Publizierbarer Endbericht

gilt für Studien aus der Programmlinie Forschung

A) Projektdaten

Allgemeines zum Projekt	
Kurztitel:	PACINAS
Langtitel:	Public Adaptation Costs: Investigating the National Adaptation Strategy
Zitiervorschlag:	Bednar-Friedl, B., Leitner, M., Schinko, T., Loibl, W., Bachner, G., Knittel, N., Mechler, R., Glas, N. (2017), Public Adaptation Costs: Investigating the National Adaptation Strategy. Final Publishable Report, Graz/Vienna.
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Projekt- und KooperationspartnerIn (inkl. Bundesland):	International Institute for Applied System Analysis (IIASA), NÖ Austrian Institute of Technology (AIT), W Umweltbundesamt GmbH (UBA), W
Schlagwörter:	Public adaptation, costing, disaster risk management, cities, public sector, macroeconomic effects
Projektgesamtkosten:	326,263 €
Fördersumme:	299,784 €
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B) Project Überblick / Project overview

1 Kurzfassung

Bereits heute zeigen Studien, wie etwa der Stern-Review, dass die Kosten von Klimaschutz und Klimawandelanpassung geringer ausfallen werden als die potenziellen Kosten des Nicht-Handelns (EC 2009). Trotzdem sind weitere detailliertere Studien notwendig, da das Wissen bezüglich konkreter Anpassungsoptionen und deren Kosten auf europäischer, nationaler und lokaler Ebene nicht ausreichend ist. Das Projekt PACINAS beschäftigt sich deshalb mit potenziellen Kosten und Nutzen von Klimawandelanpassung der öffentlichen Hand, mit besonderem Fokus auf der Implementierung der „Österreichischen Strategie zur Anpassung an den Klimawandel" (BMLFUW 2012).

Vor diesem Hintergrund beschäftigt sich das Projekt PACINAS mit den Kosten von Klimawandelanpassung in Zusammenhang mit öffentlichen Budgets und den mit Anpassung verbundenen makroökonomischen Wirkungen. Mittels Fallstudien auf Bundes- und Landesebene sowie für ausgewählte Städte konnten sowohl die derzeitigen Ausgaben für Klimawandelanpassung sowie die potenziellen zukünftigen Kosten bis 2050 abgeschätzt werden. Der Fokus des Projekts liegt auf Extremwetterereignissen sowie jenen Aktivitätsfeldern der nationalen Anpassungsstrategie, die hohe budgetäre Relevanz aufweisen.

In einem ersten Schritt wurden die 132 Maßnahmen der Anpassungsstrategie durchleuchtet und den verschiedenen Zuständigkeiten quer über die verschiedenen Phasen des Anpassungsprozesses (Initiierung, Finanzierung, Implementierung und Materialisierung der Nutzen) zugeordnet. Diese erste Analyse zeigte, dass die Initiierung sehr stark von öffentlicher Seite getrieben ist, während bei Finanzierung und Implementierung bereits mehr private Akteure ins Spiel kommen, diese Phasen aber immer noch von öffentlichen Akteuren dominiert sind. In der Phase der Materialisierung sind öffentliche und private Akteure nahezu gleichauf. Viele Maßnahmen werden zudem gemeinsam von öffentlicher und privater Seite finanziert.

Um vertiefte Einblicke in Anpassungskosten in der kurzen und langen Frist zu bekommen, wurden zwei Fallstudien durchgeführt. Einerseits auf Bundes/Landesebene und andererseits auf Gemeinde/Städte-Ebene. Erstere fokussierte auf Katastrophenrisikomanagement, mit dem Ergebnis, dass in der Praxis hauptsächlich auf das derzeitige Anpassungsdefizit geachtet wird und Klimawandelanpassungskosten weder explizit aufscheinen noch systematisch erhoben werden. Präventive Maßnahmen können allerding als Indikator für frühe Anpassung verstanden werden. Wahrscheinlichkeitsbasierte Modellergebnisse bis 2030 und 2050 zeigen, dass Überschwemmungen entlang von Flussläufen erhöhten fiskalischen Druck auslösen können, wobei jedoch sozio-ökonomische Entwicklungen der Hauptkostentreiber sind. Ebenfalls wurde gezeigt, dass der Katastrophenfonds bereits heute unter Druck ist und dieser Druck bis 2050 voraussichtlich weiter steigen dürfte und sich ad-hoc Aufstockungen häufen könnten. Auf Basis der Projektergebnisse wird daher vorgeschlagen, einen

iterativen Klimarisikomanagement-Ansatz zu verfolgen, um derzeitige sowie zukünftige klimabezogene Risiken zu minimieren.

Die Ergebnisse der Fallstudie auf Gemeinde/Städte-Ebene sind wie folgt. Anpassung in Städten konzentriert sich hauptsächlich auf Raumplanung, Wartung von öffentlichen Gebäuden, Instandhaltung von Straßen, Wasser- und Abwassermanagement sowie der Bereitstellung von öffentlichem Grünraum. Das Thema Gesundheit wird nicht im primären Zuständigkeitsbereich der Städte gesehen. In der budgetären Praxis der Städte wird meist kein Unterscheid zwischen Klima(wandel)folgekosten und Anpassungskosten gemacht, da nach einem Schadensfall Anpassung oft gleichzeitig mit Reparatur und Instandsetzung geschieht. Anpassung geschieht also implizit, es ist aber nicht möglich, Anpassungskosten zu isolieren. Nichtsdestotrotz wird von den zuständigen Abteilungen Anpassung als Strategie gesehen, um mit der derzeitigen Klimavariabilität und zukünftigen Risiken umzugehen.

Für die Abschätzung der Anpassungskosten auf Bundesebene wurden zwei Methoden entwickelt. Für jene Handlungsfelder der Anpassungsstrategie mit der höchsten budgetären Relevanz (Landwirtschaft, Forstwirtschaft, Wasser, Schutz vor Naturgefahren und Katastrophenmanagement, Ökosysteme und Biodiversität, Verkehrsinfrastruktur, Stadt und urbane Grünräume sowie Gesundheit; wobei letzteres mangels geeigneter Daten nicht berücksichtigt wurde) wurden 67 Handlungsempfehlungen genauer analysiert. Die erste Methode verfolgt einen Top-Down-Ansatz und basiert auf dem aktuellen Bundesbudget, die zweite Methode verfolgt einen Bottom-Up-Ansatz und basiert auf einer Kostenabschätzung der einzelnen Maßnahmen der Anpassungsstrategie.

Die geschätzten jährlichen anpassungsrelevanten Ausgaben des Bundes belaufen sich bereits heute auf zumindest € 2.1 Mrd. (und nur für die ausgewählten Handlungsfelder), was 1,2% des gesamten Bundesbudgets (2014) entspricht. Jener Anteil, der explizit als Anpassungsausgaben erfasst werden konnte, beläuft sich auf € 488 Mio. (mittels Top-Down-Ansatz; bzw. € 358 Mio. mittels Bottom-Up-Ansatz). Diese Anpassungskosten entsprechen 8% der relevanten Globalbudgets (in den Budgetuntergliederungen 41-43) oder 0,65% des gesamten Bundesbudgets.

Bezüglich der gesamtwirtschaftlichen Auswirkungen von Anpassung wurden Modell-Analysen bis 2050 durchgeführt. Es wurde gezeigt, dass die makroökonomischen Effekte von Anpassung in den Aktivitätsfeldern Landwirtschaft, Forstwirtschaft und Katastrophenmanagement positiv sind, verglichen zu einem Klimawandelszenario ohne Anpassung (COIN-Szenario). Durch Anpassung kann der negative BIP Effekt – kommend aus den drei analysierten Aktivitätsfeldern – ins Positive gedreht werden; der Wohlfahrtsverlust kann auf ein Fünftel reduziert werden. Weiters wurde gezeigt, dass durch Anpassung langfristige positive Beschäftigungseffekte erzeugt werden können, vor allem, wenn vermehrt auf softe Maßnahmen (z.B. Frühwarnsysteme, Forschung und Entwicklung) und grüne Maßnahmen (Ökosystemmanagement) gesetzt wird.

2 Executive Summary

The European Commission (EC 2009, 6) states in its White Paper on Adaptation that "Although more specific information on the costs of adaptation is needed, several sources [like the Stern Review] already indicate that the costs of taking action to address climate change (including mitigation and adaptation measures) will be much lower than the costs of inaction over the medium to long term." Yet, despite this recognition at the practical level, there is insufficient knowledge on the actual costs of concrete adaptation options at the EU, national and local level. The project PACINAS (Public Adaptation Costs – Investigating the National Adaptation Strategy) deals therefore with the question of potential (planned) public adaptation costs and benefits with regard to implementing the Austrian National Adaptation Strategy (BMLFUW 2012).

Against this background, the project PACINAS addresses the costs of adaptation to climate change for the public budget and the associated macroeconomic effects. Case studies on provincial and federal as well as the city level made it possible to estimate the current adaptation expenditures and the potential future costs of adaptation up to 2050. The project focuses on adaptation costs due to extreme events such as flooding, mass movements and heat stress, and covers the activity fields of the Austrian National Adaptation Strategy with high relevance for the public budget (agriculture, forestry, water, protection from natural hazards, catastrophe management, transport, cities and urban green).

As a first step we screened the 132 measures of the Austrian Adaptation Strategy and associated them with different responsible actors across different phases in the adaptation process: initiation, financing, implementation, and ultimately materialization (in terms of creating benefits from a measure). We find that the initiation is predominantly done by public actors, while financing and implementation is undertaken to a larger degree by private actors, but still dominated by public actors, whereas the materialization of benefits happens in both the public and the private domain. Moreover, many measures are implemented or financed jointly by private and public actors.

Two case studies were employed to gain insights into adaptation costs in the short and long term at the federal and provincial as well as the municipal level. For the federal and provincial level, the case study focused on Disaster Risk Management (DRM). The findings from this case study are that DRM practice in Austria is mainly focusing on the current adaptation deficit and that currently climate change adaptation expenditures are neither treated *explicitly* as such, nor are they collected in a systematic way. However, preventive measures can be interpreted as a proxy for early adaptation costs. Probabilistic modelling of future riverine flood losses indicates potential fiscal stress for Austria up to 2030 and 2050, with socio-economic developments as the strongest driver of riverine flood risk up to 2050. Already today the disaster fund, which should serve as a vehicle to strengthen resilience, is under pressure due to extreme events and we find that this pressure might increase in the future up to 2030 and 2050. Based

on these results, we therefore suggest to use an iterative climate risk management strategy for tackling current and future climate-related risks.

For the city case study, the key findings are as follows. Adaptation in cities focuses on spatial planning, facility management of public buildings, road maintenance and damage repair, water management and sanitation (sewage system), parks and public green space. So far, no focus lies on health because this is seen primarily as a provincial and federal responsibility. In cities' budgetary practice, no clear distinction is made between climate (change) impact costs and adaptation; often incremental adaptation measures are implemented together with repair measures, making it hardly possible to isolate pure adaptation expenditures. Thus, adaptation leads implicitly to a mark-up on regular maintenance expenditures. Nevertheless, the relevant departments see adaptation as a strategy to deal with current climate variability and perceived future climate risk.

To gain better insights into the current federal adaptation (relevant) expenditures two methodologies were developed in PACINAS. For the impact fields of highest budgetary relevance for the federal budget (which are agriculture, forestry, water resources and water management, protection from natural hazards, disaster risk management, ecosystems and biodiversity, transport infrastructure as well as health; the latter however could not be covered due to data limitations) 67 measures have been assessed. The first method is a top-down approach, based on the federal government's budget plan and realization report, the second method is a bottom-up approach, based on the costing of the individual measures listed in the national adaptation strategy. The estimated annual adaptation-relevant expenditures in the federal budget amount to at least € 2.1 billion already today and for the analyzed impact fields only (1.2% of the total federal budget in 2014). The share that can be explicitly attributed as adaptation is estimated to be € 488 million (top-down approach; € 358 million bottom-up). These adaptation costs are 8% of the relevant global budgets (for the three budget subdivisions 41-43) or 0.65% of the total federal budget.

Regarding the benefits and costs of public adaptation from an economy-wide perspective, we find that the macroeconomic effects of climate change adaptation in the analyzed impact fields agriculture, forestry and catastrophe management are positive, compared to the climate change impact scenario without adaptation (both for 2050). More precisely, due to adaptation the climate change-induced negative GDP effects from the three impact fields turn positive and welfare losses can be reduced to a fifth. Moreover, we find that climate change adaptation can lead to positive employment effects in the long term, when relying increasingly on soft measures (such as early warning systems, research and development) and green measures (such as ecosystem management).

3 Hintergrund und Zielsetzung / Background and goals

The European Commission (EC 2009, 6) states in its White Paper on Adaptation that "Although more specific information on the costs of adaptation is needed, several sources [like the Stern Review] already indicate that the costs of taking action to address climate change (including mitigation and adaptation measures) will be much lower than the costs of inaction over the medium to long term." Yet, despite this recognition at the practical level, there is insufficient knowledge on the actual costs of concrete adaptation options at the EU, national and local level. The project PACINAS deals therefore with the question of potential (planned) public adaptation costs and benefits with regard to implementing the Austrian Adaptation Strategy (NAS), which in turn play a crucial role for public finances and thus will strengthen the ability to make sound adaptation decisions for adequate and cost-effective adaptation activities and measures. We focus on different governance levels in Austria – municipalities (=cities) as well as provinces and the federal level to identify and assess response efforts and options to cope with changing climate impacts (heat extremes, precipitation and flooding extremes).

The objectives of the project were to:

- Disentangle which public budget positions entail significant costs of climate adaptation
- Identify adaptation needs and costs for public authorities in Austria at different governance levels (federal, provincial, and city level)
- Explore adaptation cost dynamics over time
- Explore effects of different adaptation types (soft, grey, green; operating or investment costs)
- Assess the macroeconomic effects of public adaptation
- Investigate user information needs to support public decision making for adaptation
- Develop robust adaptation paths based on economic analysis of adaptation options
- Identify synergies and potential trade-offs between public and private adaptation

4 Projektinhalt und Ergebnis(se) / Content and results

To address the objectives of the project, the following activities were performed within the project:

- Classification of 132 measures of the Austrian national adaptation strategy into public, private and mixed adaptation activities, taking account of initiation, implementation, financing and beneficiary roles.
- Federal/ provincial case study: Detailed insights into the Austrian disaster risk management (DRM) practice, its role for early adaptation to climate change, and associated costs. Assessment of medium term fiscal consequences of future climate risks under future socioeconomic developments (up to 2030 and 2050).
- City case study: Assessment of climate change adaptation and repair costs for Linz, Graz, Baden, Judenburg based on exploration of municipality budgets 2001/2002-2014, and on qualitative interviews.
- Costing of public adaptation for the federal budget: Development and application of two costing methodologies for adaptation-relevant expenditures and adaptation costs for the federal budget (covering 7 activity fields of the Austrian national adaptation strategy; 67 measures in total); development of an indicative adaptation cost path up to 2050.
- Macroeconomic analysis of federal adaptation expenditures for 2050 (based on the developed indicative adaptation cost path), and different strategies to finance impacts and adaptation.
- Stakeholder involvement, dissemination and outreach: Installation of project webpage, stakeholder workshop, regular exchange with stakeholders, final workshop, presentation of results at international conferences.

Methodological approach: Framework for analysis & scenarios

When assessing the 132 measures of the Austrian Adaptation Strategy (BMLFUW 2012), we find that the initiation is predominantly prepared by public actors, while financing and implementation is also undertaken by private actors, however still dominated by the public sector (Fig. 1). The general public (green bars) benefits from almost all measures, the benefits of around half of these measures can be considered as a national public good while the other half is rather perceived on the regional level. Moreover, around 100 measures provide further benefits to specific groups in the private domain (private households or companies). In PACINAS, we therefore define public adaptation as all measures that are publicly funded or implemented. Further details can be found in PACINAS working paper #01 (Knittel and Bednar-Friedl 2016) and PACINAS fact sheet 1 (Leitner et al. 2017).

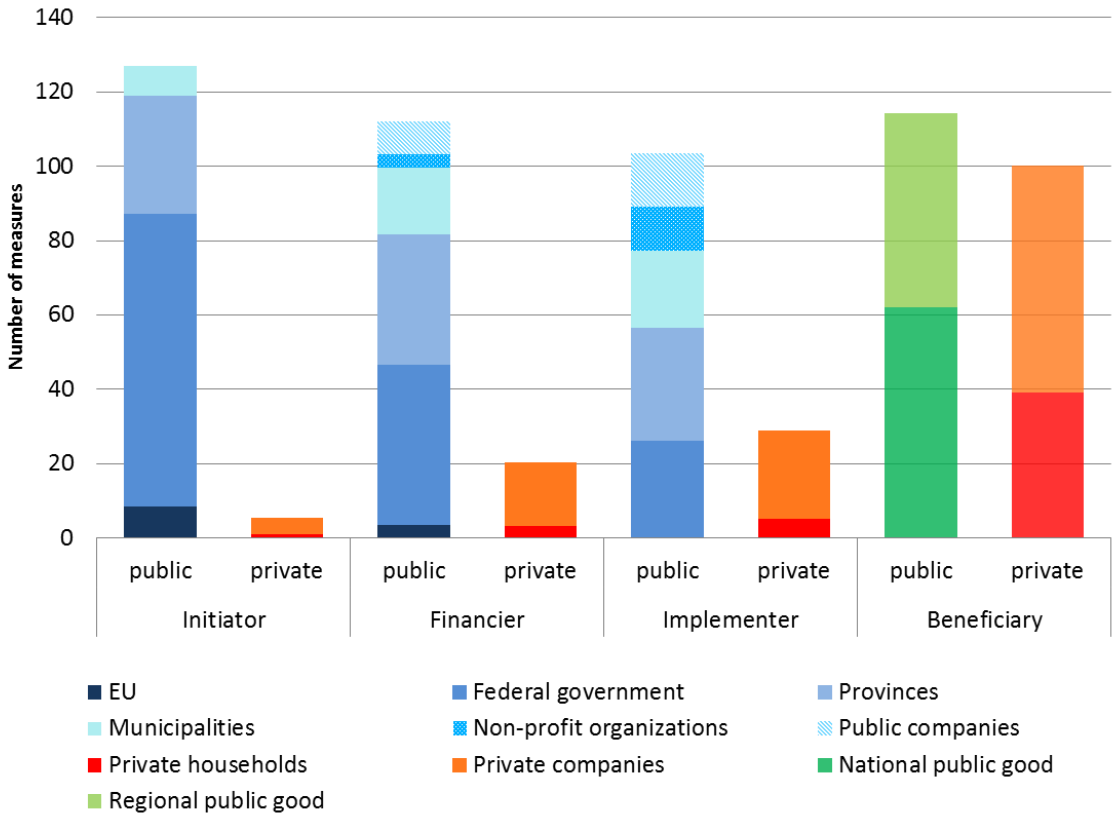

Fig. 1: Assessment of the Austrian Adaptation Strategy according to contributions by private, public and mixed actors.
Source: Knittel and Bednar-Friedl (2016)

Flood risk case study: Iterative Climate Risk Management

Disaster Risk Management as early adaptation?

The analysis of existing data, expert interviews and the results from an expert workshop have pointed out that in the current Austrian DRM practice climate change considerations do not play a major role and are not explicitly taken into account in the deliberations by the public agencies responsible for the implementation of DRM measures. The interview partners stated that the main reason for this is the considerable uncertainty associated with regional modelling of climate risks. Hence, no explicit public expenditures for Climate Change Adaptation (CCA) are currently collected and provided in the area of DRM. In part, however, climate change considerations are already implicitly taken care of. By continuously reviewing and integrating new scientific knowledge on climate change (e.g. emerging early trends and changes in variability that exacerbate existing risks or create new risks) the practitioners are adjusting their decisions over time with scientific and empirical evidence. Hence, DRM in Austria is evolving to include early adaptation to climate change, addressing current variability (and the existing adaptation deficit) while mainstreaming climate change in decision processes (as e.g. required by the EU Flood Directive RL 2007/60/EG), within an iterative climate risk management approach.

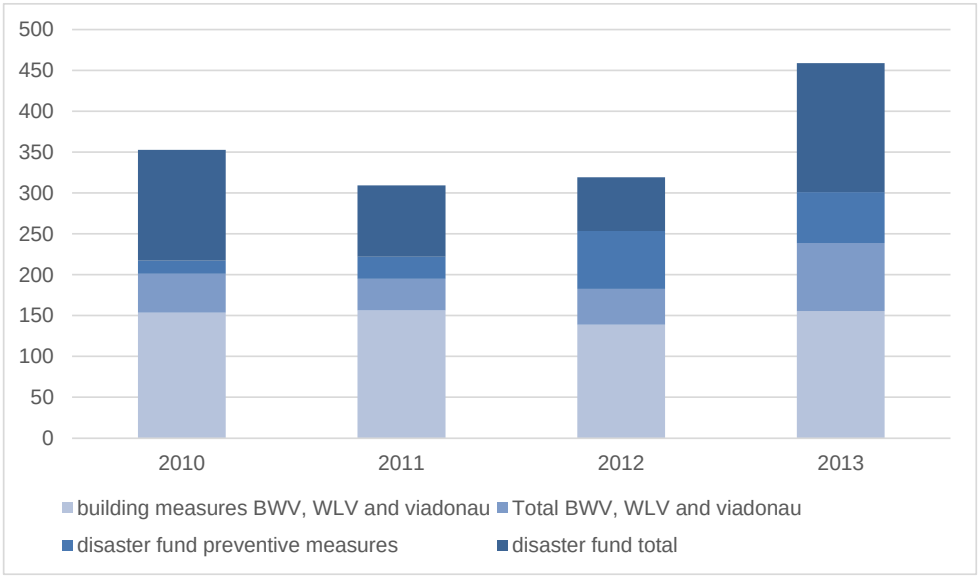

Fig. 2: Expenditures for early adaptation in the Austrian DRM practice, 2010-2014 (in million EUR)
Note: BWV: Bundeswasserbauverwaltung; WLV: Wildbach- und Lawinenverbauung.
Source: Schinko et al. (2017)

In turn, the current and past public expenditures in the Austrian DRM field can be interpreted as expenditures for no-regret and low-regret early adaption measures and could give a first impression of how much money is being spent today to address the current adaptation deficit. A detailed analysis of the disaster fund's bi-annual reports and bottom-up data of the implementing public agencies informs the identification of expenditures for early adaptation measures in the Austrian climate risk management practice. Depending on the definition of early adaptation measures (i.e. whether only expenditures for building measures as presented in the data bases of the BWV, WLV and the viadonau, their total expenditures, all expenditures by the disaster fund for preventive measures, or the total expenditures by the disaster fund are considered) one can argue for four different expenditure levels for early adaptation in the Austrian DRM practice in each year (Fig. 2).

Future fiscal flood risk up to 2050

The analysis employed the probabilistic risk-based economic CATSIM framework and compared the results of expected direct economic flood losses from the model with the Austrian disaster fund. We find that in the base year of 2015, the fund's endowment dedicated to the compensation for damages due to extraordinary extreme events, amounting to EUR 72 million, is not sufficient to cover the expected direct losses of EUR 258 million for this year (Fig. 3). The model then estimated the future expected annual flood losses in 2030 and 2050 in Austria and compared this to the business as usual funding of deposits in the Austrian disaster fund. The analysis found that the business as usual endowment of the Austrian disaster fund dedicated to the compensation for damages will not be sufficient to cover expected annual losses of EUR 354 million for 2030 and EUR 511 million for 2050. Severe stress could be put on the disaster fund's financial resilience and additional ad-hoc budget payments would become

necessary more frequently. Note that in addition to climate change, socioeconomic development drives the increase in expected losses.

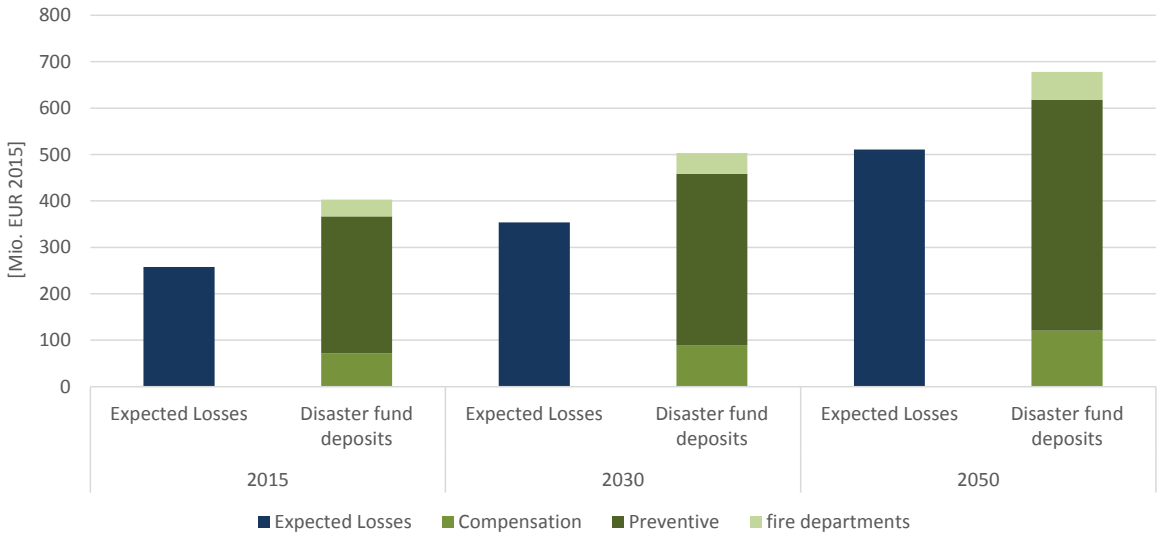

Fig. 3: Development of expected annual flood losses from 2015 to 2030 and 2050 under current levels of flood protection (in blue) compared to the development of disaster fund deposits (in green) under business as usual (assuming a real GDP growth rate of 1.5 % p.a.) (in million EUR 2015).
Source: Schinko et al. (2016)

City Case Study

70% of Austria's population lives in cities, and the influx continues. Cities and urban areas are predominantly affected by climate change due to their large number of inhabitants, dense populations, and the concentrations of assets and critical infrastructure. Graz, Linz, Baden and Judenburg were investigated as case studies for an initial assessment of adaptation costs in cities.

Currently, in the investigated cities the focus is on damage repair after extreme events (re-active adaptation). Depending on the financial situation, some additional adaptation measures are taken to reduce the impact on future natural hazards (pro-active adaptation). A distinction between pure damage repair and further adaptation measures is usually not carried out in the cities. This makes it difficult to distinguish between repair and adaptation costs.

In the annual accounts of Linz for "regular" years, costs for road construction and repair measures were about 25 to 30 M euro or 4 to 6 % of city budgets (Fig. 4). In years with or after extreme events (heavy rainfall, floods) these costs were significantly higher reaching up to 60 M euro or 8 % of the city budgets of the respective year (2008, 2009, 2013). The expenditures for flood protection construction show a peak in the years with or after extreme events. In Linz, the annual expenditures on flood protection construction are usually less than 1 million euro or < 0.1 % of the city budgets, while in peak years expenditures have reached 3 to 5 M euro or 0.1 to 0.8 % of city budgets.

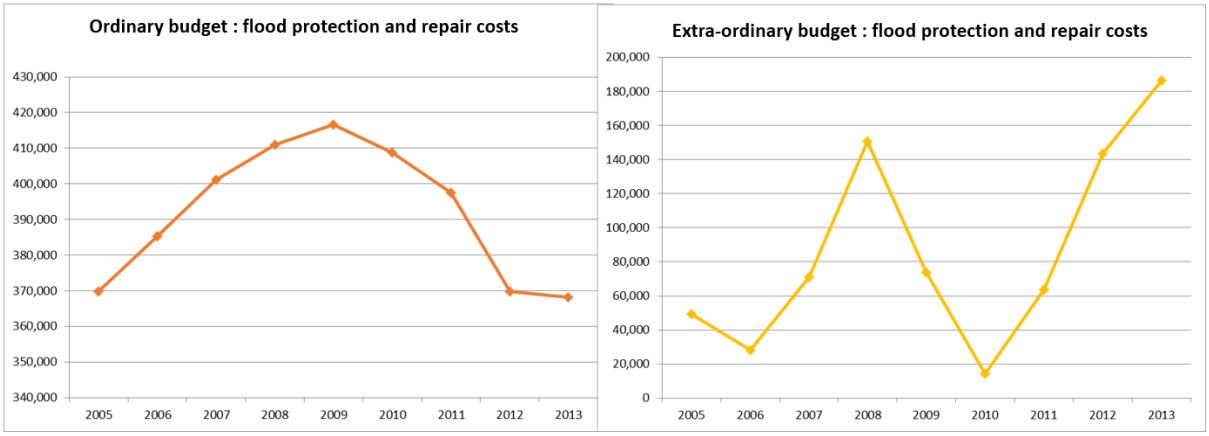

Fig. 4: Cost of flood protection measures and repairs in the city of Linz
Source: Loibl et al. (2017)

In Graz, the situation during the observation period was less pronounced. No pronounced peaks of expenditures in road construction and repair were observed, and the continuous increase in expenditure cannot be related to specific extreme events. In the case of flood protection construction, expenditures in regular years were between 0.5 and 1 M euro or <0.1 % of the city budgets. During the peak years, expenditures of up to 3 M euro or 0.4 % of city budgets was observed.

In smaller communities, the situation is similar, but varies according to topography and climate: Baden, which is less affected by flooding, spent around 25,000 euro or 0.02 % of municipal budgets on flood protection construction during regular years. In or after years of heavy rainfall or flood events, the expenditures reached 0.1 to 0.25 M euro, which is 4 to 10-fold of the regular value. Since the freely available funds are only a small proportion of the total budget, costs for unexpected damage repair and climate adaptation present themselves as large portions of the freely available shares.

Spatial planning is viewed as a key instrument for tackling the consequences of climate change through its controlling effect. Spatial planning is seen as particularly important in areas with a low potential for settlement expansion and where there is a high level of competition for land. Due to restrictions on zoning of new building land, or due to possible losses in value and the increase in the insurance risk of real estate by designation of hazard zones, there is a considerable potential for conflict between the population and the responsible policy makers.

In wastewater management the sewer network is a critical factor. The sewer network quality (tightness, hydraulic properties, capacity, and drainage capacity) must be regularly checked. Costly expenditures include the construction of new sewage separation systems (separating sewage water and sewage) and the replacement of smaller pipes by ones with larger diameters, as well as capacity extensions of sewage treatment plants, which are necessary especially in the case of mixed channel systems.

Water management is a key area that has already been impacted by climate change. Measures include the erection of dams, newly constructed, reinforced or improved with new technical means. Retention basins are another measure, but tend to be expensive as lease or acquisition of the necessary land as well as compensation payments for partial use rights is cost intensive.

Municipal building management related to climate change, concentrates on damage repair carried out after extreme events. Maintenance of open green spaces is gaining in importance.

For example, following heavy rainfall events, the city of Baden must pay for the restoration of paths in parks and the replacement of existing trees with dry resistant species. Furthermore, new methods for irrigation have been tested and pest control measures developed. In Graz, additional costs are also accrued through the alternative or additional irrigation of urban trees, as well as from a greater volume of green space planning effort. The use of "urban climate robust" species requires a shift in resources and the greening of treeless roads, as a measure of cooling by shading, can entail considerable investment but also operating costs.

The biggest financial challenges are that the cities have no way of providing reserves for future spending because of limited resources. Furthermore, the budget structure for assigning climate relevant costs lacks transparency, and municipalities do not have a clear overview of the direct costs caused by climate change. Loans for major repairs and adjustments are covered in the extraordinary budget and are often assigned to the expenditure account "finance management" (Finanzwirtschaft), which makes it impossible to allocate annual expenditures to certain adaptation measures.

Even if the annual loan repayments are allocated to the thematically correct expenditure account, the cost impacts of adaptation against damage repair remain unclear due to the relatively low annual pay back amounts. The refunds of costs from the disaster fund is, on the other side, allocated to the account "finance management" as income allocated to the ordinary budget.

Costs of adaptation for the federal budget

Two methodologies were developed in PACINAS to assess the costs of adaptation for the federal budget: one based on the federal government's budget plan and realization report (top-down approach), and one based on the costing of the individual measures listed in the national adaptation strategy (bottom-up approach). See Section 6 below for details.

Using the top-down approach we found that in 2014, annual adaptation-relevant expenditures in subdivision (SD) 41, SD 42 and SD 43 amounted to € 2.1 billion, i.e. the total amount of expenditure for which climate change adaptation was identified as a primary or secondary goal. The relevant annual adaptation costs within these total expenditures were estimated at € 488 million. Figure 5 shows how these costs are distributed across activity fields and 'other measures'. 'Other

measures' include expenditures that foster adaptation, but are not stated in the Austrian strategy for adaptation to climate change, such as flood protection measures. These adaptation costs are 8% of the relevant global budgets (the three SDs) and 0.65% of the total federal budget in 2014. When the annual costs of the Austrian disaster fund are added (some expenditures thereof are already covered in the top-down approach), the adaptation and damage costs rise to € 886 million, which is 1.2% of the total federal budget.

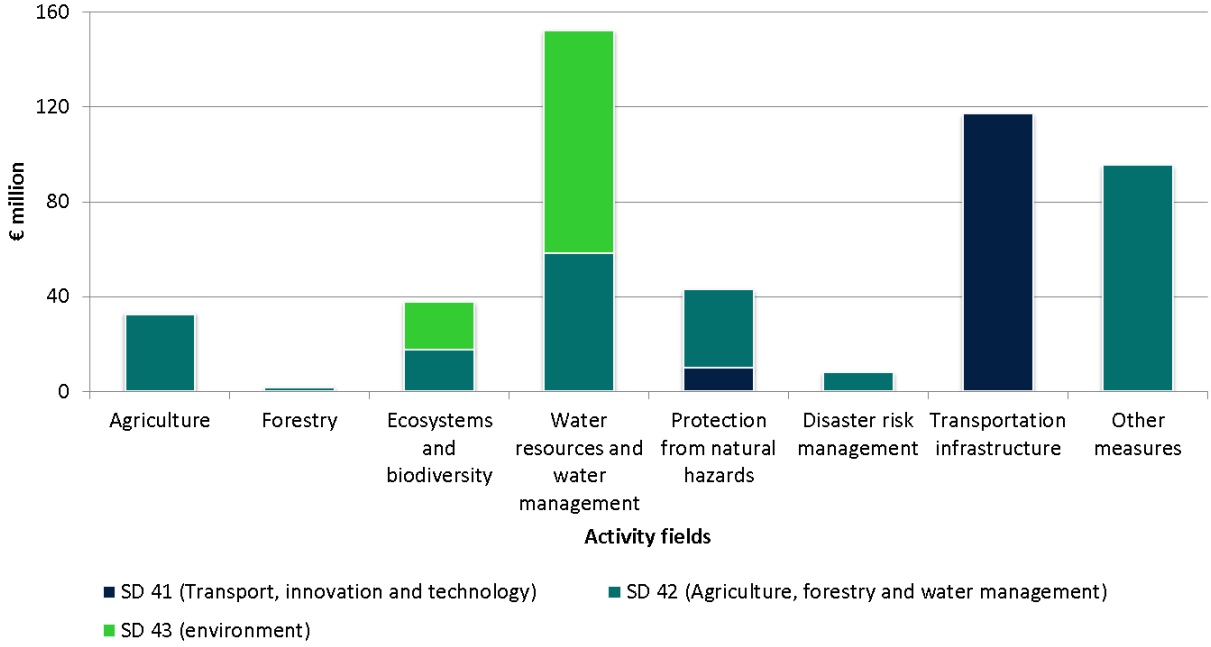

Fig. 5: Annual adaptation costs in SD 41 (transport, innovation and technology), SD 42 (agriculture, forestry and water management) and SD 43 (environment) split by activity fields in € million (2014), top-down approach.
Source: Knittel et al. (2017a)

According to the alternative bottom-up approach using expert elicitation, the average annual adaptation costs currently amount to € 385 million (with a range from € 286 million to € 485 million). It is important to note that several measures are not yet fully implemented, which means that increasing effort in the future will lead to higher costs. The distribution across activity fields is shown in Figure 6.

The difference between the top-down and bottom-up approaches results from the varying coverage: while the top-down approach covers all adaptation activities that are currently implemented by the federal budget, the bottom-up approach only accounts for those activities that are part of the Austrian strategy for adaptation to climate change. Note that these numbers only give an estimate for today's adaptation (relevant) expenditures, which might further increase with increasing risks.

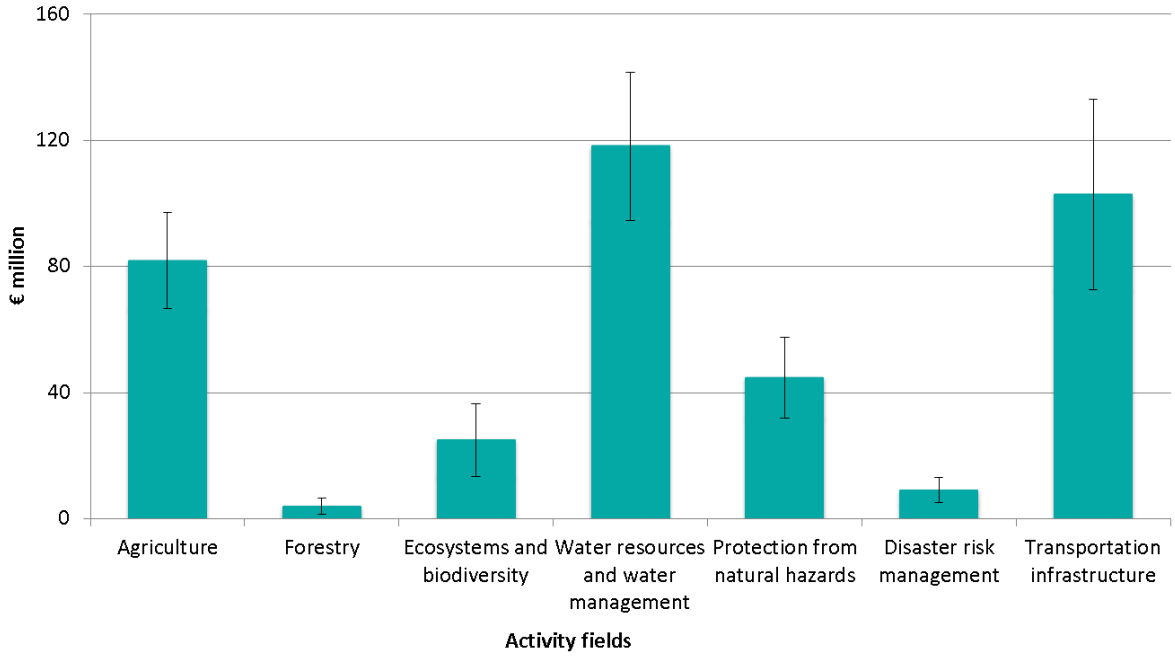

Fig. 6: Annual adaptation costs for activity fields in € million (current), bottom-up approach. Bandwidth shows minimum and maximum values.
Source: Expert interviews; Knittel et al. (2017a)

Macroeconomic assessment of adaptation options

In the macroeconomic assessment, we focus on the effects from climate change and adaptation in three impact fields, namely Agriculture, Forestry and Catastrophe Management, and cross-cutting expenditures on research and development. To assess the economy-wide effects of public adaptation until the mid-century, PACINAS developed a scenario for public adaptation over this period. Starting from today's adaptation-relevant expenditures, we developed an indicative scenario for adaptation-relevant expenditures up to 2050. This future estimate combines expert judgment on the additional resources needed for single adaptation measures (e.g. on soft measures such as monitoring systems), international recommendations on the useful timing and phasing of gray, green, and soft measures (Watkiss et al. 2014), and the mid-term budget forecast for the Federal State (BMF 2015). Figure 7 illustrates this scenario, separated by type of measure and activity field.

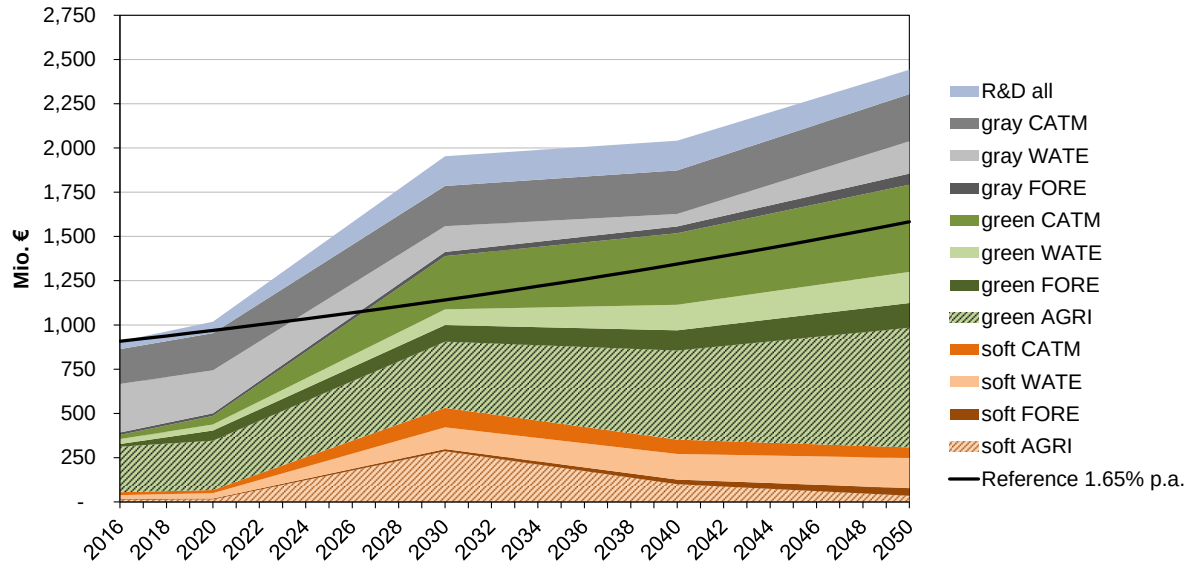

Fig. 7: Indicative scenario for adaptation-relevant expenditures in public budgets (sub-classifications UG41-43) for impact fields Agriculture (AGRI), Forestry (FORE), Water (WATE) and Catastrophe Management (CATM) as well as for Research and Development (R&D) for the period 2016-2050

Source: PACINAS Working Paper #4 (Knittel et al. 2017a); Bachner et al. (2017b)

Public adaptation in these impact fields reduces the economy-wide impacts. Figure 8 illustrates that the effect of climate change impact from these three impact fields on GDP is slightly negative without adaptation and turns positive with adaptation (+0.07%); compared to a reference scenario without climate change, respectively. In the underlying scenario, adaptation therefore has a positive effect on GDP. The reasons for this are twofold; first, there are economy-wide positive effects from adaptation-specific productivity gains (Agriculture) and employment effects (e.g. in Forestry and especially due to the implementation of soft and green measures) and second, there are reductions of climate change impacts (e.g. less damages to protective forests due to bark beetles). Note that the effects turn positive on an economy-wide, or macroeconomic, scale due to positive indirect effects, whereas at the sector level there still might be a residual damage (i.e. the direct effect might still be negative, but less severe due to adaptation).

When assessing the effects of adaptation on welfare, we find that the positive effect is stronger than for GDP. Without adaptation, climate change in these three impact fields reduces welfare by -0.3% while with adaptation welfare declines only by -0.06% (both numbers relative to the reference scenario without climate change). Adaptation leads to a welfare gain because it reduces potential damages to private property and also generates additional income, as employment effects are positive. It is important to note, that there are substantial uncertainties involved. The here presented analysis assumes a "mid-range" climate scenario with impact quantification for selected impact chains only (see Steininger et al., 2016 for details).

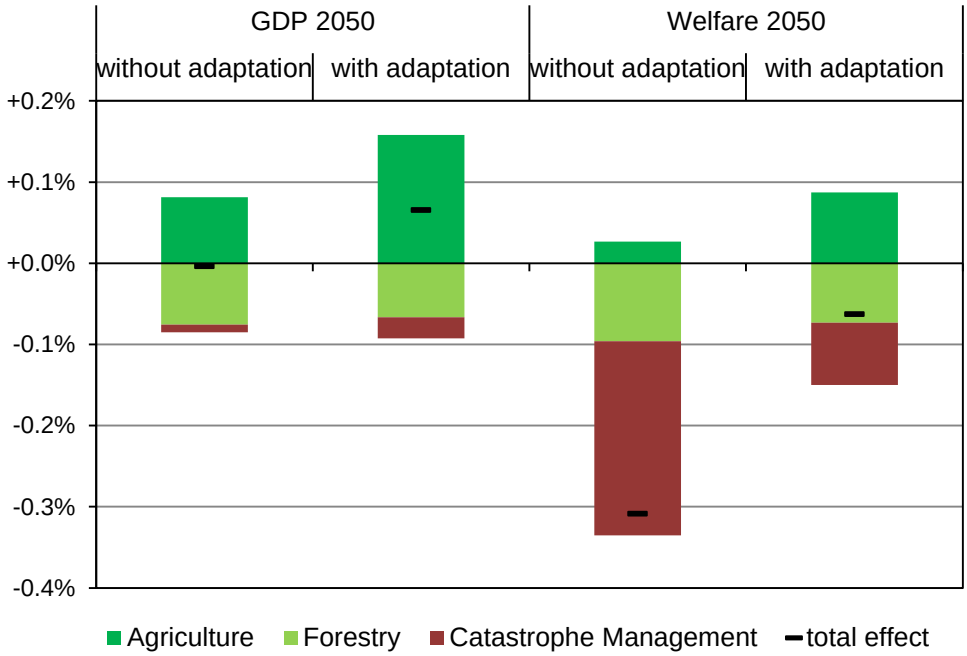

Fig. 8: Effect of climate change on gross domestic product (GDP) and welfare with and without adaptation for 2050 (relative to reference scenario without climate change), distinguished by impact field and in total.
Source: Bachner et al. (2017a)

Stakeholder involvement, dissemination and outreach

The project results were compiled in six PACINAS factsheets in German and English, discussed with stakeholders before, during, and after the final workshop, and are available at http://anpassung.ccca.at/pacinas/:

- Factsheet 1: Project overview and method
- Factsheet 2: Flood risk case study: Iterative Climate Risk Management
- Factsheet 3: Case study cities: cost relevance of adaptation in cities
- Factsheet 4: Federal spending on climate change adaptation
- Factsheet 5: Macroeconomic effects of public adaptation to climate change
- Factsheet 6: Adaptation pathways

5 scientific papers were prepared and more than 20 presentations were given at international scientific conferences.

Regular meetings, focus groups and workshops were organized and held for stakeholders in the respective departments:

- Federal Ministry of Agriculture, Forestry, Environment and Water Management
- Federal Ministry of Finance
- Presentations of budget exploration results in Linz, Graz, Judenburg
- City case-study Linz - focus group discussion with city representatives
- Inter-ministry modeling expert group to discuss consistent scenarios and assumptions across mitigation and adaptation projects

The project team was also invited as speakers to two Conferences of the Austrian Cities Association (Städtebund):

- Conference of the Committee of Environment Officers, March 2015
- Conference of the Committee of Financial Officers, June 2017

PACINAS has organized two national workshops and co-organized an international workshop:

- Stakeholder-Workshop: June 29, 2015 at Umweltbundesamt, Wien.
  Workshop title: Katastrophen-Risiko-Management als frühe Anpassung? (Disaster risk management as early adaptation)
- PACINAS Final Workshop on March 2, 2017 at ZAMG, Wien; Workshop title: Kosten der Klimawandelanpassung für die Öffentliche Hand (Costs of Climate Change Adaptation for the Public Sector)
- ECONADAPT Policy Workshop, Brussels, September 27-28, 2016

On the international level, PACINAS has been linked up to OCED and JPI Climate activities, and the EU FP7 project ECONADAPT.

Finally, PACINAS results were summarized in the newsletter klimawandelanpassung.at for the final workshop in February 2017 and for the final results in July 2017. PACINAS will be also showcased in the European Newsletter by Climate-ADAPT in July 2017.

5 Schlussfolgerungen und Empfehlungen / Conclusions and recommendations

Methods for costing adaptation in public budgets

a) Why is it important to cost adaptation in public budgets?

- In addition to monitoring progress on adaptation, it is also important to identify the associated expenditures in order to assess at which costs the selected measures are achieving their targets.
- Climate change has become a major challenge for policy makers, similar to demographic change or migration, and therefore long-term budgetary planning needs to account for potential future adaptation costs.

b) What are the challenges in costing adaptation in public budgets?

- The main difficulty is that adaptation is often an additional but hidden cost involved in regular activities by public authorities, such as in infrastructure provision. It is therefore necessary to differentiate between adaptation-relevant expenditures (which contribute to adaptation but also to other goals) and adaptation costs (which are only the share of expenditures that is due to adaptation).
- Another major challenge is that at the political level the concept of adaptation to climate change is not yet as well understood as mitigation, and therefore the attribution of expenditures to adaptation poses additional difficulties. We note, however, that this has remarkably changed throughout the course of this project, not least because of the extensive stakeholder engagement at various steps of the analysis.

c) How can costs of public adaptation be measured?

- In a top-down approach, current expenditures, budget descriptions and accompanying documents can be screened and adaptation costs be identified.
- In a bottom-up approach, the costs of adaptation measures listed in the national adaptation strategy can be estimated and then added up to derive the aggregate costs.
- It is likely, that these approaches will lead to different estimates, because some measures listed in the adaptation strategy are not implemented yet and because some adaptation actions undertaken today are not included in the adaptation strategy.
- While both approaches can be applied for the federal level, budgetary rules are less demanding at municipal levels (i.e. they do not require a description of the specific goals for each budget position) and budgetary practice is moreover somewhat different across provincial states. A consistent assessment of the costs of adaptation was therefore only possible for the federal, but not the provincial or municipal level.

Disaster Risk Management (DRM) and the costs of adaptation

a) How is climate change included in Disaster Risk Management in Austria today?

- DRM practice in Austria is mainly focusing on the current adaptation deficit
- No explicit climate change adaptation expenditures are currently collected in a systematic way.
- Currently observed preventive measures can be interpreted as a proxy for early adaptation costs.
- Current disaster risk management and natural hazard management practice in Austria can be seen as early adaptation to climate change.

b) What are the challenges for Disaster Risk Management under future climate change and how can they be addressed?

- Probabilistic modelling of future flood losses indicates potential fiscal stress for Austria up to 2030 and 2050.
- Socio-economic developments are the strongest driver of riverine flood risk up to 2050.
- Still (high) uncertainties in climate models.
- The financial resilience of Austria's disaster fund is jeopardized already today and this risk will increase in the future up to 2030 and 2050; ad-hoc budget diversion to address major events could become more frequently.
- An iterative climate risk management (ICRM) strategy is useful for tackling current and future climate-related risks, which are expected to increase due to climate change and socioeconomic developments.

Costs of public adaptation in cities and municipalities:

a) What are the key areas for adaptation in cities and municipalities in Austria?

- Adaptation in cities focuses on spatial planning, facility management of public buildings, road maintenance and damage repair, water management and waste water management (sewage system), parks and urban green
- In particular, adaptation refers to (i) flood protection (including unsealing of surfaces, soil drainage and flood retention basin construction), (ii) urban heat exposure mitigation (establishing urban green concepts with step-by-step implementation such as networking of green areas, balancing green area deficits, promoting green roofs and facades) and (iii) recast and regular revision of alarm and catastrophe plans, renewal of disaster control equipment, catastrophe prevention training and awareness raising (at regional level) to better deal with risk and damage caused by extreme weather events.
- With respect to climate change adaptation, cities do not focus on health because it is seen as a provincial and federal responsibility

b) How is adaptation included in current expenditures?

- Adaptation-relevant expenditures target avoiding, reducing or exploiting resulting opportunities from current climate variability (adaptation deficit) as well as future effects of climate change on ecological, social and economic systems.
- However, there is no clear distinction made between impact costs and adaptation, often repair and incremental adaptation are implemented together.

c) How is future climate change taken care of?

- Adaptation deals with current climate variability and to a limited extent with qualitative future risk perception based on earlier experience since detailed science based results are often not available at the local scale.

Costs of public adaptation for the federal government

a) What are the costs of adaptation for federal budgets today?

- Estimated annual adaptation-relevant expenditures amount to at least € 2.1 billion currently (for the analyzed subdivisions 41, 42 and 43). The share that can be explicitly attributed as adaptation is estimated at € 488 million (top down approach; € 358 million according to the bottom-up approach). These adaptation costs are 8% of the relevant global budgets (the three SDs) and 0.65% of the total federal budget in 2014.
- When the annual costs of the Austrian disaster fund are added, the adaptation and damage costs rise to € 886 million, which is 1.2% of the total federal budget.

b) How sensitive are these estimates to the methodology used?

- The difference between the top-down and bottom-up approaches results from the varying coverage: while the top-down approach covers all adaptation activities that are currently implemented by the federal budget, the bottom-up approach only accounts for those activities that are part of the Austrian strategy for adaptation to climate change.

c) What are the costs of adaptation for federal budgets under future climate change?

- Preliminary work in PACINAS has indicated that future adaptation expenditures are likely to rise rapidly in the next two decades due to climate change. This will have important implications on the federal budget and public finances. It is recommended to start developing more detailed and structured forward projections on likely adaptation expenditures under climate change and to consider the implications on the federal budget.

The benefits and costs of public adaptation from an economy-wide perspective

a) What are the net benefits of public adaptation, taking account of both the costs of adaptation and the reduction in climate change impacts?

- The macroeconomic effects of climate change adaptation in Agriculture, Forestry and Catastrophe Management are positive, compared to the climate change impact scenario without adaptation (both for 2050).

b) What are the macroeconomic effects of public adaptation on GDP, welfare, and employment?

- The total of climate change-induced negative GDP effects from the three impact fields Agriculture, Forestry and Catastrophe Management turn positive and welfare losses can be reduced to a fifth with adaptation measures.
- Climate change adaptation can lead to positive employment effects in the long term, when increasingly relying on soft and green adaptation measures.

C) Projektdetails / Project details

6 Methodik /Methodology

(max. 10 Seiten)
Begründung und Darstellung des gewählten Forschungsansatzes.

As shown in Figure 9, the project combines methodological development and policy case studies as both may inform each other and contribute to more robust decision making in adaptation. WP1 served as an overarching work package by developing the overall methodological framework of the project and by ensuring exchange between all project partners and the international experts. WP2 contributed policy case studies on adaptation both on the federal and provincial as well as on the municipal level (cities of various sizes). In WP3 the costs for adaptation were assessed at the federal level. In WP4 the indirect costs and benefits of adaptation were assessed at the national scale. WP5 provided stakeholder involvement as well as outreach and dissemination throughout the project. In the following, the methodology within each work package is described in more detail.

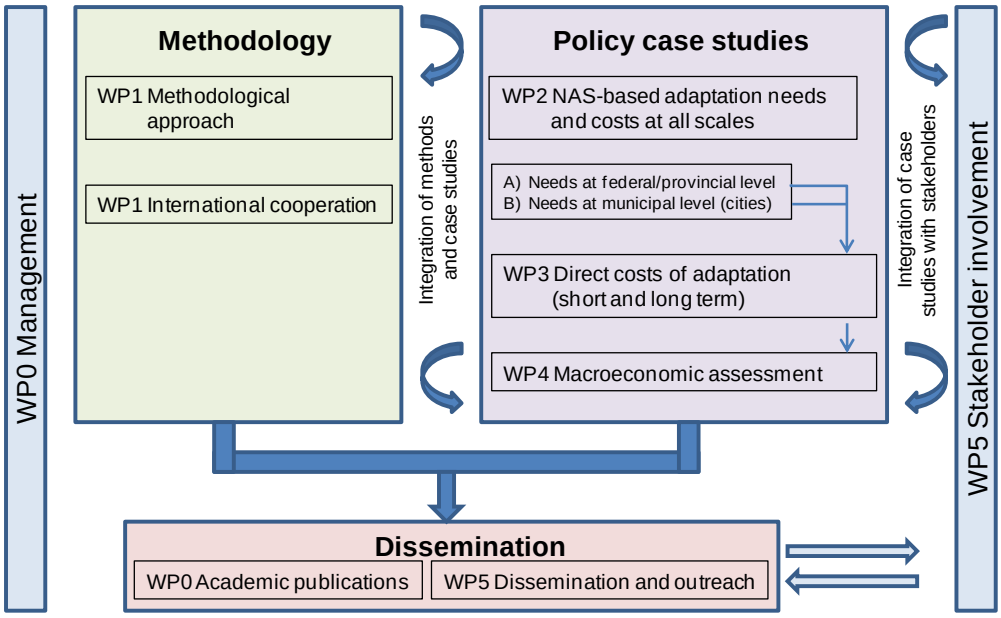

Fig. 9: Project structure of PACINAS

WP1: Methodological approach: Framework for analysis & scenarios

The objective of WP1 was to develop the overall modelling framework and a methodology to allow for transfer and scaling of case studies for costs at the national level. The main task was the assessment of the Austrian National Adaptation Strategy (NAS) regarding the share of public vs. private adaptation (Task 1.1) which was conducted in collaboration with the companion project PATCHES on private adaptation. Each of the 132 measures in the 14 activity fields of the Austrian national adaptation strategy (NAS) was screened regarding its initiation, financing, implementation phase and the beneficiary (public or

private actor) and based on the financing and the implementation phase, each activity field was either assigned as primarily public, primarily private or mixed (both private and public) activity field. Complementary, a screening of the federal budget plan was conducted to identify which budget positions might entail adaptation activities. Moreover, methodologies for transfer and upscaling of case studies to the national scale were reviewed (Task 1.2) and it was decided that there is no robust way to transfer the results from the four city case studies (see WP2) to the national scale, due to the very different characteristics across the analyzed cities but also between urban and rural regions in general.

In preparation for the macroeconomic assessment in WP4, the final task involved the development of scenarios by refining the COIN scenarios towards public budgets (Task 1.3). Scenarios that reflect different options how climate change induced declines in tax revenues can be counterbalanced have been set up. The different alternative of additional taxation of capital revenues, labor input, production output as well as cuts in transfers to private households have been analyzed within the COIN-CGE model.

WP2: Adaptation needs, costs and benefits: Policy case studies

In WP2, two case study applications were developed to (i) identify already applied and planned adaptation practice, (ii) estimate current adaptation expenditures by the public sector, and (iii) elicit possible developments for future adaptation expenditures. The first case study conducted by IIASA and UBA targets federal and provincial governance levels regarding their responsibilities and strategies for disaster risk management and protection from natural hazards. The second case study conducted by AIT and UBA focused on adaptation expenditures by cities. In both case studies, both short term risk management (Task 2.2) and long term adaptation (Task 2.3) were investigated.

Case Study A: Federal and provincial level

A survey, interviews and a set of workshops were conducted with key federal ministries [Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of the Interior (BMI), Federal Ministry of Finance (BMF), Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) and Federal Ministry of Science and Research (BMWFW)]. For the provincial level, interviews and meetings were held with responsible departments from the provinces Styria and Upper Austria. By means of federal budget analysis (the Austrian disaster fund – Katastrophenfonds – and public agencies that implement measures financed by the disaster fund: WLV, BWV and viadonau) and interviews with Disaster Risk Management (DRM) experts, the costs of the current Austrian risk management approach to cope with impacts of recent events were assessed (Task 2.2). For medium-term (up to 2030 and 2050) climate risk management an ex-ante analysis of risk behavior related to extreme events (focus: riverine floods) was combined with an assessment of the potential impacts of extreme events on Austria's fiscal budget and in turn on planning procedures and budgeting practices (Task 2.3). This was accomplished by

interviews on future adaption and climate risk management needs with experts responsible for budgets in ministries, a financial and economic risk-based analysis with IIASA's CATSIM model, and a stakeholder workshop. The conclusions and lessons learned were summarized in Task 2.4.

Case Study B: City level

In the second case study a sample of 4 Austrian cities covering the size range from 200.000 down to 10.000 inhabitants and physical characteristics (regarding terrain, land use and climate) typical for Austria were considered. The set of cities allowed to obtain quantitative and qualitative information about the entire range of adaptation measures and related costs/expenditures through municipality budget investigation and interviews with the cities' officers responsible for finance and for sectoral issues, associated with climate change related repair and adaptation (see next paragraph). In particular, the intention was to select two medium sized cities and two provincial capitals.

Regarding short term risk management (Task 2.2), the following activities were conducted: (i) budget analysis of the ordinary and the extraordinary budget for the cities of Graz and Linz based on official and public data (offenerhaushalt.at) (ii) budget review by obtaining data directly from the smaller cities of Baden and Judenburg, as no data was available for these cities to the public via web; (iii) analysis of budget-critical activities with respect of recent events and related catastrophe management as well as pro-active adaptation measures in different sectors like infrastructure/transport, green infrastructure, water-management and protective infrastructure, emergency services and rescue; (iv) interviews with the responsible persons of the case study cities (heads of departments and staff for municipal building management, road infrastructure, flood protection, green spaces maintenance, spatial planning, catastrophe and risk management, finance and budget management, climate and energy depending on sectoral responsibilities). Regarding medium to long term risk management, (Task 2.3) the following activities were conducted: (i) interviews with the persons in charge of cities' budget on future risk management.; (ii) test survey of politicians experience and expectations with respect to climate change, adaptation needs and adaptation costs; and (iii) synthesis of current and expected future practice and identification of stakeholder needs regarding options and costs of public adaptation. The conclusions and lessons learned were summarized in Task 2.4 for both case studies.

WP3: Costs of adaptation for the federal budget

The goal of WP3 was to assess the costs of different adaptation activities for selected key public expenditures. To ensure consistency, a guidance document was prepared which clarified the definition of "adaptation-relevant" expenditures, adaptation costs and provided a classification matrix to be used by the stakeholders and the project team to characterize public adaptation expenditures in municipal, provincial, and federal budgets.

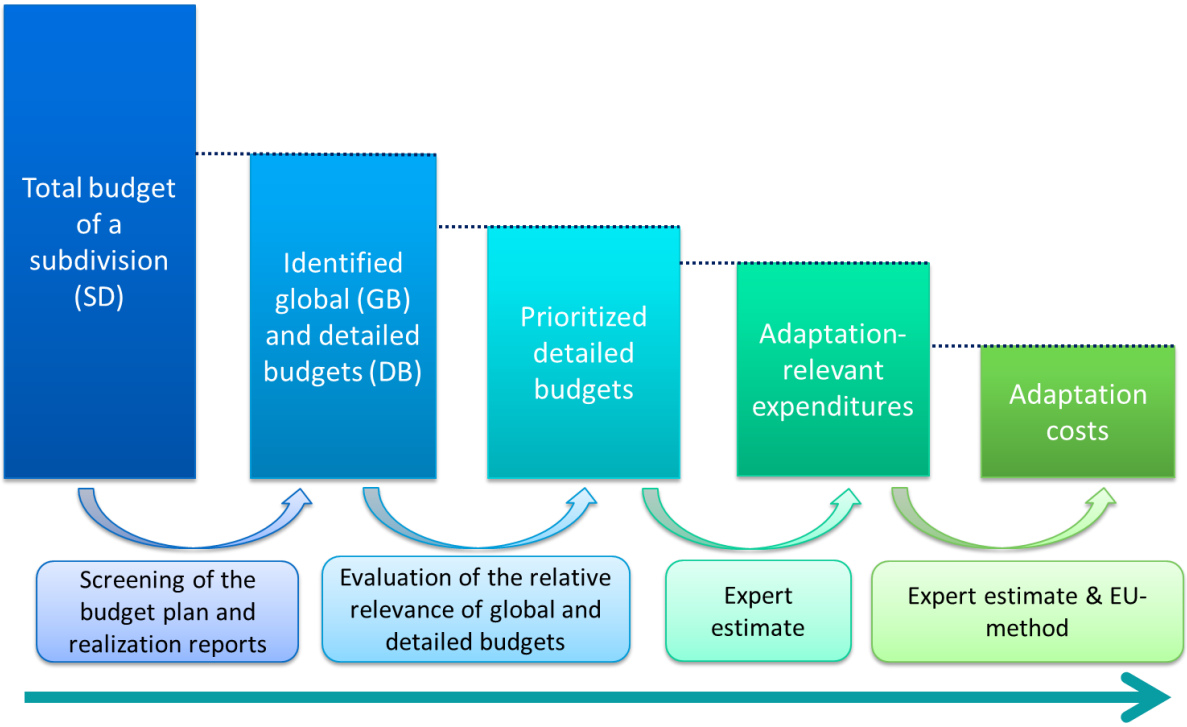

Fig 10: Methodology of the top-down approach

For the federal budget, it was also possible to elicit and analyze adaptation-relevant expenditures. Two methodologies were developed for this purpose: one based on the federal government's budget plan and realization report (top-down approach), and one based on the costing of the individual measures listed in the NAS (bottom-up approach). Figure 10 delineates the steps of the top-down approach which combined assessments by the project team with expert estimates provided by the respective departments of the federal ministries and an "adaptation marker" method building on the OECD DAC Rio Markers and the EU Common Methodology for tracking climate action (EC 2016; OECD DAC 2016). In the end, adaptation-relevant federal expenditures were identified for the subdivisions (SD) 42 (agriculture, forestry and water management), SD 43 (environment) and SD 41 (transport, innovation and technology). SD 11 (internal affairs) and SD 24 (health and women) are potentially also relevant, but are primarily engaged in organizational and coordination tasks and as a result, costs could not be attributed to adaptation.

The aim of the bottom-up approach was to estimate and aggregate the current costs of adaptation measures that are listed in the Austrian strategy for adaptation to climate change, focusing on those funded by the federal government. Expert interviews with Federal ministry staff were used to identify adaptation costs for each of the 67 measures. Costs were attributed by assigning different numbers of a scale ranging from 0 to larger than € 60 million per measure. Expert review was used to revise the estimates, with a final group of experts and authors meeting to jointly agree on assigned costs.

Based on the results of these two methodologies, it was possible to differentiate between investment costs (Task 3.1) and recurrent costs (Task 3.2) for seven activity fields (agriculture, forestry, water resources and water management, protection from natural hazards, disaster risk management, ecosystems and biodiversity and transportation infrastructure). Expenditures for research and development were assigned across activity fields. As a final step, an exemplary adaptation cost pathway up to 2050 was developed based on input from the ministerial departments and general suggestions for adaptation phasing in the literature (Task 3.4). As argued above, the upscaling of case study data to the national scale (Task 3.3) could only be credibly done for the federal case study, but not the city case study.

WP4: Macroeconomic assessment of adaptation options

The objective of WP4 was to conduct a macroeconomic assessment of public adaptation, because climate change impacts and adaptation have direct effects on the budget (e.g. higher disaster relief payments) but also indirect ones, such as changes in the tax base due to changed economic activity in response to climate change.

The economy-wide effects of adaptation are assessed with the COIN model (Bachner et al. 2015a,b), a computable general equilibrium (CGE) model for Austria which assesses the macroeconomic effects of climate change impacts for ten impact fields (Agriculture, Forestry, Water, Energy, Heating and Cooling, Transport, Manufacturing and Trade, Tourism, Catastrophe Management, Cities and Urban Green) until the mid-century (2050). In the PACINAS project, the COIN model was extended to allow for analysis of public adaptation. The study focused on those impacts with the highest budgetary importance: Agriculture, Forestry, Water, Catastrophe Management (including Protection from Natural Disasters) as well as Research and Development (as a supplementary adaptation activity).

To assess the macroeconomic effects of public adaptation, the COIN CGE model was therefore extended to include (i) the costs of public adaptation according to the adaptation cost pathway developed in WP3, (ii) the effectiveness of these adaptation actions in reducing climate change impacts, based on international literature (e.g. the meta study conducted by the ECONADAPT project) and expert estimates for Austria (provided by COIN project partners), and (iii) to implement different budgetary rules to deal with this increased pressure on public budgets (adjustments in different taxes rates, public transfers, and debt levels). The following tasks were therefore conducted: the preparation of model input data (Task 4.1), the expansion of the COIN CGE model towards adaptation (Task 4.2), and the integration of adaptation cost estimates for the seven activity fields listed above, which were then attributed to the respective impact fields as they were defined in COIN (Task 4.3). The final step involved the assessment of the macroeconomic costs of adaptation within the CGE model (Task 4.4).

WP5: Stakeholder involvement, dissemination and outreach

The dissemination and exploitation of results is a key focus of PACINAS and this Work Package (WP5) was dedicated to this. The objective of WP5 was to guarantee the visibility of the project and its results via tailored dissemination as well as the translation of the results for various audiences. This includes direct stakeholder engagement with key users of the project results (cf. WP2) throughout the project. In order to guarantee an adequate dissemination of the produced information, the UBA – leading this WP – was involved in information generation from the very beginning of the project. Active stakeholder involvement throughout the project ensured that the analysis addresses the needs of decision makers (Task 5.1). In addition, intermediate and final results were disseminated to various academic and professional audiences via the webpage and national and international portals (Task 5.2). Moreover, a fact sheet series was produced in German and English (Task 5.3).

7 Arbeits- und Zeitplan / Work and time plan

Tasks / Milestones	Start MM/YY	End MM/YY
WP 0: Project management and coordination	09/14	03/17
Task 0.1: Project management		
Task 0.2: Subcontracting to international advisor		
Task 0.3: Publication strategy		
WP 1: Methodological Approach: Framework for analysis & scenarios	09/14	12/15
Task 1.1: Categorization of Austrian NAS along the criteria private/public and governance levels		
Task 1.2: Scaling, transfer, and aggregation		
Task 1.3: Refinement of plausible COIN scenarios towards public budgets		
WP 2: Adaptation need, costs and benefits: Policy case studies	11/14	12/16
Task 2.1: Collection and synthesis of current and expected future practice and identification of stakeholder needs		
Task 2.2: Short term risk management coping with impacts of recent extreme events		
Task 2.3: Long term adaptation: coping with heavy precipitation and heat wave		
Task 2.4: Conclusions and lessons learned		
WP 3: Direct costs of adaptation options for the short and long term	03/15	02/17
Task 3.1: Estimation of adaptation costs: forced investment		
Task 3.2: Estimation of adaptation costs: forced maintenance costs		
Task 3.3: Upscaling of case study data to national scale		
Task 3.4: Development of a set of robust adaptation paths		
WP 4: Macroeconomic assessment of adaptation options	05/15	02/17
Task 4.1: Preparation of model input data: consistency and baseline		
Task 4.2: Model refinement		
Task 4.3: Integration of sectoral cost assessments into macroeconomic framework		
Task 4.4: Assessment of macroeconomic costs of adaptation		
WP 5: Stakeholder involvement, dissemination and outreach	11/14	03/17
Task 5.1: Participatory approach		
Task 5.2: Dissemination und outreach via national and international portals		
Task 5.3: Dissemination and decision support at federal and provincial level		

8 Publikationen und Disseminierungsaktivitäten / Publications and dissemination

See also the PACINAS webpage: http://anpassung.ccca.at/pacinas/

Publications	**Journal**	**Other**
1. Schinko, T., Mechler, R., Hochrainer-Stigler, S. (2016) A methodological framework to operationalize climate risk management: managing sovereign climate-related extreme event risk in Austria. Mitigation and Adaptation Strategies for Global Change, 1-24. doi:10.1007/s11027-016-9713-0.	X	
2. Bachner, G., Bednar-Friedl, B. (2017) Counterbalancing the Effects of Climate Change Adaptation on Public Budgets: Factor Taxes, Transfers, or Foreign Lending? under review.	X	
3. Knittel, N., Bednar-Friedl, B., Watkiss, P., Leitner, M. (2017) The twofold approach for measuring climate change adaptation costs: current spending and the costs of implementing the national adaptation strategy in Austria. To be submitted.	X	
4. Bachner, G., Bednar-Friedl, B., Knittel, N. (2017) Revealing the Economy-Wide Effects of Public Adaptation to Climate Change and its Implications for Public Budgets. To be submitted.	X	
5. Laurien, F., Bednar-Friedl, B. (2017), A bottom-up climate impact cost assessment for road infrastructure in alpine regions. In preparation. Presented at Klimatag 2017.	X	
6. Bachner, G., Bednar-Friedl, B. (2016) Counterbalancing the Effects of Climate Change Adaptation on Public Budgets: Factor Taxes, Transfers, or Foreign Lending? Graz Economic Papers 2016-07. Available at: IDEAS/REPEC repository.		X
7. Knittel, N., Bednar-Friedl, B. (2016), The role of public authorities in Austria's national adaptation strategy. PACINAS Working Paper #01, February 2016, University of Graz, Austria. Available at http://anpassung.ccca.at/pacinas.		X
8. Knittel, N., Bednar-Friedl, B., Leitner, M., Bachner, G. (2017), The Costs of Climate Change Adaptation for the Austrian Federal Budget. PACINAS Working Paper #04, Graz/Vienna, June 2017. Available at http://anpassung.ccca.at/pacinas.		X
9. Loibl, W., Leitner, M., Stollnberger R., Neumann, H.M. (2017): Adaptation need, costs and benefits: Pilot case study municipal level, PACINAS Working Paper #02, February 2017, Vienna, Austria. Available at http://anpassung.ccca.at/pacinas.		X
10. Schinko, T., Mechler, R., Leitner, M., Hochrainer-Stigler, S. (2017), Iterative climate risk management as early adaptation in Austria – Policy case study "Public adaptation at the federal & provincial level", PACINAS Working Paper #03, February 2017, Vienna, Austria. Available at http://anpassung.ccca.at/pacinas.		X
11. Bachner, G. (2016): A macroeconomic assessment of climate		X

change impacts and adaptation in a computable general equilibrium framework, Dissertation, University of Graz; available at http://resolver.obvsg.at/urn:nbn:at:at-ubg:1-105930		
12. Knittel, N. (2016), Public Adaptation to Climate Change. An identification of public expenditures on adaptation. Master Thesis, University of Graz, Austria. Available at http://resolver.obvsg.at/urn:nbn:at:at-ubg:1-98642		X
13. Laurien, F. (2016), An Economic Assessment of Climate Impacts and Adaptation for Transport Infrastructure. Master Thesis, University of Graz, Austria. Available at http://resolver.obvsg.at/urn:nbn:at:at-ubg:1-95515		X

Dissemination activities	**Fact sheet**	**Presen-tation**
14. Leitner, M., Balas, M., Bednar-Friedl, B., Knittel, N., Schinko, T., Bachner, G., König, M., Glas, N. (2017) PACINAS Factsheet 1: Projektüberblick und Methode / Project overview and method.	X	
15. Schinko, T., Leitner, M., Mechler, R., Balas, M. (2017) PACINAS Factsheet 2: Fallstudie Hochwasser: Iteratives Klimarisikomanagement / Flood risk case study: Iterative climate risk management.	X	
16. Leitner, M., Loibl, W., Balas, M., Glas, N. (2017) PACINAS Factsheet 3: Fallstudie Städte: Kostenrelevanz von Anpassung in Städten / Case study cities: Cost relevance of adaptation in cities.	X	
17. Bednar-Friedl, B., Knittel, N., Leitner, M. (2017) PACINAS Factsheet 4: Ausgaben des Bundes für Klimawandelanpassung / Federal spending on climate change adaptation.	X	
18. Bachner, G., Bednar-Friedl, B., Knittel, N. (2017) PACINAS Factsheet 5: Volkswirtschaftliche Effekte von öffentlicher Klimawandelanpassung / Macroeconomic effects of climate change adaptation.	X	
19. Glas, N., Leitner, M., Bednar-Friedl, B., Balas, M., Bachner, G., Mechler, R., Knittel, N., Loibl, W. (2017) PACINAS Factsheet 6: Anpassungspfade / Adaptation pathways.	X	
20. Bachner, G. (2015), Land Transport Systems under Climate Change: A Macro-economic Assessment of Adaptation Measures for the Case of Austria, Klimatag 2015, WU Wien, April 29 2015.		X
21. Bachner, G. (2015), Land Transport Systems under Climate Change: A Macro-economic Assessment of Adaptation Measures for the Case of Austria, European Climate Change Adaptation Conference (ECCA 2015), Copenhagen, May 12-14, 2015.		X
22. Bachner, G. (2015), Counterbalancing the Effects of Climate Change on Public Budgets – The Case of Austria, CGE Workshop, Zentrum für Europäische Wirtschaftsforschung, Mannheim, November 25-26, 2015.		X
23. Bachner, G., Bednar-Friedl, B. (2016), Counterbalancing the		X

Effects of Climate Change Adaptation on Public Budgets: Factor Taxes, Transfers, or Foreign Lending? European Association of Environmental and Resource Economists 22nd Annual Conference, Zurich, June 22-25, 2016.		
24. Bachner, G., Bednar-Friedl, B. (2016), Counterbalancing the Effects of Climate Change on Public Budgets – The Case of Austria, Österreichischer Klimatag, Graz, April 6-8, 2016.		X
25. Bachner, G., Bednar-Friedl, B., Knittel, N. (2017), Revealing the Economy-Wide Effects of Climate Change Adaptation – A Macroeconomic Assessment of Adaptation Funding for the Case of Austria. European Climate Change Adaptation Conference (ECCA 2017), Glasgow, June 5-9, 2017.		X
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37. Mechler, R. (2016), Weather extremes and fiscal risk management. ECONADAPT Policy Workshop, September 27-28, 2016, Brussels.		X
38. Schinko, T. (2015), Iterative disaster risk management as early adaptation? Insights from Austria, Klimatag 2015, WU Wien, April 29 2015.		X
39. Schinko, T. (2016). A methodological framework to operationalize Climate Risk Management: Managing sovereign climate-related extreme event risk in Austria, Adaptation Futures Conference, 9-13 May 2016, Rotterdam, Netherlands.		X
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Workshops organized & invited talks	**National**	**Inter-national**
41. Stakeholder-Workshop „Katastrophen-Risiko-Management als frühe Anpassung?" (Disaster risk management as early adaptation), June 29, 2015, Umweltbundesamt, Wien.	X	
42. PACINAS Final Workshop "Kosten der Klimawandelanpassung für die Öffentliche Hand" (Costs of Climate Change Adaptation for the Public Sector), March 2, 2017, ZAMG, Wien.	X	
43. ECONADAPT Policy Workshop, Brussels, September 27-28, 2016, co-organized by PACINAS.		X
44. Organization of a Thematic Session "Climate Change Adaptation and Public Finance", European Association of Environmental and Resource Economists, Zurich, June 22-25, 2016.		X
45. Loibl, W., Leitner, M. (2015), Kosten des Klimawandels für öffentliche Haushalte: Auswirkung von Schadensbehebung und Anpassung auf Gemeindebudgets, Conference of Environmental Department Heads of the Austrian Cities Association, Klagenfurt, March 16, 2015 (invited talk).	X	
46. Bednar-Friedl, B. (2017), Kosten von Klimawandelanpassung für die öffentliche Hand, Conference of Finance Department Heads of the Austrian Cities Association, June 6, 2017 (invited talk).	X	

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Diese Projektbeschreibung wurde von der Fördernehmerin/dem Fördernehmer erstellt. Für die Richtigkeit, Vollständigkeit und Aktualität der Inhalte sowie die barrierefreie Gestaltung der Projektbeschreibung, übernimmt der Klima- und Energiefonds keine Haftung.

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