General Fund, external funds such as grants, federal or state assistance, etc. may be needed. These funding parameters can help to prioritize strategies when sequencing them on a pathway (see Step 3 below).

Lead time should also be specified. Lead time refers to how long the strategy would take to implement, including approvals, funding (as designated above), construction, and other steps involved in implementation. If available, an exact lead time for each strategy is preferable, but if the lead time is uncertain, a range of years such as 0-5 years, 5-10 years, and 10 or more years suffices. If strategy implementation is continuous and does not have an end-date, “ongoing” is appropriate. Strategies should be initiated early enough so that they are in place by the time they are needed. It is important to recognize the uncertainty inherent in deciding trigger points based on a real, albeit incomplete, understanding of risk and the constraints of staff time/funding.

To help organize strategy pathways (see Step 3), strategies may be grouped according to their type (i.e., program, infrastructure improvement, etc.) or category (e.g., nature-based solution, gray infrastructure, facility, etc.). If there are several strategies regarding green stormwater infrastructure that build off one another, for example, a planner could group those strategies together since a strategy pathway will connect them in the adaptation pathways canvas.

EXAMPLE CASE

Goal	Strategy	Funding	Lead Time	Foundational	Indicator
Plan for and build a resilient and equitable city	Increase the number of Cool Zones facilities	Exisiting	Medium	Foundational	# heat waves/yr
	Develop resilience hubs in coordination with County Health Department to provide shelter, food distribution, healthcare, and other services.	Exisiting	Long	Supporting	# heat waves/yr
	Provide solar microgrid battery backup to Cool Zones	Needed	Long	Supporting	# heat waves/yr
	Pursue supplemental funding sources to cover capital costs	Exisiting	Short	Foundational	# heat waves/yr
Resilient Infrastructure and Healthy Ecosystems	Increase tree canopy cover to 28%	Available	Short	Foundational	# heat waves/yr
	Increase tree canopy cover to 35%	Available	Short	Supporting	# heat waves/yr
Support and prioritize thriving natural environments and enhance adaptability	Develop green infrastructure design standards for new development	Available	Short	Foundational	# heat waves/yr
	Partner with nonprofit groups on green infrastructure implementation	Available	Medium	Supporting	# heat waves/yr

Table 1: Adaptation Strategies

A city selected a suite of adaptation strategies (see Table 1 above) from its local climate resilient plan which includes implementation policies and strategies. The city selected these policies based on their ability to address acute vulnerabilities and build resilience to extreme heat impacts. To enhance effectiveness, the suite of strategies pertains to both the built environment (i.e., gray infrastructure) and the natural environment (i.e., green infrastructure), which are complementary in a complete approach to climate adaptation.

For each strategy, the City categorized the funding required for each according to whether funding was available, existing, or needed. Funding considerations are important for prioritizing strategies and can impact lead time. Strategies that require a significant new funding source, for example, may necessitate long lead times to acquire funding. Furthermore, if another strategy that entails a lower level of investment is equally as effective, planning departments may prioritize that strategy. Next, the city estimated lead time as short, medium, or long, representing 0-5 years, 5-10 years, and 10+ years, respectively. Finally, the city indicated strategies that are foundational and those that are supporting.

EXAMPLE CASE (CONT.)

Note how the city categorized strategies: the top three strategies address the gray infrastructure; the bottom four strategies are concerned with green infrastructure, and the strategy concerning funding acquisition, foundational to all other strategies, is placed in the center. This type of categorization is optional but can be helpful for connecting related strategies.

STEP 3: SEQUENCING ADAPTATION STRATEGIES

After establishing a measurable indicator, adaptation strategies, funding, lead times, and foundational/supporting categories, the next step is to set trigger points and transfer points, and create pathways, which represent sequences and combinations of strategies to build resilience to climate change impacts. This sequencing and combining of strategies is necessary because a single strategy is often insufficient to adapt to increasingly severe hazard conditions; a suite of strategies, strategically implemented, is needed to reduce vulnerability to acceptable levels.

The timing and sequence of adaptation strategies is influenced by both the need to mitigate hazard risks and resource constraints. With no resource constraints, jurisdictions might as well implement all needed adaptation strategies simultaneously and as soon as possible. However, staff time, funding, and other limitations necessitate careful timing and sequencing considerations.

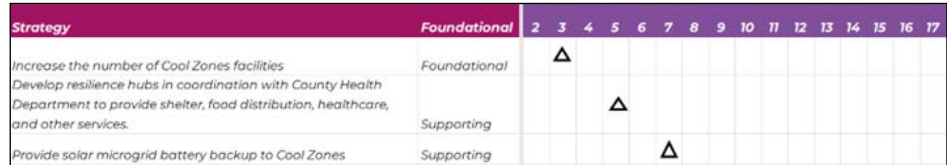
Before getting into specific steps for creating pathways, some additional guidelines may be helpful:

- Adaptation pathways should be designed to first address acute vulnerabilities. Acute vulnerabilities are those that are susceptible to severe or sudden impacts, whether physical, social, economic, or environmental. For example, an aging coastal roadway undergoing erosion may be at risk of collapse, and older adults in mobile homes may face acute health risks during heat waves. These kinds of impacts should be mitigated as soon as possible before severe impacts occur.
- Strategies should also be sequenced to first address impacts in more vulnerable areas. For example, a tree canopy enhancement program might first target high heat island areas, then routes to school, followed by public buildings. This way, extreme heat is incrementally reduced starting with priority areas.
- Lead time is especially important for sequencing strategies. It is extremely difficult to initiate strategies to be completed exactly when they will be needed. Creating effective pathways is more art than science. If possible, it is best to err on the side of caution by implementing strategies with generous lead time to accommodate potential delays and the uncertainty of when exactly trigger conditions will be met.

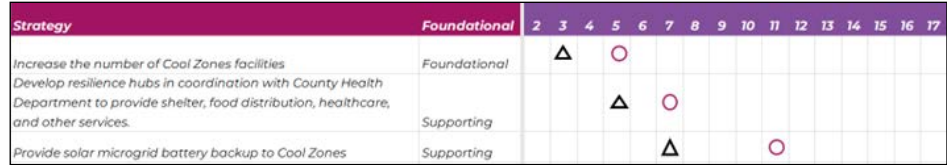
- Another consideration for how to sequence strategies is funding. Strategies that require significant new funding sources might be less feasible than strategies for which funding has already been identified, or those with funding already secured. For example, nuisance flooding might be addressed first by increasing stormwater retention with green infrastructure; if flooding becomes more severe, the sanitary sewer system would then be upgraded to increase capacity. In this way, the jurisdiction could first implement lower-investment strategies to mitigate less severe impacts, then implement high-investment strategies when it becomes necessary.

Although the process by which jurisdictions craft adaptation pathways may vary, the below shows the basic steps applicable to any pathway:

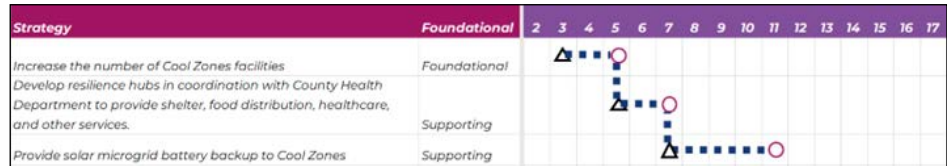
1. Determine when strategies should be triggered, factoring in resource constraints, lead time and whether the strategy is foundational or supporting.



2. Determine transfer points: the points at which a strategy is no longer sufficient to adapt to climate changes.



3. Connect strategies to form pathways. Note several strategies may occur simultaneously, if resources allow, and so pathways may run parallel to one another.



EXAMPLE CASE



Three heat waves per year triggers three foundational strategies, which mitigate acute vulnerabilities, set development standards, and ‘unlock’ subsequent supporting strategies with funding acquisition. Strategies include:

- Increase the number of Cool Zones facilities
- Develop green infrastructure design standards for new development, and
- Pursue supplemental funding sources to cover capital costs.

At five heat waves per year, there are two transfer points because the city expects the strategies initiated at three heat waves per year to no longer be sufficient. Following from the Cool Zones strategy, the city initiates its resilience hubs strategy, which provides additional risk reduction from extreme heat. Following from green infrastructure design standards, the city initiates two green infrastructure-related strategies: increase tree canopy cover to 28% and partner with nonprofit groups on implementation.

EXAMPLE CASE (CONT.)

At seven heat waves per year there are two more transfer points. Following resilience hubs, the city initiates a strategy to provide solar microgrid battery backup to Cool Zones, building the facilities' resilience to power outages, which are a risk factor of heat waves. Following the strategy to build 28% of tree canopy cover, the city initiates additional increases to tree canopy cover, with the goal of 35%. This aims to further enhance the city's resilience to extreme heat by further reducing urban heat island effect.

From this point, the city is well-positioned to be resilient to heat waves for the foreseeable future. The city will continue to maintain the strategies it has implemented and adjust as it continues to monitor performance and the impacts of climate change. As such, the city may adjust its pathways, including strategies and how it prioritizes them, in the future.



Resilience Metrics



PURPOSE AND WHEN TO USE

In addition to the Adaptation Pathways tool, the Metrics Worksheet is another tool that may assist jurisdictions monitor and track progress of climate adaptation strategies.

The purpose of the Metrics Worksheet is to help answer the simple question: How do we know we are succeeding in our adaptation efforts? To gauge whether you are succeeding in your adaptation efforts, you must know what “success” means to your stakeholders and to all those involved in your adaptation efforts. So, while there is no easy answer, if you do the hard work of developing metrics, you will find an answer to this central question.

The goal is to develop metrics from climate adaptation plans. A metric is a variable that can be measured (if quantitative) or otherwise tracked (if qualitative) to indicate states of something of interest, e.g., the steps of an adaptation process, the state of a system after adaptation actions have been implemented, the level of capacities built in a community, etc.

This worksheet is meant to spark conversation and create a common language across implementing departments so that stakeholders understand their progress. It is recommended that local agencies include metric development in project request for proposals and project workplans as a final stage when feasible; otherwise the metric worksheet can be used by local agency staff after a plan is adopted.

CONTEXT

Implementation strategies are separated into two types: foundational – those that are crucial for the implementation of closely related strategies – and supporting – those that support CAP measures but are not directly quantifiable. Each strategy is accompanied with the following:

- A description that is directly adapted from the CAP
- The City department responsible for leading implementation and any departments that may be able to support its implementation
- External partners such as non-profit organizations or private organizations
- Costs over a five-year period
- Implementation status as reported by the relevant department(s)

This resilience metrics template intends to assist other local jurisdictions track progress and measure success for their adaptation planning efforts. Descriptions of the template’s elements are provided below to facilitate this process. Jurisdictions are welcome to modify the template where necessary by inserting or removing columns on the Excel worksheet. For example, a “Strategy Location” column may be added to help categorize strategies that are adapted from multiple existing documents, including specific plans.

TEMPLATE CONTENTS

Goal

An overarching goal for related strategies.

Strategy

A strategy related to climate resilience and mitigation, typically derived from existing or new documents such as a jurisdiction’s general plan, climate action plan, climate adaptation plan, or similar document.

Category

Refers to the strategy’s primary category, grouped with similar type that includes:

- **Programs.** These strategies will require additional research and development for proper implementation to occur. They may require future partnerships and financing mechanisms to be in place down the road, but most immediately, jurisdiction staff will need to integrate program research and development into the context of existing workloads and programs whenever possible.
- **Community Engagement.** The purpose of these efforts is to provide educational materials that might influence behavior on an individual or community scale, and/or to publicize a local or State program/service/benefit people can sign up for. This can also include events.
- **CIPs (Capital Improvement Projects).** Large-scale construction projects of physical infrastructure, green

4 This includes sea level rise, storm surge, and coastal erosion.

or gray. Has a general location and would only need site specific research.

- **Partnerships.** Inter-agency coordination and partnerships with other organizations are critical to ensuring implementation of certain measures.
- **Policy/Code Changes:** Guidelines and standards for new development (public and/or private).
- **Funding and Financing.** Securing funding through taxes or private funding or providing tax incentives to private development.

Relevant Hazard

Includes four climate-related hazards that may be addressed through strategy implementation.

- **Wildfire**
- **Extreme Heat**
- **Coastal Hazards⁴**
- **Flooding and Drought**

Priority Communities

Certain strategies might have a more significant impact on specific communities or areas that are prone to bearing the effects of climate change hazards. The names and types of communities may vary depending on the jurisdiction and can be adjusted in the workbook’s Names sheet. The template provides three types of priority communities.

- **Transit Priority Areas.** As defined by [Senate Bill 743](#), this is an area that is located within a half mile of a major transit stop. This may include planned stops that are scheduled to be completed within the planning horizon of a Transportation Improvement Program. As this is embedded in State law, all jurisdictions should include this information.
- **Communities of Concern.** Also known as Disadvantaged Communities, or DACs, these areas represent the top 25% scoring census tracts in CalEnviroScreen and are disproportionately burdened by pollution.
- **Areas of High Heat Risk.** Areas that are prone to higher temperatures during heat warnings and heat waves, often due to the lack of any mitigation measures such as tree canopy.

Responsible Party

Refers to the department in the jurisdiction that will take the lead in a strategy’s implementation. Though jurisdictions may have different names and functions for their departments, the ones included in the template are typical in most jurisdictions and can be adjusted accordingly in the Names sheet. These include:

- Public Works
- Community Services
- Development Services
- Planning Department
- Police
- Fire
- Finance
- Parks and Recreation
- Multiple, in the case more than one department is needed to implement the strategy.

Target Metrics

Measures illustrating a strategy’s success and how they can be measured (e.g., number of buildings with cool roofs, existing buildings with retrofits, energy use City-wide). These measures will be within the jurisdiction’s control and measured by the jurisdiction. The table below provides a sample of metric types for each type of strategy.

Strategy	Potential Metrics Type
Program	Programs developed; plans adopted
Community Engagement	Meetings and attendance; materials developed and distributed
CIP	Built projects; linear miles of improvement
Partnerships	Meetings; agreements; MOUs
Policy / Code Change	Adoption; permits or use of new process
Funding and Financing	Dollar amounts

Future Tracking

Changes to strategy or the physical or legislative environment that should be periodically reviewed to evaluate the continued relevance of a strategy (e.g., California Building Code, number of extreme heat days). These are items outside of local government control but should be tracked as they would affect successful implementation.

Funding

This item asks for the sources of funding for each strategy. Three categories include:

- **Available.** The strategy does not required funding.
- **Existing.** The strategy requires new but known funding sources.
- **Needed.** The strategy may incur a high one-time or ongoing cost, necessitate a new budget line item, or requires outside grant funding from unknown sources.

This criteria is based on information from SANDAG’s [Prioritization Tool Guidebook](#), which is part of the Holistic Implementation of Adaptation and Transportation Resilience Strategies Project, intended to facilitate the process of identifying potential adaptation strategies and action.

Timelines

This involves ordinal ranking of when strategies are expected to be implemented. These categories include:

- **Ongoing.** Efforts for this strategy are currently underway.
- **Short.** 0-5 years lead time.
- **Medium.** 5 to 30 years lead time.
- **Long.** 30+ years lead time.

Like the category above, these timelines originate from SANDAG’s [Prioritization Tool Guidebook](#).

Type

This item asks if the strategy is foundational or supporting. “Foundational” is appropriate if a strategy needs to occur first before other strategies can be implemented. A foundational strategy may be land or funding acquisition or a planning process, which other related strategies build on. “Supporting” is applicable if a strategy enhances or builds upon previously implemented or initiated strategies.

Additional Notes

Specific notes for each strategy or additional information such as supporting responsible parties can be included here, as well as links and other relevant information.