ARCHIMEDES
AiR Climate Health Impact in the MEDiterranean Eastern and Southern regions)

Economic assessment of climate change

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The big challenge: Determine how much society is willing to give up today to reduce the consequences of climate change tomorrow, through:

- mitigation policies (reduce emissions of GHG),
- adaptation policies (reduce the consequences of climate change).

Main differences between economic assessment of local air pollution impacts and climate change impacts:

- impacts on health: almost no difference (see yesterday's presentation),

- impacts other than health are more important

- non-market dimensions are involved

- more uncertainty

- more distant time horizon

Sketch of the presentation

1. Overview of the impacts involved

2. Market and non-market values

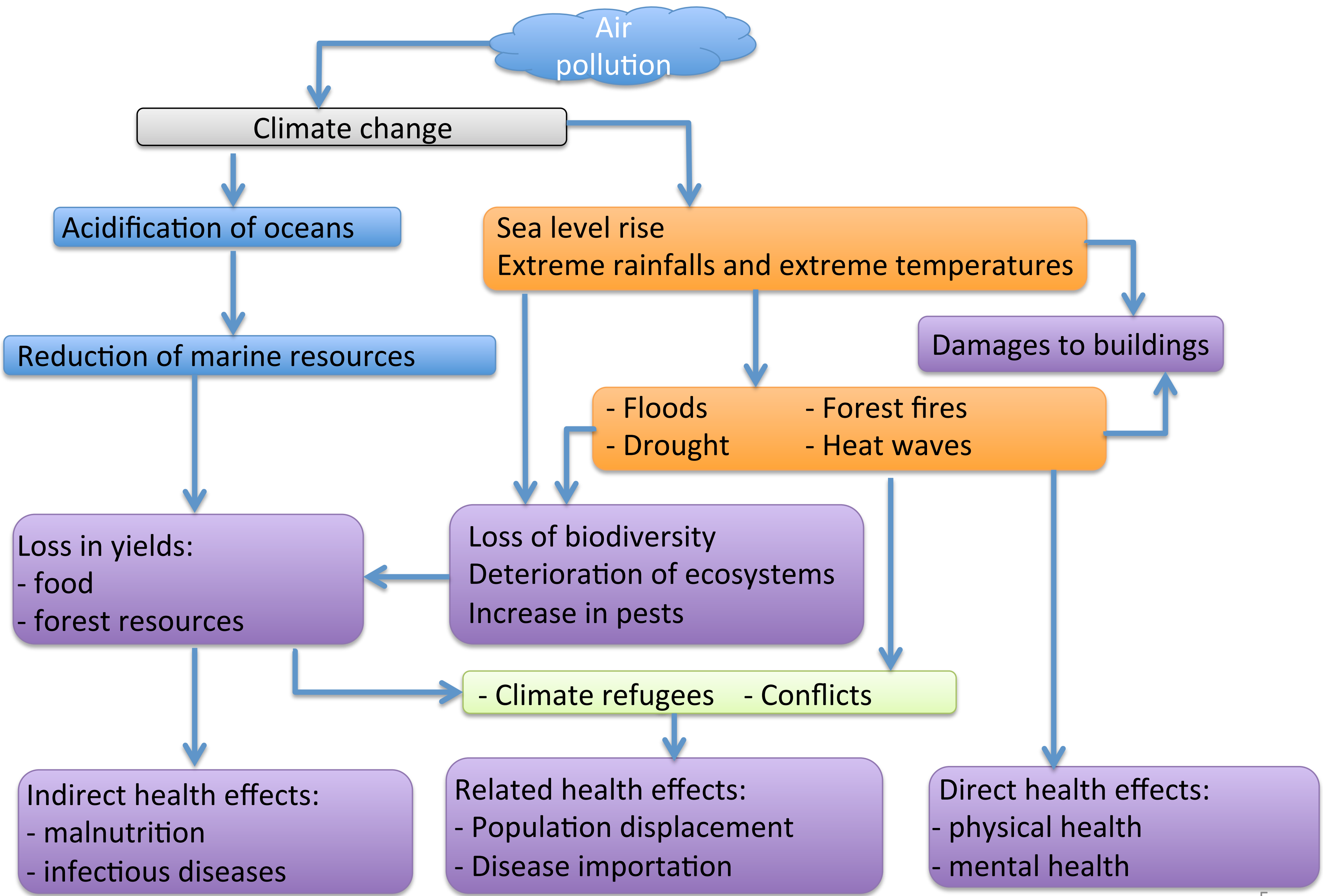
3. Economic assessments of the costs and benefits of climate change

4. The influence of time

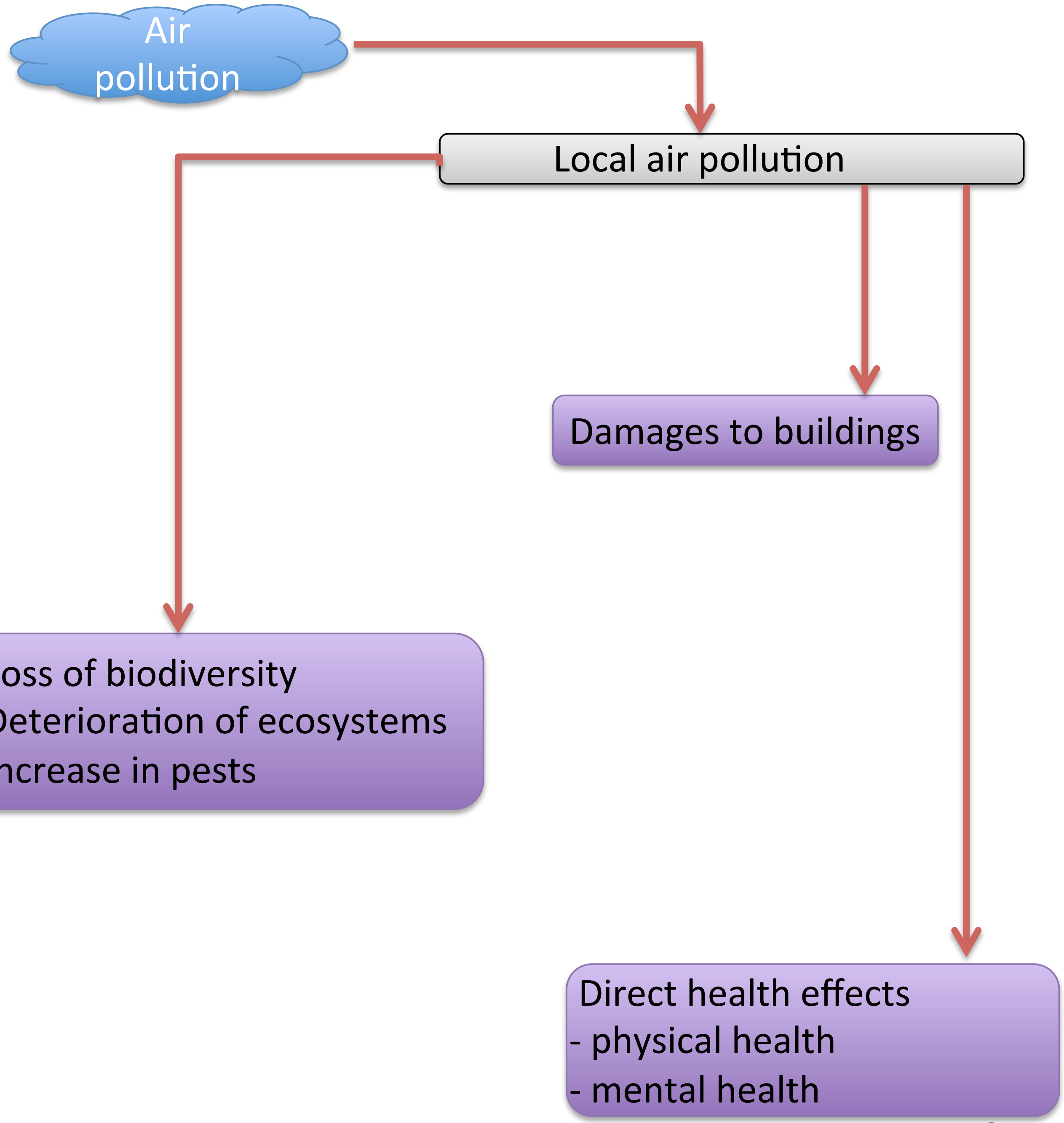
5. Case study 2: Climate change in Camargue (South of France)

NO CONFLICT OF INTEREST

1. Overview of the impacts involved



Air pollution
Climate change
Acidification of oceans
Sea level rise
Extreme rainfalls and extreme temperatures
Reduction of marine resources
Damages to buildings
- Floods
- Drought
- Forest fires
- Heat waves
Loss in yields:
- food
- forest resources
Loss of biodiversity
Deterioration of ecosystems
Increase in pests
- Climate refugees
- Conflicts
Indirect health effects:
- malnutrition
- infectious diseases
Related health effects:
- Population displacement
- Disease importation
Direct health effects:
- physical health
- mental health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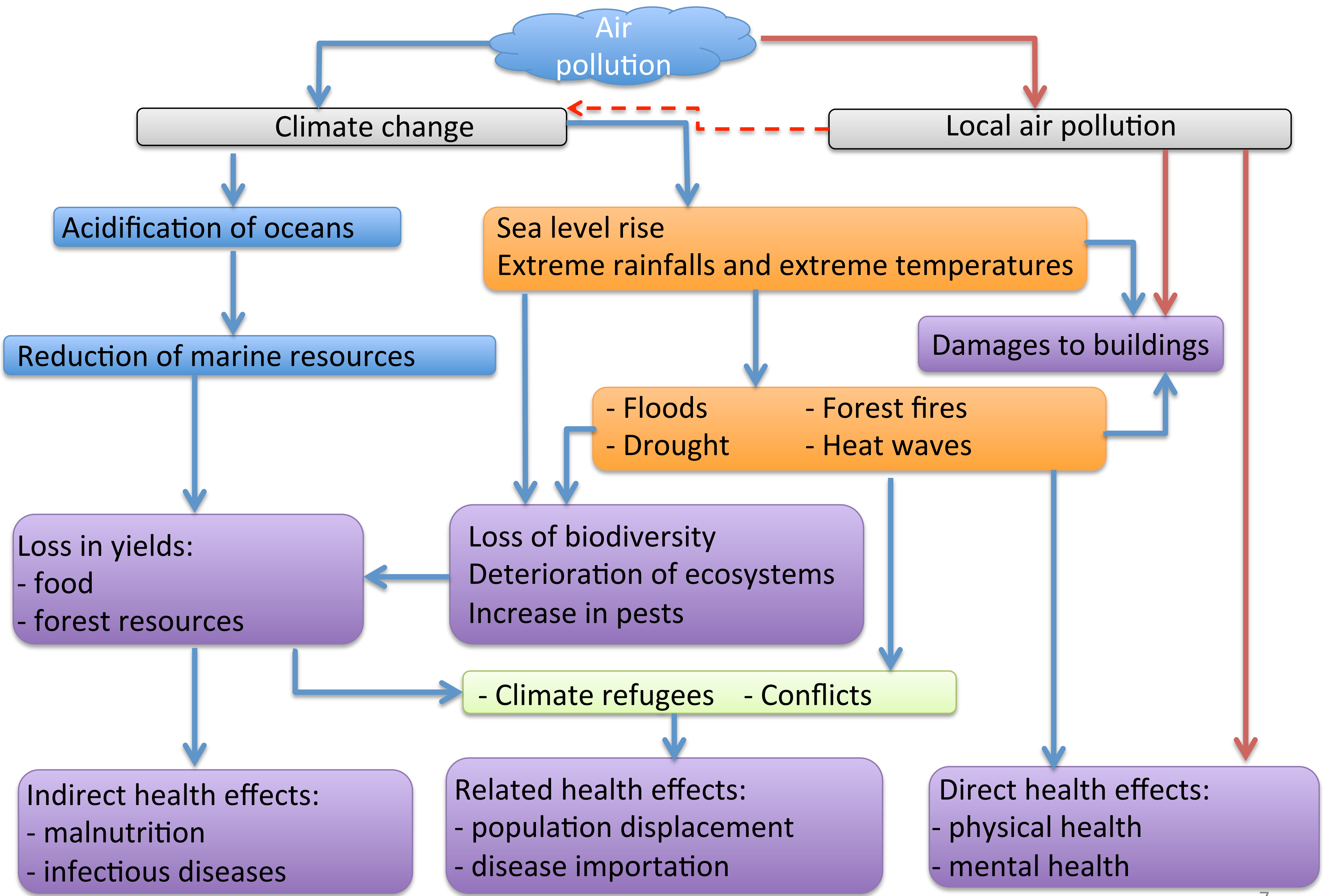

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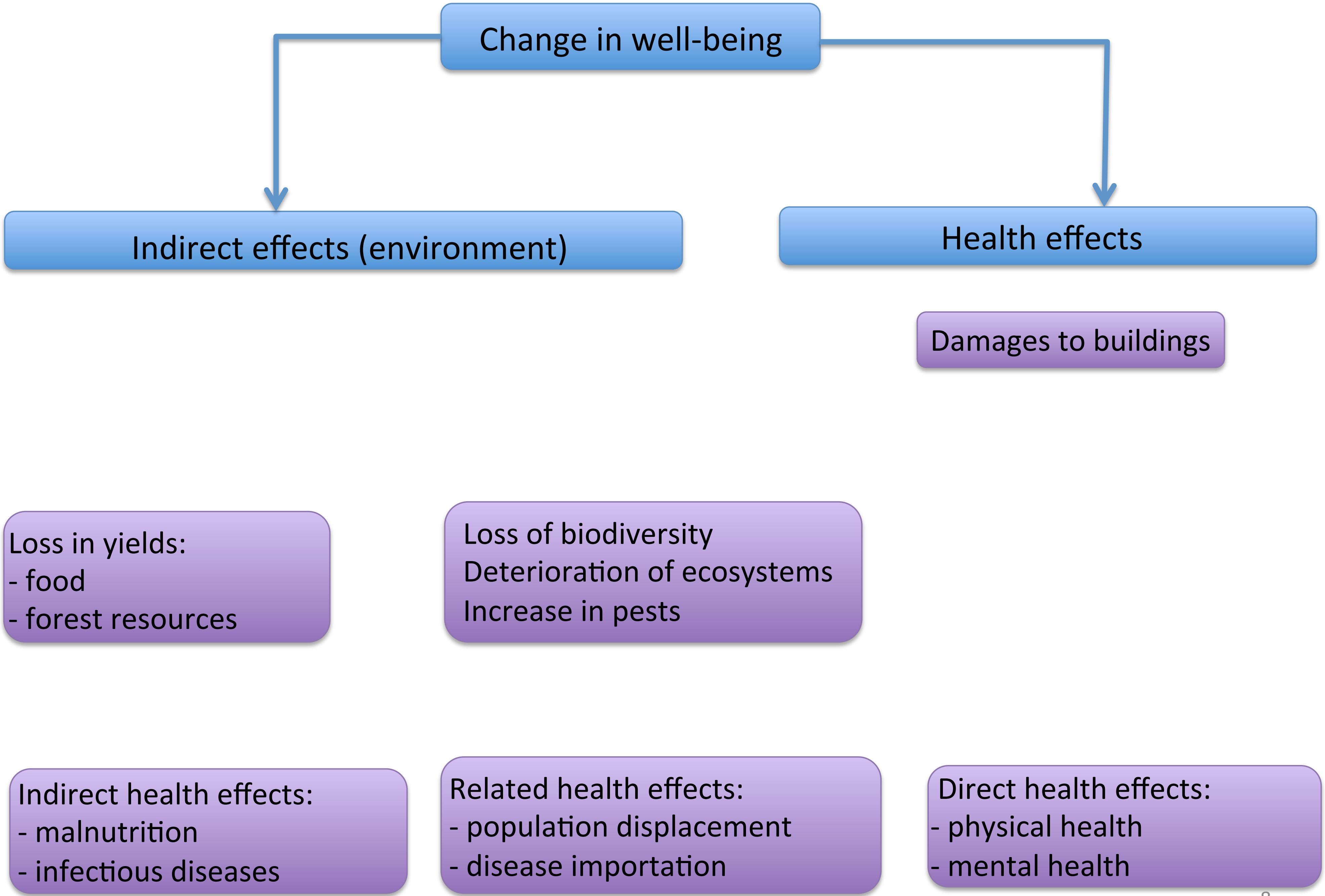
Change in well-being
Indirect effects (environment)
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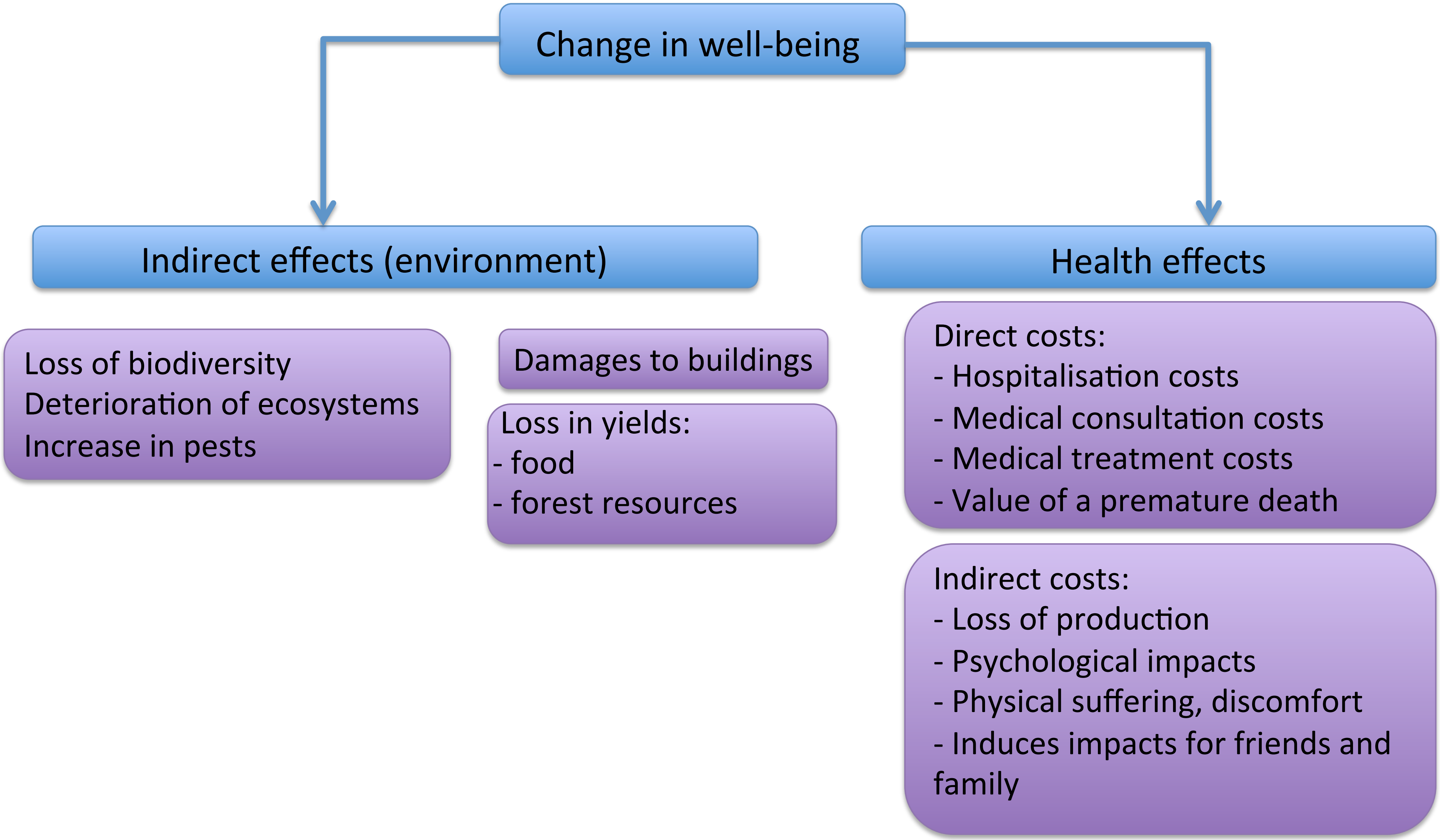
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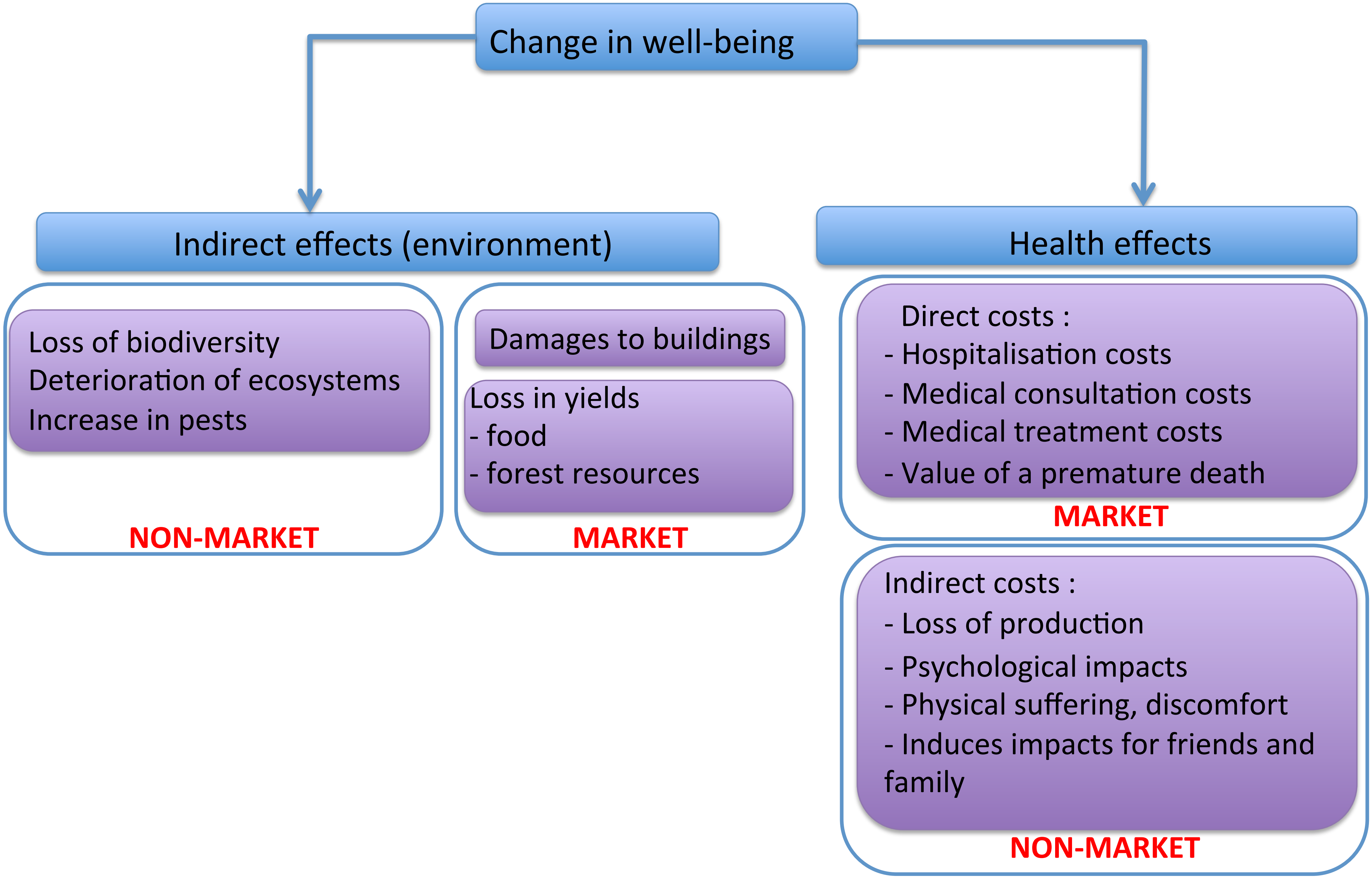
- Psychological impacts
- Physical suffering, discomfort
- Induces impacts for friends and family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NON-MARKET
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NON-MARKET

2. Market and non-market values

2.1 The total economic value

2.2 Why account for the total economic value?

2.3 How to account for the total economic value?

- 2.3.1. The market price approach: Observed preferences
- 2.3.2. Indirect approach: Revealed preferences
- 2.3.3. Direct approach: Stated preferences

2.1 The total economic value

The economic "value" of environment and natural resources:
1) is anthropocentric.
2) expresses the degree to which a good or service satisfies individual preferences.
3) is determined by individuals' willingness to make trade-offs: when an individual spends money for one good, s/he prefers this good to another or s/he sacrificed time to obtain it.

However, many goods or services offered by an ecosystem or biodiversity are not trade on markets, hence the economic value differs from the market value.

2.1 The total economic value

Breakdown of the total economic value

Use values

- **Direct use value** with consumption (fisheries, timber, agriculture) or without consumption (recreational and educational activities).
- **Indirect use value**: derives from services provided by the ecosystem (the carbon sequestration services provided by some coastal ecosystems, self-purifying properties of a wetland).

Potential Use values (unrelated to a current or future use)

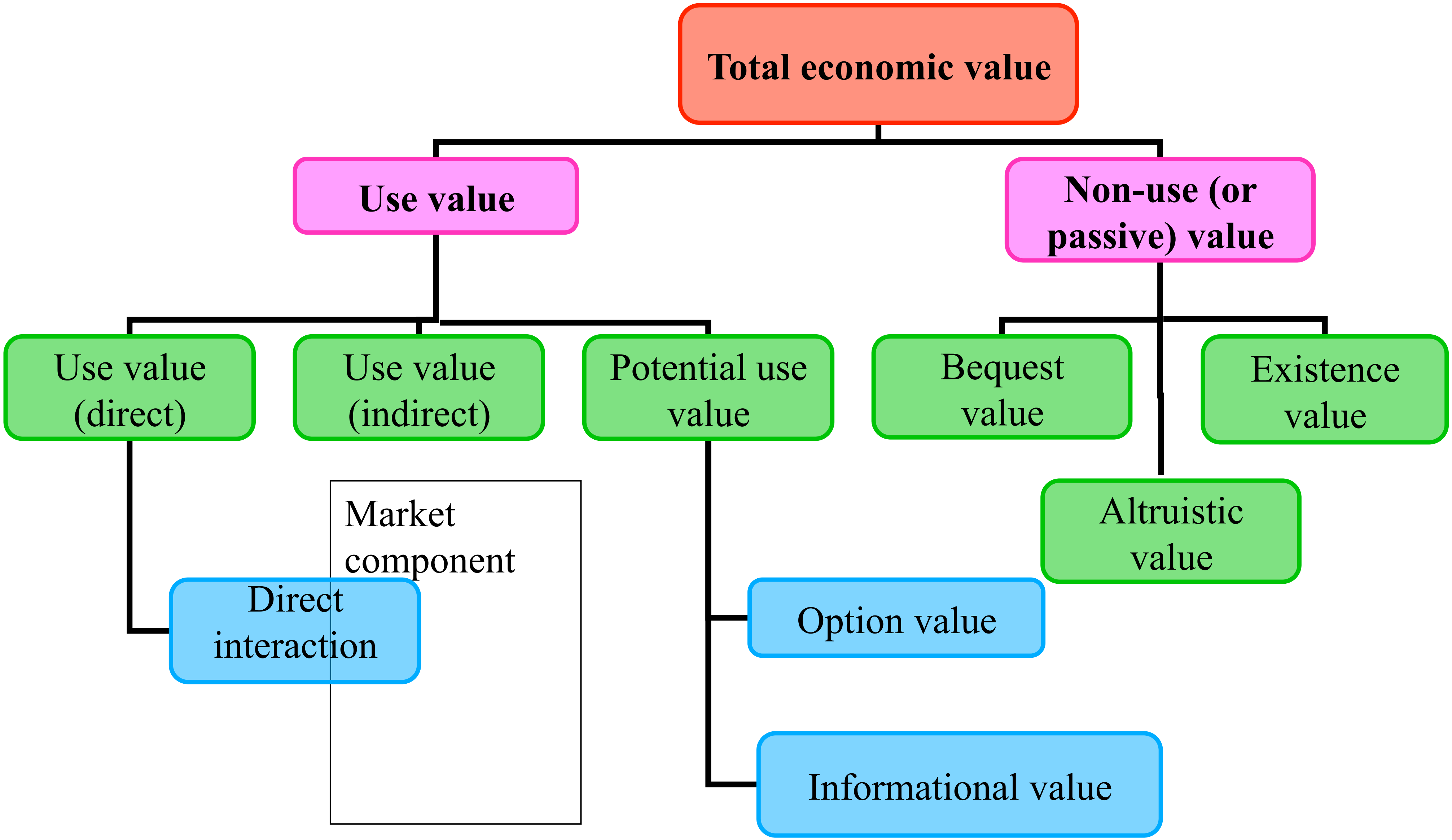
- **Option value:** potential to be available in the future for personal direct or indirect use.
- **Informational value**: value of delaying an irreversible decision waiting for future information (on not yet established usefulness of a substance, or on the evolution of CC).

2.1 The total economic value

<u>**Non-use value or Passive use** (implicitly relies on altruism)</u>

- **Existence value**: value from simply knowing that a certain good or service exists, whether or not it is useful to others.
- **Bequest value**: value from ensuring that certain goods will be preserved for future generations.
- **Altruistic value**: value from knowing that others benefit from a good or service.

2.1 The total economic value



2.2 Why account for the total economic value

If the non-market component is not accounted for, individuals' decisions will not lead to an optimum without public intervention (to reduce negative externalities for instance).

Monetary assessment of the non-market component allows:
- to help better allocate public funds,
- to propose sound and relevant choices among alternatives in cost-benefit analyses (CBA).

From the 60's, CBA are increasingly used (World Bank, European Union, IMF, OECD...). They were simpler fifty years ago than today, because generally restricted to projects with only tangible / market outputs. Now, considerations like improved recreation, visual amenities, small cancer risk changes, loss of biodiversity enter the analysis, and require more complex techniques of valuation.

Nowadays, non-market valuation constitutes one (necessary) step in a CBA.

2.2 Why account for the total economic value

CBA are generally organized as follows:

Benefits

1. Identify the things that are damaged: plants, animals, human health, aesthetics, etc.
2. Determine /estimate / choose a relationship between every possible action and every damage level,
3. Place monetary value on each damage.

Costs

Assess the cost of an action / a policy.

Comparison of costs and benefits

1. Aggregate costs and benefits at every date in the future,
2. Discount future costs and benefits,
3. Account for uncertainties.

2.3 How to account for the total economic value

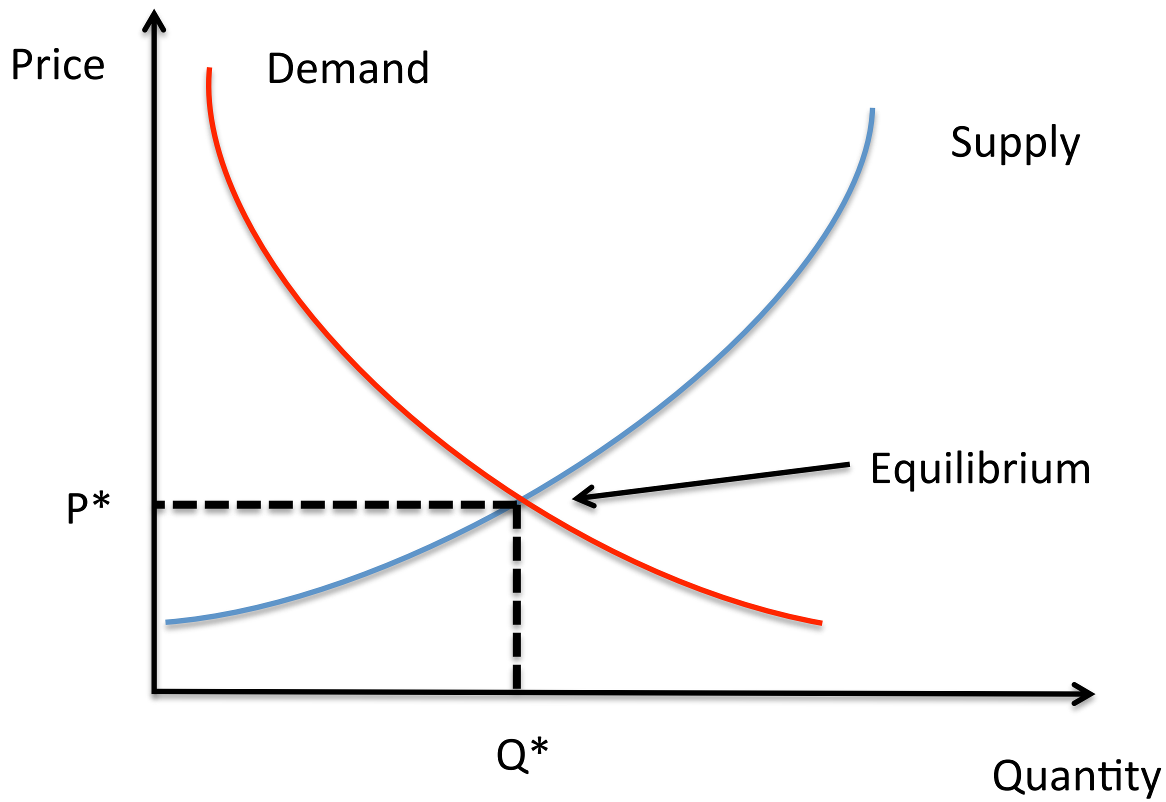
They consist in being as close as possible to the way an economic market works (see yesterday's presentation): observation of prices, indirect revelation of values (or revealed preferences) or direct revelation of values (stated preferences).

2.3.1 The market price approach: Observed preferences

It can be used when the values can be associated with a market that allows an observation of prices **(**based on market prices somehow).

Market prices are used for damages to buildings, losses in agricultural, fishery or timber yields, health (morbidity and losses of production).

2.3.1. The market price approach: Observed preferences



But can also be used to value some environmental goods or services from the (market) costs that would be necessary should these goods and services disappear (or decrease in quality).

QUESTION:

How would you value a wetland loss (or degradation) due to CC ?

2.3.1. The market price approach: Observed preferences

* An increase in flood risks (the wetland no longer mitigates the damages due to flood) => health costs of flooding
=> costs of damages to buildings, agriculture, commercial activities …

* A decrease in recreational use (fishing, leisure,)
=> costs of a decrease in local economic activity.

* A decrease in biodiversity, requiring the re-introduction of extirpated species to regain the quality of the damaged ecosystem
=> costs of reintroduction of these species.

* A decrease in the self-purifying properties of the wetland
=> cost of new (or larger) water treatment plants.

However, the direct method only accounts for the market component of use values and underestimates the social well-being (can be used as a lower bound).

2.3.2. Indirect approach: Revealed preferences

Use actual data to derive a measure of value (based on revealed preferences), for estimating shadow prices based on observed behaviour on real-world settings.

=> we get an **indirect** observed WTP. However, these methods account for the **market and non-market components of use values only**.

2.3.3. Direct approach: Stated preferences

Using hypothetical data from surveys to derive a measure of value, based on a fictitious (or contingent) market.

⇒ we get a **direct** declared WTP for non-market goods or services (air quality, noise, clean water, biodiversity, scenic landscapes, life, time, pain…).

They allow the **revelation of both use and non-use values.**

For 30 years, most of the non-market valuation empirical studies rely on these approaches (more than 6000 published studies).

2.4 Conclusion

The economic assessment of climate change will require the consideration of many impacts specific to different sectors of the economy.

Some will already have a market price, others will require specific methods to estimate their value.

This assessment will only be a prerequisite, and will need to incorporate the temporal dimension, the link with other environmental effects, and be compared to the costs of mitigation and adaptation policies.

3. Economic assessment of climate change

3.1 Overview

3.2 Economic assessment …

3.2.1 … of damages avoided (benefits)

3.2.2 … of the costs of policies of mitigation and adaptation

3.3 Comparing the costs and benefits & Optimal policies

3.1 Overview

Economic evaluations can be classified into two main categories.

The first evaluates the effects of climate change by calculating the expected damages for two scenarios that differ in magnitude or consequences. The difference represents the **benefits** expected from the transition from one scenario to the other, and therefore from a reduction in damages.

Example: From Business As Usual (BAU) (i.e. +4.5°C by 2100 w.r.t. pre industrial level) to COP21 *Intended Nationally Determined Contributions* (INDC) (i.e. currently about 3.5°C).

The second evaluates the **cost of policies** that would either reduce the magnitude of climate change (mitigation) or adapt societies to the consequences of climate change (adaptation). It therefore represents the costs necessary to obtain the benefits.

3.2 Economic assessment

Economic assessment of damages avoided (benefits)

According to the OECD (2015), although some effects may be positive (tourism), the GNP of all countries except Canada and Russia will be negatively affected by climate change.

Africa and Asia will be the continents that will bear the greatest economic losses.

Health and agricultural impacts account for more than 80% of total impacts, with tourism, energy, extreme events and impacts on coastal areas accounting for about 20%.

These assessments are based on complex climate, agricultural and economic models and have large uncertainties at each step of the analysis.

3.2.1 Economic assessment of damages avoided

An increase in temperature of 2°C would result from 2050, in most studies, in an impact estimated between 1 and 3% of GNP per year and up to 5-6% under specific assumptions. GNP (World Global GNP is about $\$78\ 10^{12}$ in 2016).

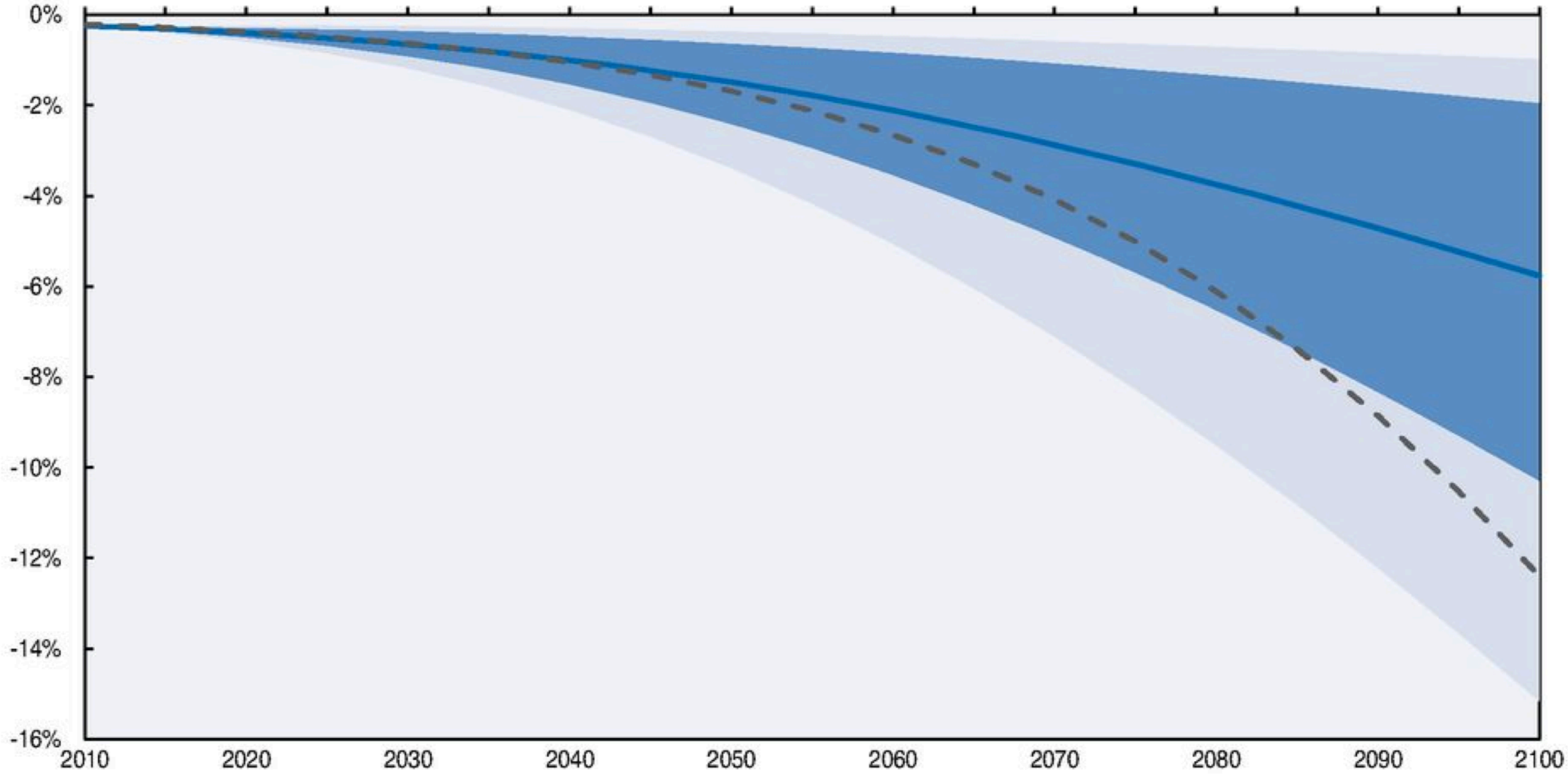
If the temperature increases by 4°C in 2100, it could be 10% of GNP from 2100 (OECD 2015, Stern 2007).

These uncertainties are explained by different assumptions about the effects to be assessed (see section 1), the valuation methods used (see section 2), the choice of the discount rate (see section 4) and whether or not extreme events are taken into account.

The following figure illustrates the influence of uncertainty and the consideration of extreme events.

3.2.1 Economic assessment of damages avoided

Impact on GNP, for different margins of uncertainty (in blue) and for taking into account extreme events (gray dots). Source OECD (2015, Table 3.2 p.85)



Source: AD-DICE model.

3.2.2 Economic assessment of the costs of policies

Economic assessment of costs of mitigation policies

Policies that would allow a 25% reduction in CO2e emissions compared to 2015 have an estimated annual impact between 1% and 3% of global GNP.

There are disparities between countries related to the share of carbon energy, their sources of emissions and their way of life.

With the most favorable assumptions, this cost can be negative (therefore, representing a profit): Stern (2007) thus achieves a positive impact of almost 4% per year!

Economic assessment of costs of adaptation policies

Climate change adaptation policies are estimated between 0.2% and 1% of global GNP (half of which is for developed countries).

How to compare these implementation costs of policies and the expected benefits of the damages avoided?

3.2.2 Economic assessment of the costs of policies

Discounting (see section 4) allows inter-temporal comparisons of financial flows ... and the choice of the rate is crucial.

Until the 2000s (Nordhaus and Boyer, 2000), the annual rate used was 5 to 10%. The weight of the future was declining rapidly, and the ambitious policies were discouraged in the short term was low.

Stern (2007) proposed an annual discount rate of 1.4%, giving significant weight to the future, and advocating immediate and important measures to limit climate change.

3.3 Comparing the costs and benefits & optimal policies

Comparing costs and benefits of mitigation policies

Economists are divided on the scale and the implementation agenda of GHG emission reduction policies even if most advocate for prompt and important action, and agree that costs remain lower than the consequences.

Comparing costs and benefits of adaptation policies

The conclusions are more concordant. Their costs are about 3 to 4 times lower than those of mitigation policies and they generally prevent half of the damage expected from climate change (OECD, 2015).

These policies differ by country (see UNEP, 2014, OECD, 2015 or ONERC 2016) and the economic sectors studied.

They also reduce uncertainties about future damage, since future vulnerability will be reduced regardless of the effects.

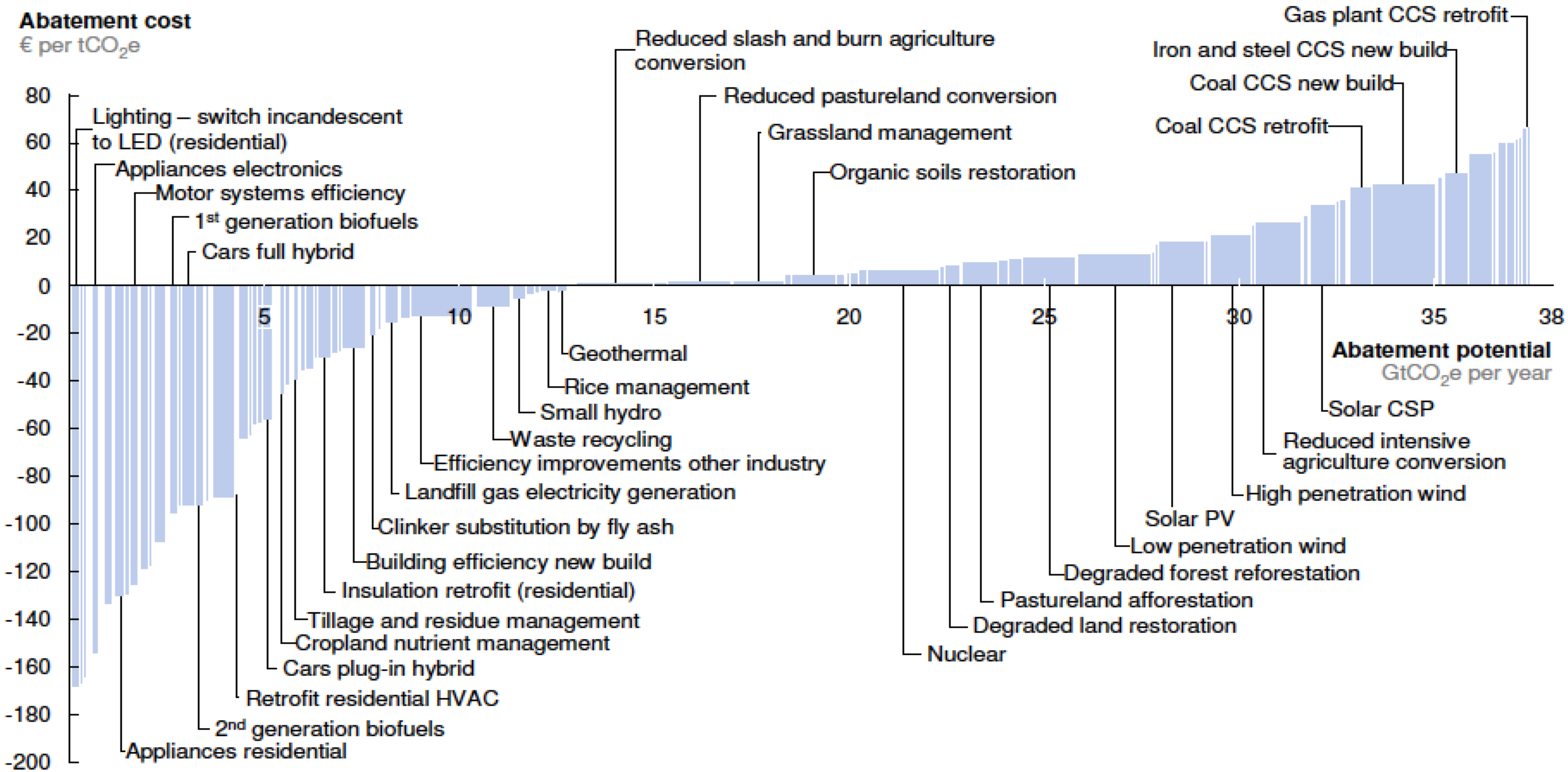
3.3 Comparing the costs and benefits & optimal policies

Optimality of policies in terms of efficiency

McKinsey and Company (2010) estimates that to respect a 2°C increase in 2100 requires emissions to be reduced by 38 GT CO2e per year (from 66 BAU to 28 GT, currently about 50 GT).

Starting in 2010, the investment required to obtain this benefits are estimated about 864 billion/year (about 1% GNP) if optimally done, with corresponding abatement costs from -170 €/t CO2e to 80€/t CO2e.

3.3 Comparing the costs and benefits & optimal policies



Source: Global GHG abatement cost curve Beyond BAU 2030 (McKinley & Company, Exhibit 6, p.9)

3.3 Comparing the costs and benefits & optimal policies

Optimality in terms of timing

McKinsey and Company (2010) estimates the impact of delaying the decision by 10 years.

Starting in 2020 would only allow a reduction of 19 GT CO_2e per year (from 66 GT BAU to 47 GT) and would not allow to respect a 2°C increase in 2100, but rather 3°C).

On optimal timing, see also section 4.

3.4 Conclusion

Since measures to limit climate change will probably be insufficient, adaptation and limitation will significantly reduce the damages due to climate change and offer economic opportunities in some cases (co-benefits).

They will also reduce scientific uncertainty (such as the impact of extreme events or possible feedback effects) … but must be taken quickly and in the most flexible possible way (see section 4).

Attention must be paid to ethical issues when considering a global issue like CC if assessed with country-specific values, especially for the Value for a prevented fatality.

4 Influence of time

4.1 Discounting

4.2 Different components of uncertainty

4.3 Irreversibility effects

4.4 Consequences on optimal decision: looking for flexibility

4.1 Discounting

Climate change is going to imply changes in the future, that are expressed in monetary terms at different dates.

Mitigation policies and adaptation policies are going to reduce the consequences of CC, but they have a cost today, and in the future.

Discounting allows us to compare the assessment of economic flows that occur at different dates by expressing them in present.

The choice of a discount rate is a crucial because we are considering events very far in the future.

4.1 Discounting

The economic theory considers that the rate used to discount (the discount rate) is composed by four components.

The pure preference for the present: I prefer to hold an amount of money today than tomorrow, because it offers me the opportunity to do things today that I would no longer be able to do tomorrow.

The growth rate of the economy: my expectation regarding the way the wealth of a country is going to evolve in the future.

The relative aversion of intertemporal inequality: the way I accept to sacrifice my consumption today for the future generations, depending on my expectations regarding their future wealth.

The precautionary effect: the fact that the more the future is uncertain, the more I am willing to invest today to reduce uncertainty and make the future more reliable.

4.1 Discounting

Overall, these four components are subjective / beliefs, and some of them being negative, positive or null, the discount rates chosen in economic analysis cover a wide range, generally from 0.5 to 10% per year.

The more distant the temporal horizon is, the heaviest are the consequences of discounting on the valuation of future monetary flows.

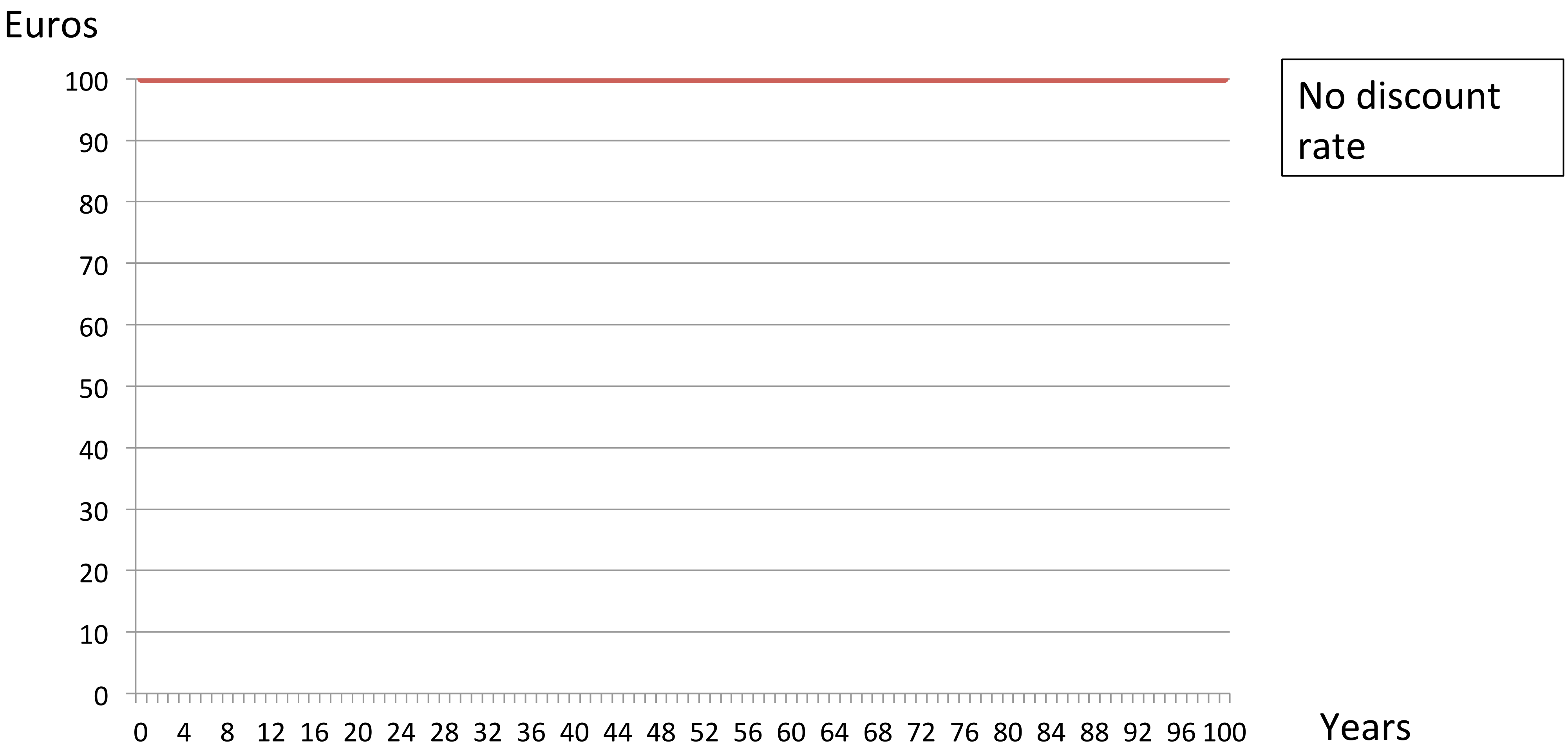
The next slides present what are €100 worth in the next 100 years, when the annual discount rate is 0% (no discounting), 1.4% (value proposed in Stern (2007)'s report) and 10% (rate used up to the 2000's)

The first set of figures expresses what are €100 worth in each of the next 100 years, whereas the second set of figures expresses what are the cumulated flow of €100 per year worth from today to each of the 100 next years.

4.1 Discounting

4.1 Discounting

What will be worth €100 in the future for various discount rates



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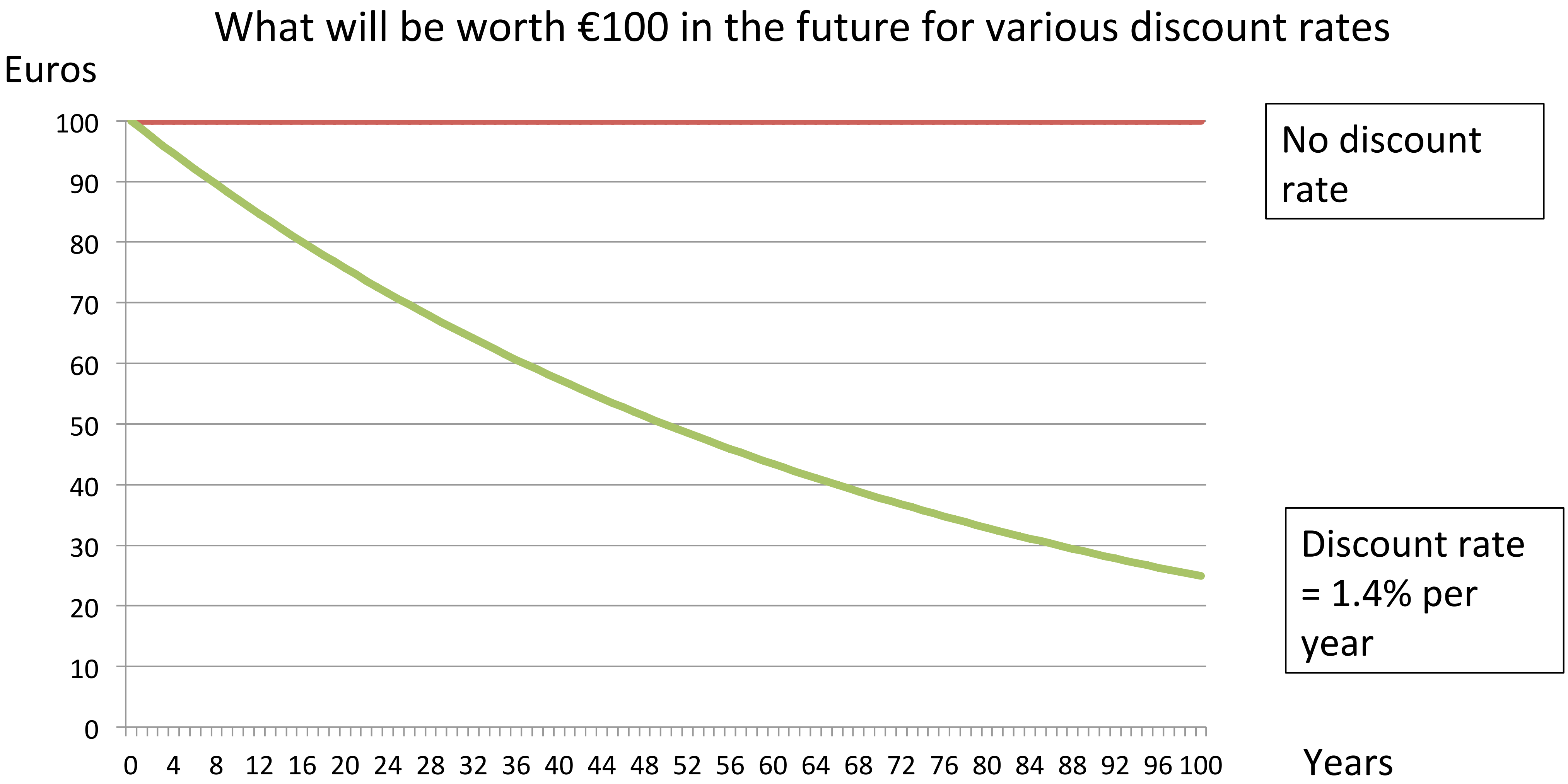

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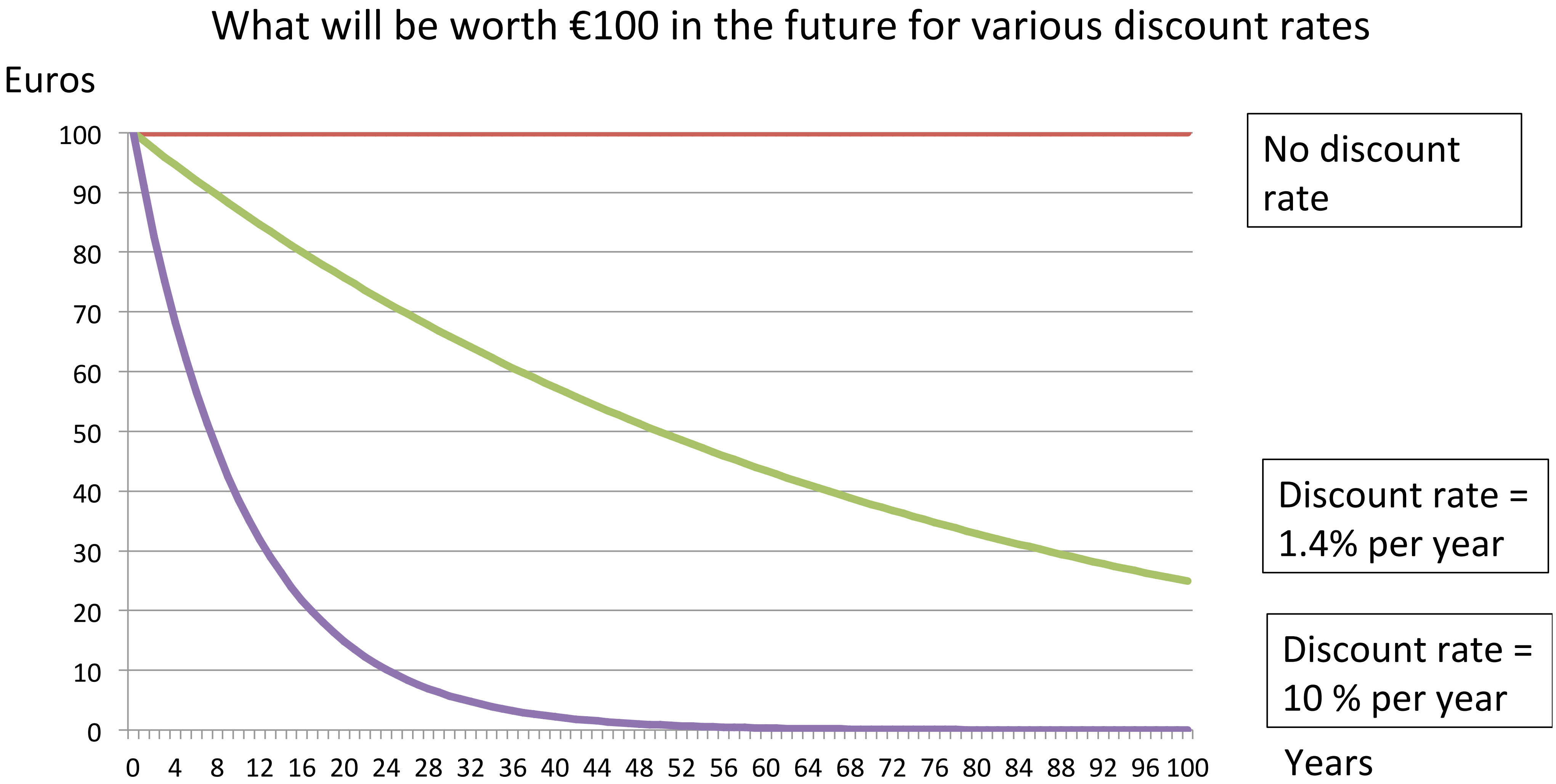

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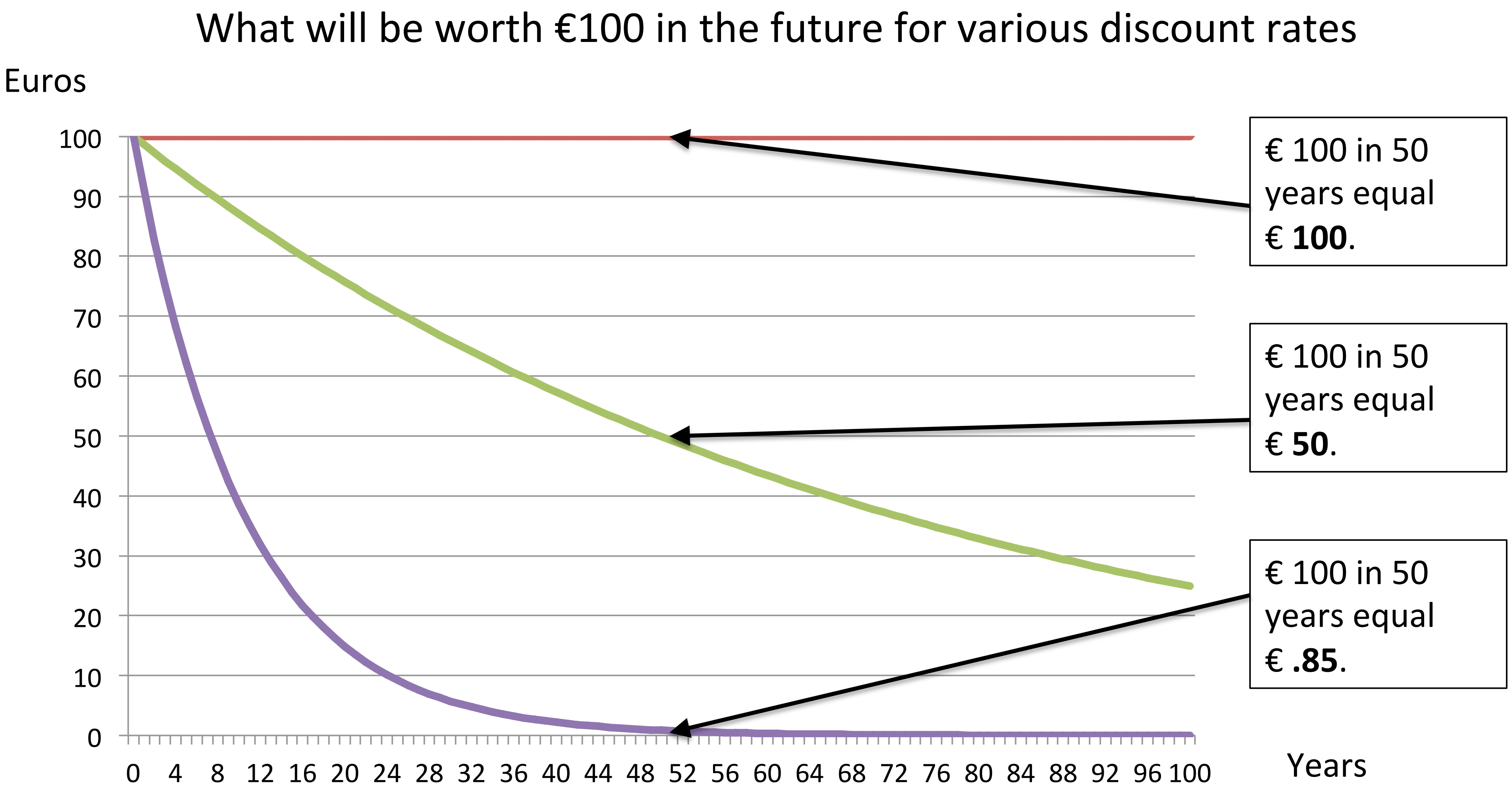
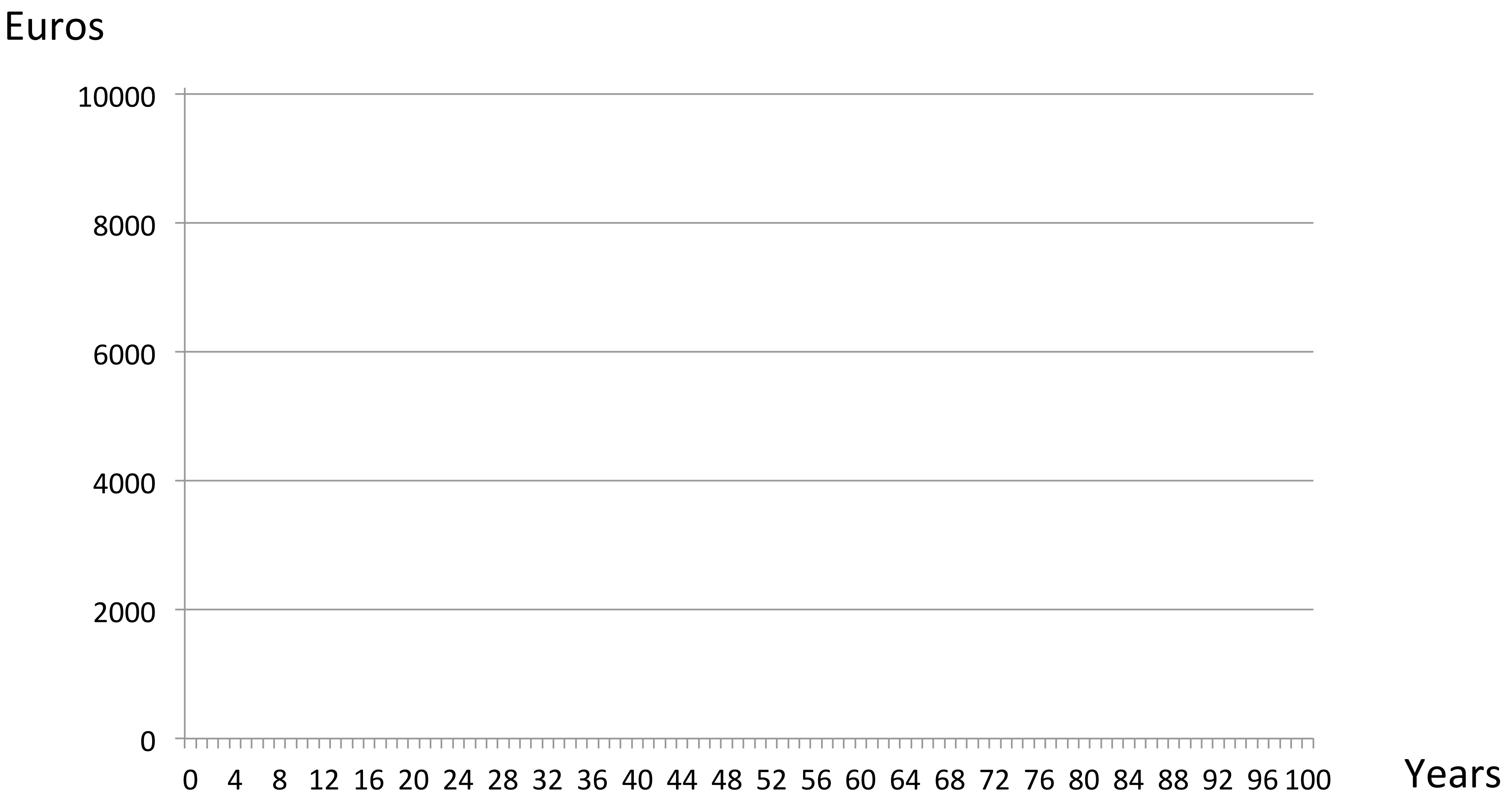


4.1 Discounting

What will be worth a flow of €100 / year in the future for various discount rates



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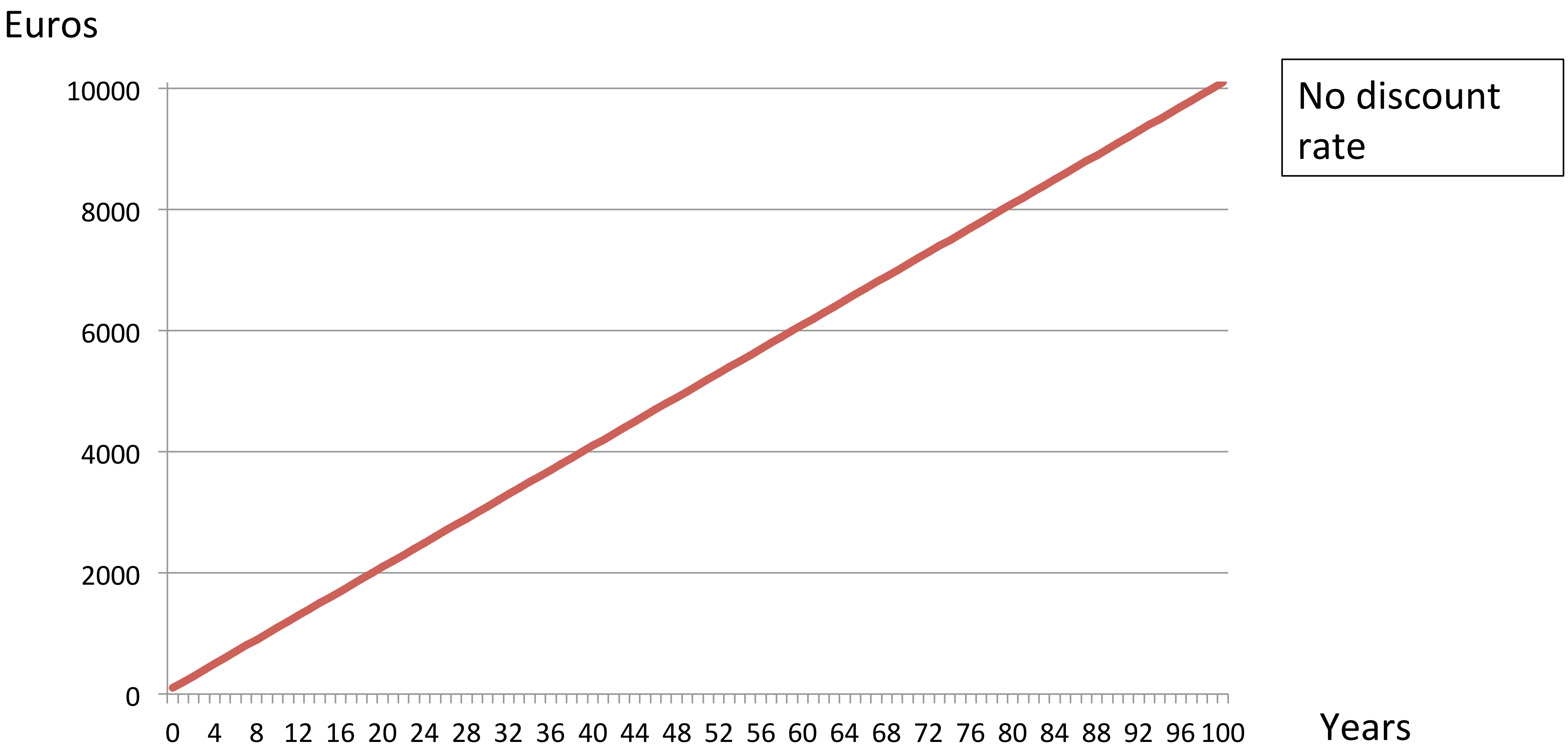

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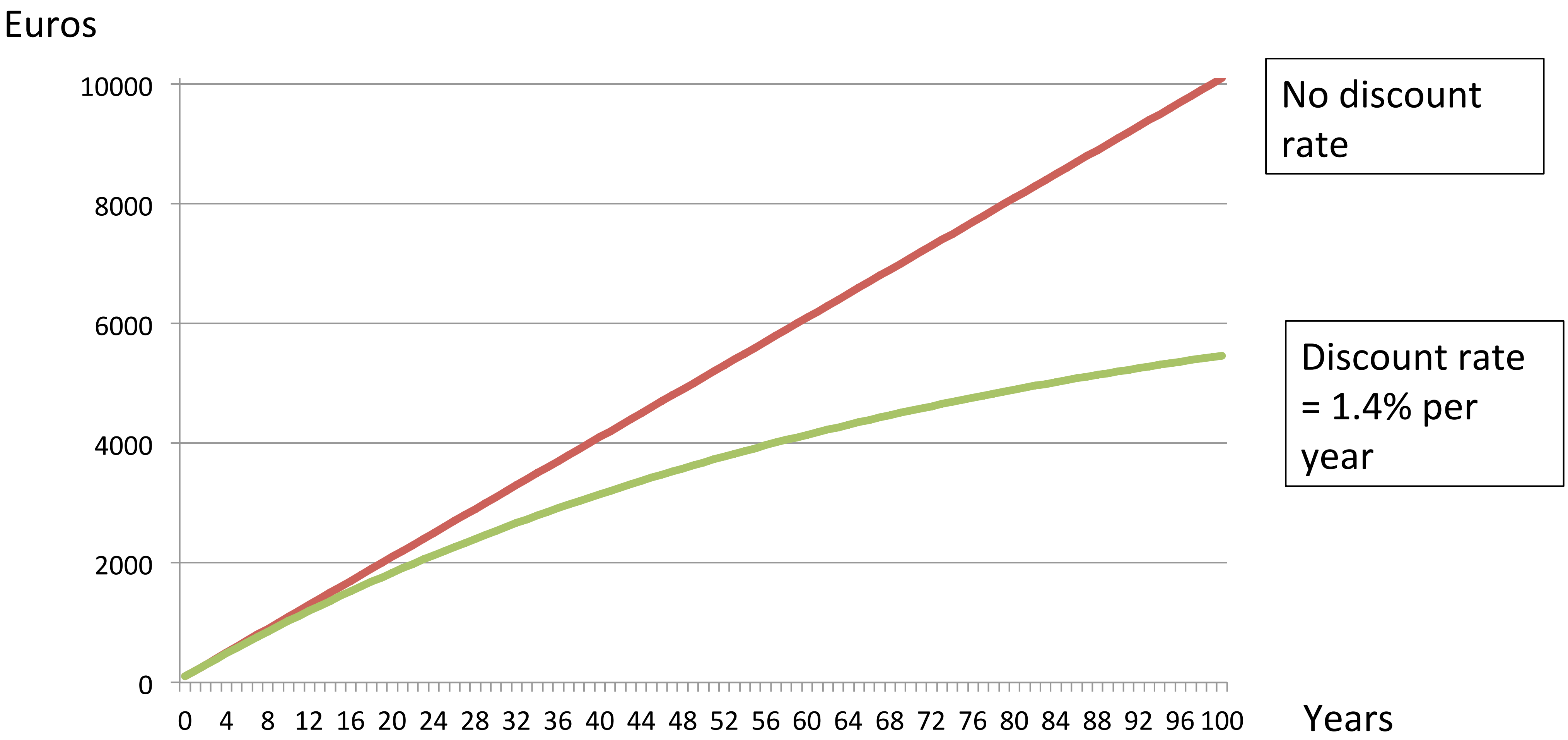

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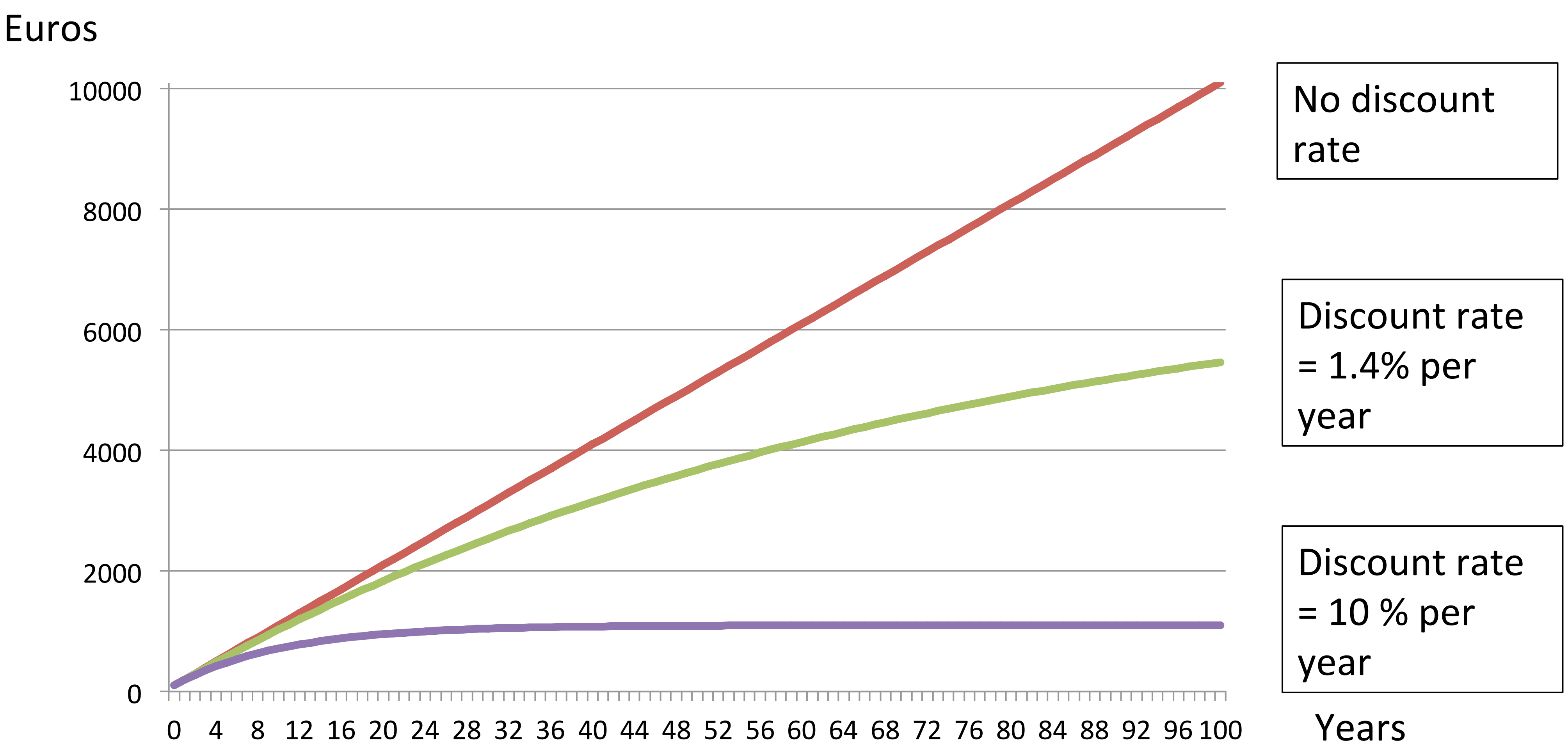

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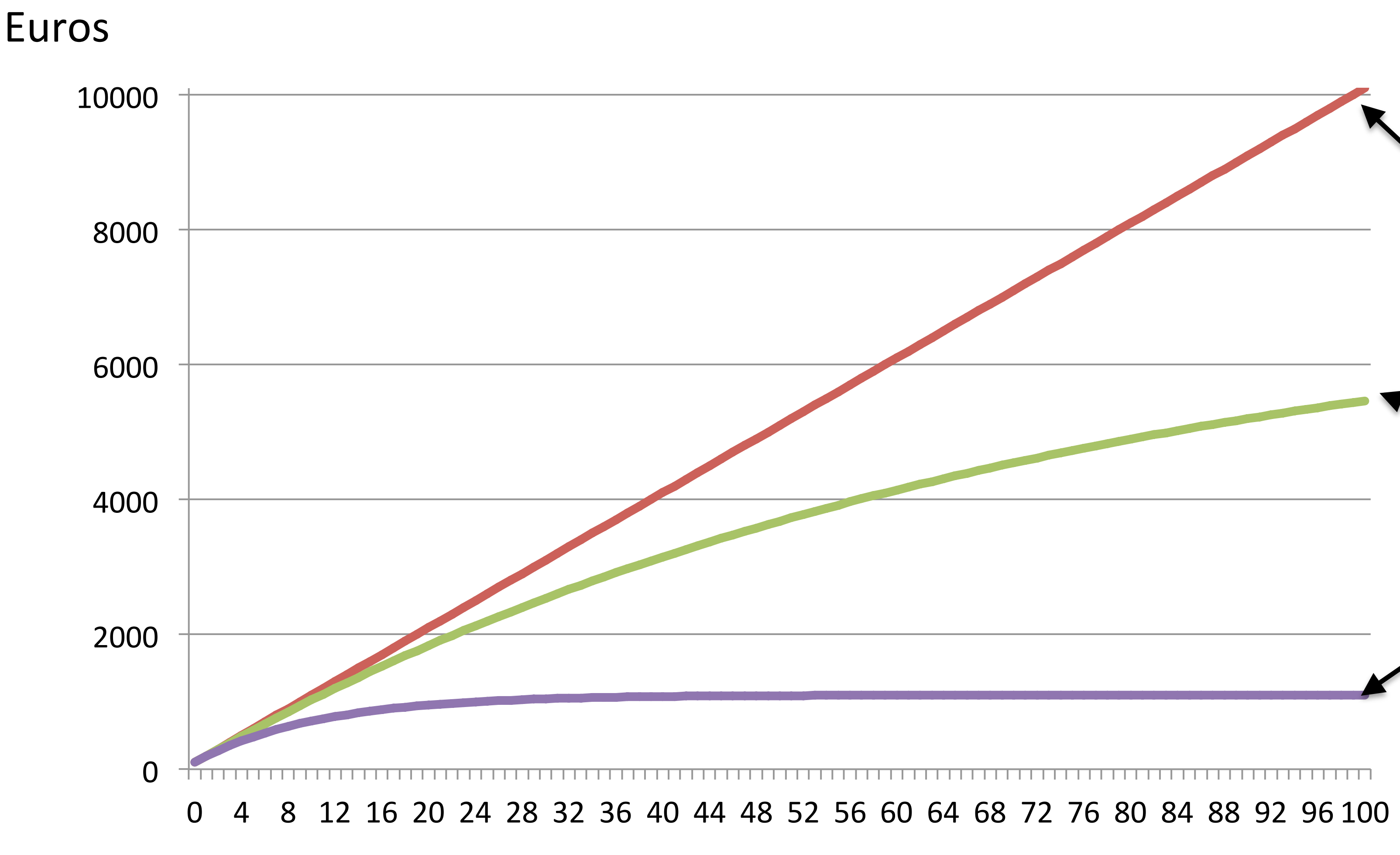


A flow of €100 / year for 100 years worth € **10 000**.

A flow of €100 / year for 100 years worth € **5 360**.

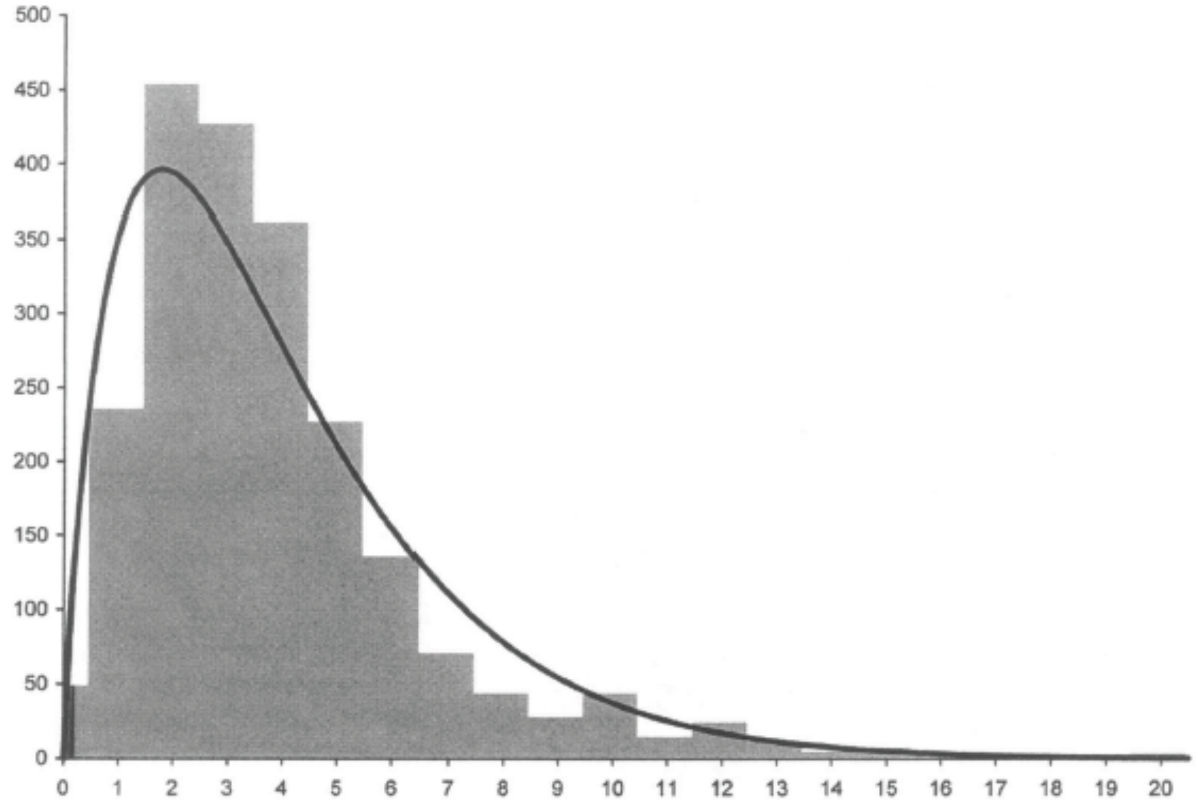
A flow of €100 / year for 100 years worth € **1 000**.

4.1 Discounting

Which discount rate should be used?

Weitzman (1998) surveyed 1 700 economists, and suggested that the discount rate for projects with distant effects (more than 30 years) should be lower than 2% / year.

Frequency



Discount rate per year (in %)

4.2 Different components of uncertainty

Several types of uncertainties impact the economic assessment of the consequences of climate change and local air pollution.

Scientific-related uncertainties on the nature, the speed and the consequences of the phenomenon (higher for climate change than for local air pollution).

Human-related uncertainties on the evolution of the population, of the economic conditions, of the technology, of the effectiveness of policies aiming to reduce local air pollution and the consequences of climate change.

Methodological-related uncertainties specific to the economic assessment: methods, scope, choice of the discount rate or of the Value for a Prevented Fatality,...

Overall, the cumulative effects of all these uncertainties make the economic assessment very uncertain, especially when it involves distant effects.

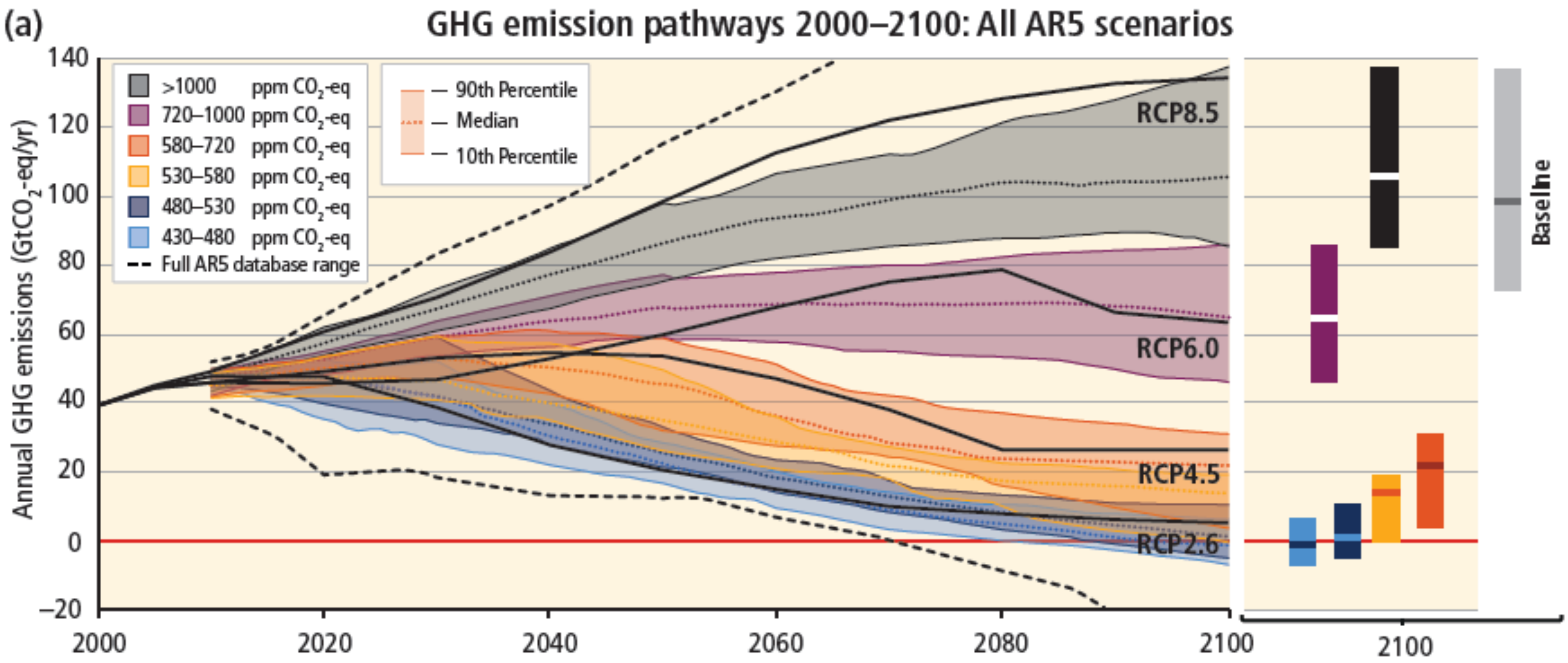
4.2.1 Scientific uncertainties

Air pollution: more limited, because impacts are well known: mainly health (long-term mortality) + crops, impacts on buildings.

Climate change: very large, relate in particular to changes in emissions and GHG concentrations, changes in temperature and precipitation distribution over the Earth's surface, the existence of non-linearities or thresholds in the effects associated with climate change (feedback effects, positive or negative), the improvement of forecasting models, of assumptions in the models (CO_2-enrichment effect on crop productivity, changes in distribution of contagious diseases) ...

The confidence intervals around values given in IPCC reports, for instance, reflect the influence of these uncertainties on the assessment of GHG emission trends.

4.2.1 Scientific uncertainties



Source: IPCC (2015) « Climate change 2014, Synthesis report, Summary for Policy makers », Figure 11(a), p. 21.

4.2.2 Human and methodological uncertainties

The human uncertainties relate in particular to the evolution of the population, the rate of growth of world wealth, the future productivity of crops, the evolution and availability of technologies for the reduction of emissions, the spread of infectious diseases, binding nature of future climate agreements (COP) …

Methodological-related uncertainties specific to the economic assessment, as already seen:

- the method chosen (observed, revealed or stated preferences),
- the scope of the effects considered,
- the unit monetary values chosen (cost of a morbidity episode, inability to work, the value of human life, damage to buildings, impacts on agriculture),
- the discount rate.

4.3 Irreversibility effects

Very large ecological irreversibilities for GHG

- 50% of CO_2 emitted disappear in 30 years, 30% in a few centuries, 20% in a few millennia.
- Target is 550 ppm CO_2e (currently 400 ppm) to limit the temperature increase at 3°C in 2100 => requires a 25% reduction in CO_2e in 2050 (w.r.t. 2005).
- Even with that, according to IPCC, 100-300 years required to stabilize CO_2e concentration, several centuries to stabilize temperature increase, a few millennia to stabilize sea level.

Almost no ecological irreversibilities for local pollutants

Local pollution is not actually irreversible: mean particle concentrations in the air can decrease rapidly (by 90% in a few days); natural regeneration fairly rapid and no problem of stock build-ups.

Large economic irreversibilities for GHG and local pollutants

Costs entailed in putting fundamental policies into practice are closely linked to lifestyle

=> takes a relatively long time and (probably) involves sunk costs.

4.4 Consequences on optimal decision: looking for flexibility

Uncertainties contribute to a wide dispersion of monetary assessments, in addition to the assumptions used in each valuation. However, some of these uncertainties will decrease as time passes.

Indeed, the arrival of information is continuous on the physical consequences of climate change (scientific publications every day), is regular on the economic consequences (reports of evaluation of the effects, effectiveness of the implementation of the policies) and policies (regular climate conferences and government announcements of measures to reduce CC).

At the same time, the irreversibility of the phenomena will not allow a rapid policy change.

Therefore, the policies we choose to implement at a given date for a given objective must be flexible enough to adapt to this arrival of information: we must therefore take into account the informational value (a component of the total economic value).

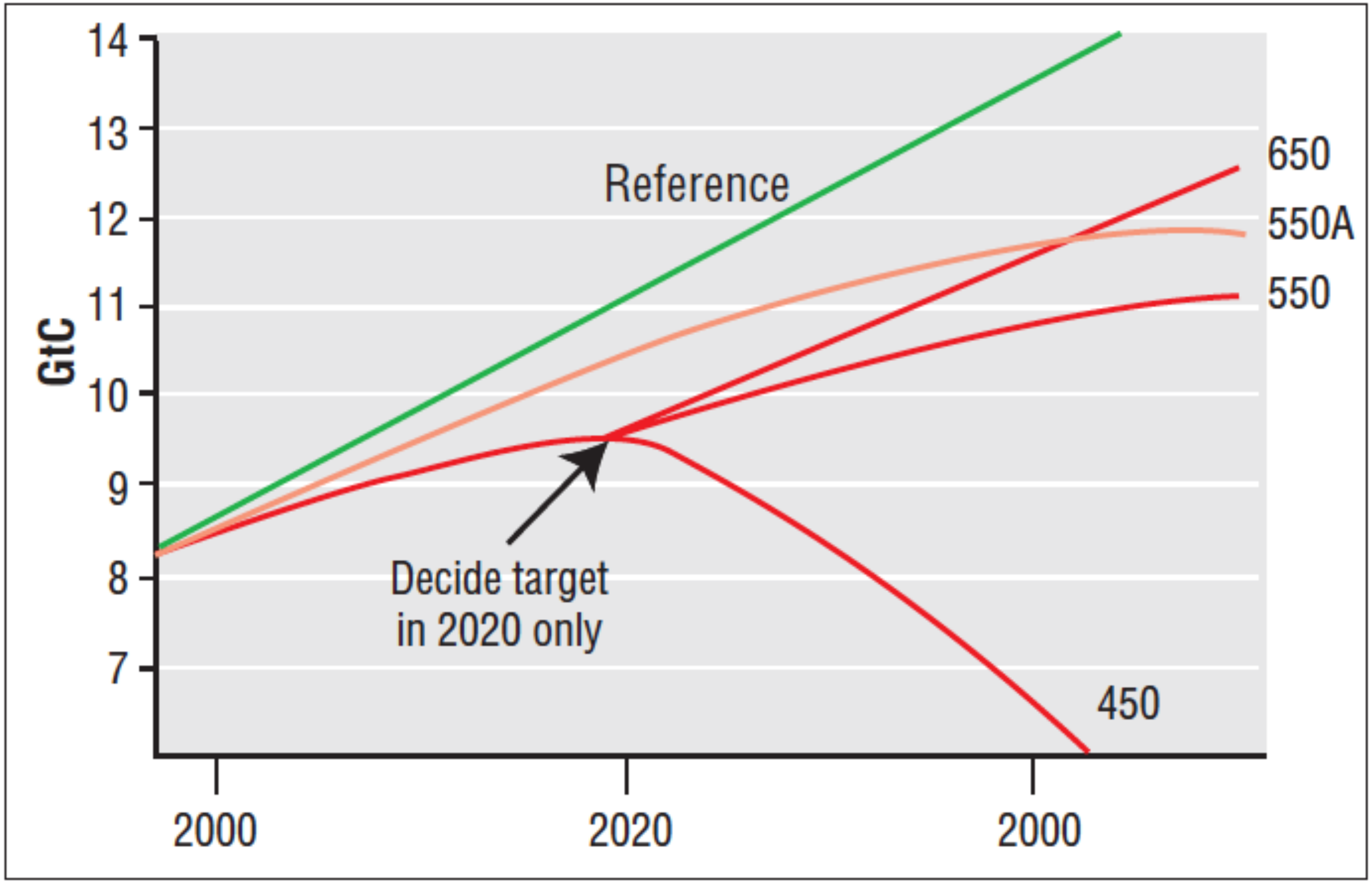
4.4 Consequences on optimal decision: looking for flexibility

Mitigation of GHG emissions is conditioned by the economic instruments and policy agreements. Policies face a double-edge constraint (IPCC):

- Avoid acting too rapidly and too strongly, which could have significant short-term effects on the economy and the population,
- Avoid acting too late and not be able to meet reasonable targets to limit climate change.

In the development of a climate policy, it is necessary to try to take into account all the risks and uncertainties, and in particular the so-called catastrophic events, i.e. with low probability of occurrence, but huge consequences.

4.4 Consequences on optimal decision: looking for flexibility



Source: Figure 10.1 Optimal carbon dioxide emissions strategy, using a cost-effectiveness approach (IPCC-WP3 (2001), « Climate Change -Mitigation p. 613).

4.5 Conclusion

Taking into account time in the economic approach of the effects of climate change is essential but leads to more complex analyses and more uncertainty about its economic evaluation.

Indeed, it adds a subjective dimension when choosing the discount rate and when choosing the future evolution of the different uncertainties.

Overall, taking into account the temporal dimension calls for fast and flexible action to reduce the consequences of climate change.

Case study 2:
Climate change in Camargue

5.1 What is Camargue?

5.2 Why is Camargue particularly exposed to climate change ?

5.3 The impacts of climate change

5.4 Economic consequences of a flood and adaptation measures.

5.1 What is Camargue?

The Camargue Regional Park (100,000 ha i.e. 100 km2) is located in the Rhône delta. 70% is less than 1 meter above sea level, 25% below sea level.

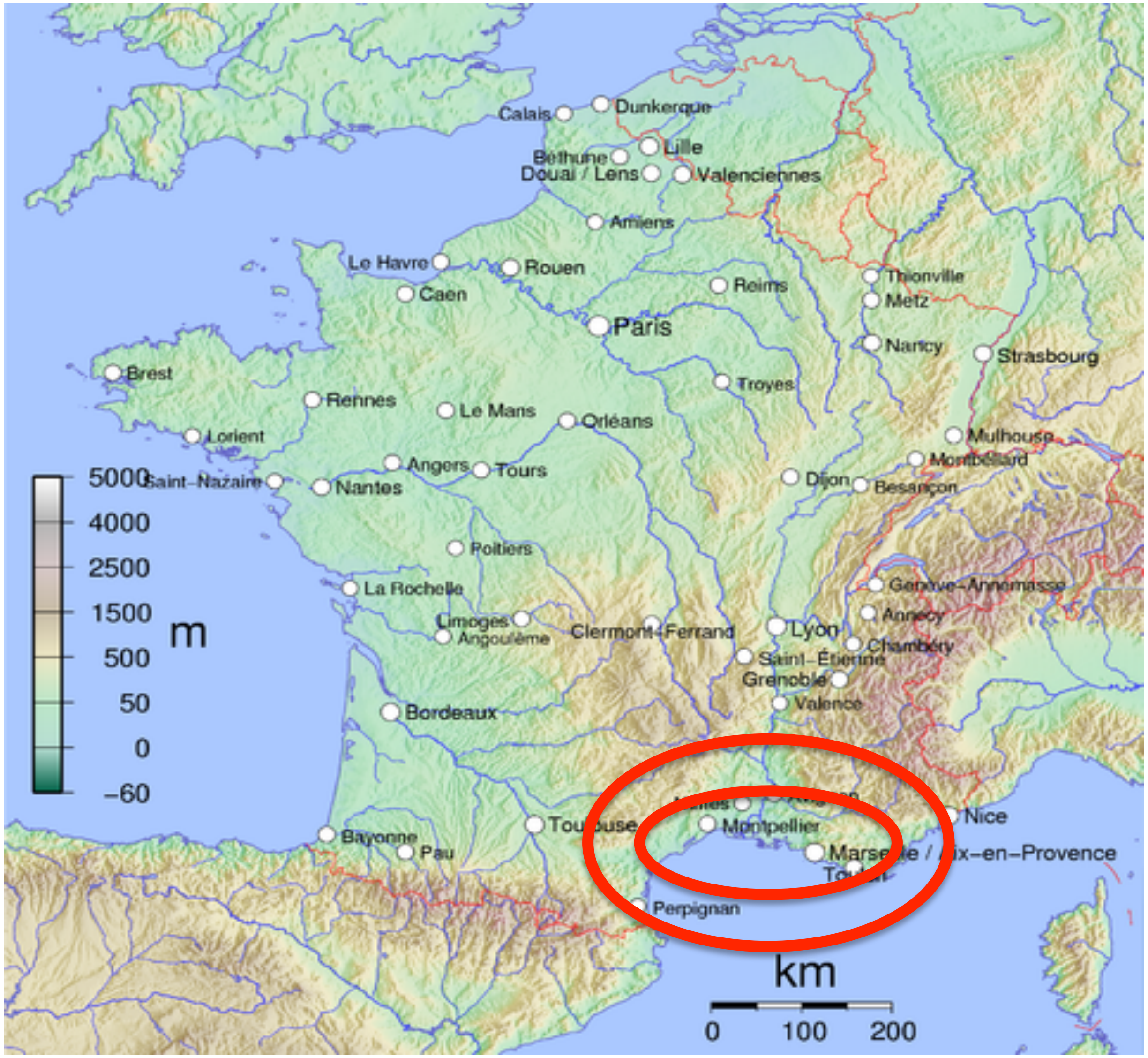
It suffered major storms (in 1982, 1997 and 2003) and major floods (1840, 1856, 1993-4 and 2003) and lost 330 ha since 1945, gained by the sea.

Classified biosphere reserve by Unesco, it is a place of meeting between wetlands and dry land, freshwater and Mediterranean sea, agriculture (culture and breeding), industry (salt exploitation), tourism, fauna and flora.

5.1 What is Camargue?

Source: By O H 237 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=38364150

5.1 What is Camargue?



Source: David Monniaux, Wikipedia, CC BY-SA 3.0

5.1 What is Camargue?

Source: Parc Naturel Régional de Camargue

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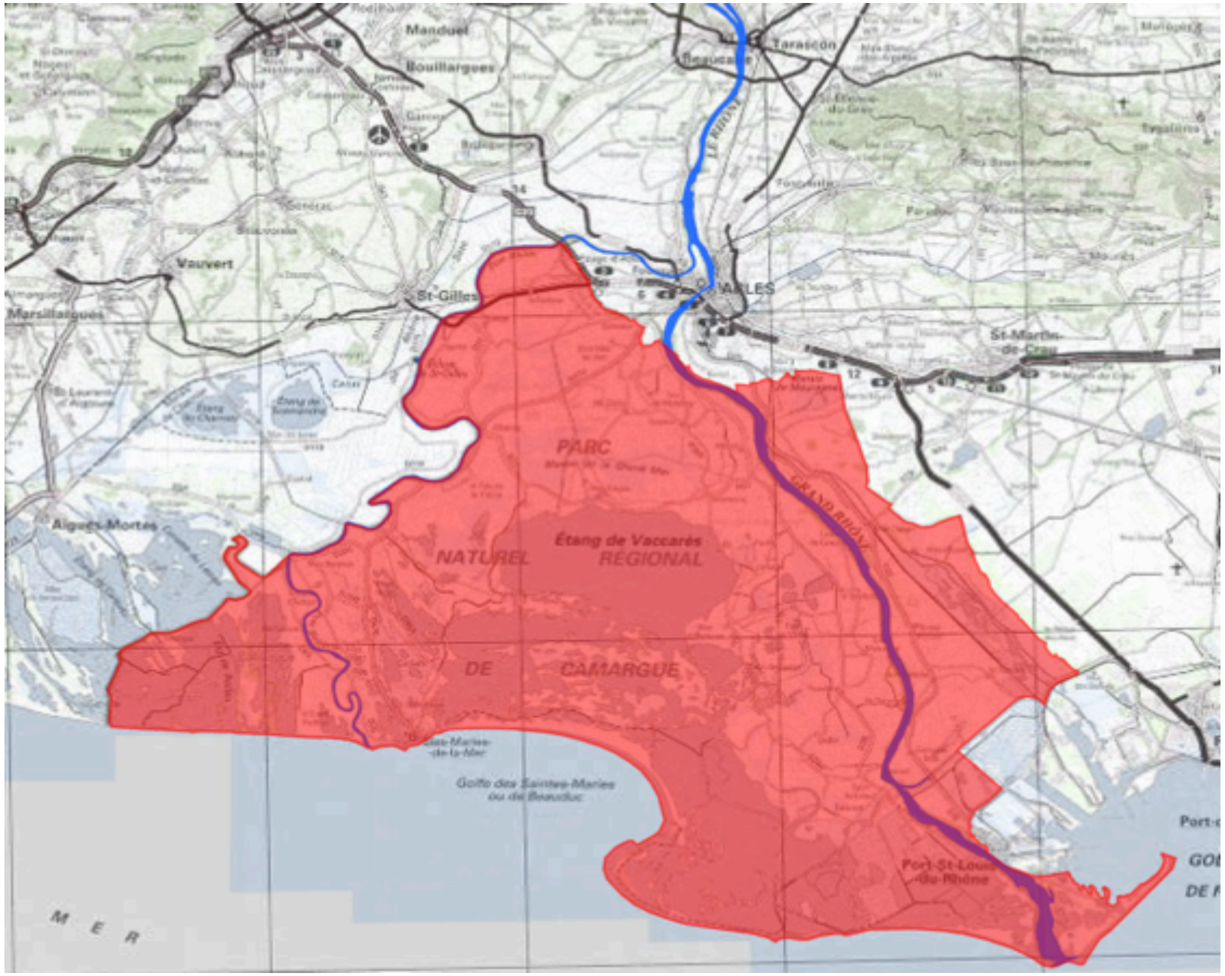

Source: Parc Naturel Régional de Camargue

5.1 What is Camargue?

NATURE

Source: Pixabay, CCO

5.1 What is Camargue?

WILDLIFE

Source: Pixabay, CCO

5.1 What is Camargue?

WILDLIFE

Source: Pixabay, CCO

5.1 What is Camargue?

AGRICULTURE
Cattle

Source: Pixabay, CCO

5.1 What is Camargue?

AGRICULTURE
rice

Source: Pixabay, CCO

5.1 What is Camargue?

INDUSTRY
salt

Source: Pixabay, CC0

5.1 What is Camargue?

TOURISM

Source: Pixabay, CCO

5.2 Why is Camargue particularly exposed to climate change?

Camargue is subject to the influence of three effects of climate change.

1) **The sea level rise**, causing a sea advance of about 4 meters per year for 50 years. This leads to an increase in sea salt, which hinders agriculture and degrades flora, a degradation of the dam at sea protecting the coastline, and an increase in the risk of marine submersion during storms.

2) **Rains and storms of higher intensity** fill the ponds, which are difficult to empty when the sea level is too high and cause floods of the Rhone, which increase the risk of breakage of dikes.

3) **The loss of average flow of the Rhône** (due to drought) leads to a rise of salt in the soil (salt wedge) more and more inland, and a loss of freshwater resources.

5.2 Why is Camargue particularly exposed to climate change?

In addition, two aggravating factors independent from climate change.

1**) The reduction of alluvium carried by the Rhone** (division by 4 in a century). It is due to domestication (dam, dredging) ... ... and change in agricultural practices on the Rhone and Durance. The construction of dikes also no longer allows the river to deposit the remaining alluvium.

2**) The Rhône delta** (consisting of alluvial deposits) **sinks** by 1 mm per year, aggravating the effect of the rise in mean sea level.

All these effects contribute to make Camargue one of the areas the most exposed to climate change consequences.

5.3 The impacts of climate change

From the report "Etude de la vulnérabilité du Pays d'Arles au changement climatique ("Study of the vulnerability of the Pays d'Arles to climate change (2014)", we are going to present the main effects of climate change in Camargue, by grouping them:

- by category of impacts (economic, social and ecological),

- by their degree of vulnerability to climate change:

Very strong vulnerability
Strong vulnerability
Medium vulnerability
Weak or uncertain vulnerability

- by their market, non-market and mixte nature:

Market valuation
Non-market valuation
Market and non-market valuation

QUESTION:

WHAT ARE THE IMPACTS OF CLIMATE CHANGE IN CAMARGUE ?

5.3 The impacts of climate change

Economic impacts	
Agriculture	Breeding (goats, bulls, horses)
	Rice
	Wheat
	Vineyard
Tourism	Beach and building destruction due to coastal erosion
	Worsening of thermal comfort (heat waves and mosquitos)
	Change in seasonal activities
Industry	Salt marsh and Solvay chemical factory

5.3 The impacts of climate change

<table>
<tr><th colspan="2">Economic impacts</th><th colspan="2">Social impacts</th></tr>
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<tr><td>Industry</td><td>Salt marsh and Solvay chemical factory</td><td>Rhône floods</td></tr>
</table>

5.3 The impacts of climate change

Economic impacts		Social impacts		Ecological impacts	
Agriculture	Breeding (goats, bulls, horses)	**Health**	Worsening of thermal comfort (heat waves and mosquitos)	**Water resources**	Difficulty of discharge in winter by the sluices
	Rice		Vector diseases		Rising salt wedge
	Wheat		Allergenic diseases	**Environments**	Invasive species
	Vineyard		Waterborne diseases		Salinization and erosion of the littoral zone
Tourism	Beach and building destruction due to coastal erosion		Infectious diseases		Pollution and salinization of forests bordering the Rhône
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	Change in seasonal activities		Marine submersion		Salinization and modification of the freshwater wetland cycle
Industry	Salt marsh and Solvay chemical factory		Rhône floods		

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Industry	Salt marsh and Solvay chemical factory		Rhône floods		

QUESTION:

MARKET OR NON-MARKET IMPACTS ?

5.3 The impacts of climate change

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5.3 The impacts of climate change

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5.4 Economic consequences of a flood and adaptation measures.

The December 2003 flood was the third largest since 1800. It was the result of exceptional floods of the Rhone and its tributaries, a total saturation of the hydraulic networks in Camargue following heavy rains, and a marine surge annoying the operations draining.

Overall, 130 km2 were flooded, of which three quarters of the Regional Park of Camargue (73 km2), of which 20 by the floods and 53 by the rains. About 12,000 people were affected, particularly in the Arles region.

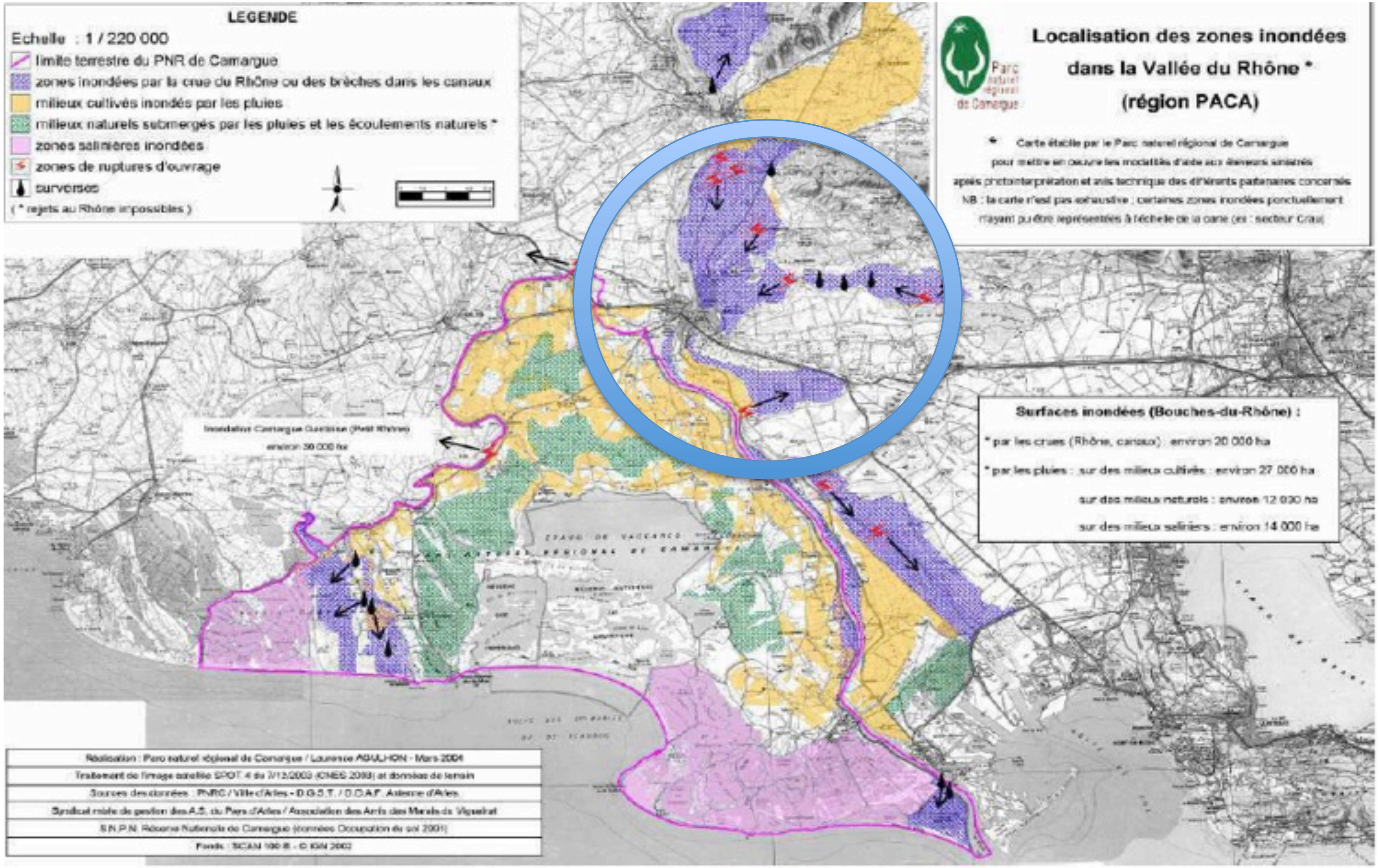
5.4.1 Economic consequences of a flood

Economic impacts		Social impacts		Ecological impacts	
Agriculture	Damages to agriculture and hydraulic network: **€76.8 Million**	**Health**		**Water resources**	
Tourism		**Buildings and infrastructures**	Damages to buildings: **€320 Million**	**Environments**	
			Damages to infrastructure: **€51.2 Million**		
Industry	Damages to factories, shops, and commercial properties: **€367 Million**		Damages to dikes and rivers: **€31.4 Million**		

Total: €847 Million

Source: Etude de la vulnérabilité du Pays d'Arles au changement climatique (2014)

5.4.1 Economic consequences of a flood



5.4.1 Economic consequences of a flood

Symadrem studied the impact of dike management measures between Tarascon-Beaucaire and Arles, which would reduce vulnerability in the event of a 2003 flood (return period = 100 years).

A breach in the railway embankment would result in a spill of about 500 million m3, a water depth of between 1 and 4 meters, about 50,000 people affected, and a damage cost of about €1,200 million, of which 930 for housing, 120 for agriculture and 115 for businesses.

5.4.1 Economic consequences of a flood

A breach in the dike protecting railway underpasses would result in a spill of about 15 million m3, a water depth of between 0.5 and 2 meters, about 300 people affected, and a damage cost of about 40 million euros, of which 17 for housing, 15 for agriculture and 5 for businesses.

5.4.1 Economic consequences of a flood

In both cases, the construction of dikes would make it very unlikely that the Rhône overflows, the cost of damages would be zero and there would be no disaster.

The expected benefits from management measures are equal to the costs of damage avoided:

- €1200 million for a breach in the railway embankment,
- €40 million for a breach in the dike protecting railway underpasses.

5.4.2 Economic consequences: adaptation measures

The cost of the development of the dikes on the studied area (downstream of Beaucaire) to limit the risks of flooding is evaluated to €310 million.

However, all the work of securing the dikes and concerted management of the river (including 210 km of dikes) is estimated at about €800 million.

5.4.3 How a benefit-cost analysis would work

Benefits (damages avoided)

1) For a type of flood (and a given period, a century for example):

- Calculate the benefits avoided in the event of backfill failure, breach in a hopper and overflow of the Rhone despite developments **at different places.**
- Take into account the probability of occurrence of each of these events.

2) Do the above calculations for different types of floods, with the corresponding probability of occurrence.

Mitigation costs

Evaluate all the work of securing dikes and concerted management of the river over the same period.

Choose a discount rate to express the benefit and cost streams in net present value.

5.5 Conclusion

Camargue is an area extremely exposed to climate change, which translates into increased risks of flooding by flood or runoff, aggravated by rising sea level.

Economic assessments of the effects of climate change involve a large number of sectors. In addition, there are non-market impacts associated with the degradation of ecosystems and water resources that have not been accounted for, as well as non-market health related effects (psychological effects of flood, fear …).

The evaluation of the cost of damages associated with floods makes it possible to establish the order of magnitude of the benefits to be expected from a decrease in the probabilities of flooding whether it is through the implementation of (global) policies to limit climate change or local policies to attenuate the effects of climate change.