Start Clim 2022

Key Measures, Measurability and Emergency Scenarios

Final Report

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Abstract

StartClim has been studying adaptation to climate change since 2008. The projects in StartClim2022 addressed the questions of children at risk of poverty, mitigation and adaptation in companies, measurability of climate resilience, hail events and torrential disasters, city greening and vulnerability to forest fires.

Children at risk of poverty in the climate crisis: vulnerability, adaptation and social infrastructure

The prevalence and limits to adaptation to the climate crisis vary widely, with both financially weak households and children being particularly vulnerable. Against this background, a survey of families affected by poverty was conducted. Around one-third of respondents reported very severe or severe heat stress for their children. Parents perceived numerous specific health changes that were significantly related to the number of heat days observed in 2022 in the home. These changes included thirst and drinking (85%), poorer sleep (67%), restlessness, discomfort and increased crying (62%), less motivation to exercise (54%), aggressive behaviour (51%), nausea, rashes, headaches and dizziness (45%) or withdrawal (43%).

Heat in the home was perceived by many as a burden. In almost all households, the apartment was ventilated (91%) in order to be less burdened by heat. However, one-fifth of the households stated that they did not or preferred not to open the windows because of noise. Many darkened their apartments with external blinds (19%) or internal blinds (71%). Not all protection strategies were available to everyone, however. Many of the households indicating a need for air conditioners (70%) or outside blinds (30%) were unable to purchase them because of the acquisition and operating costs.

Heat was also strongly felt in public spaces, but they were also used to cool down and to escape hot apartments. Many children complained about heat in playgrounds or parks (36%) or on the street or when walking with their parents (24%). At the same time, more than half of the families surveyed went to public places (56%) or left the home (16%) to escape the heat. Almost half (45%) of households said that although they would like to go to a swimming pool or lake, they could not. High costs were cited as a barrier by 44 per cent. A free local public infrastructure would therefore be a good a starting point, both in terms of climate and social policy, to help financially weak families in general and at the same time better protect them from heat.

Promotion of climate change mitigation and adaptation in companies through transformative competencies

Our society has had little success so far in its efforts to mitigate climate change and reduce its impacts. One reason for this is seen in the failure of efforts to address the root of the problem: the world views, values and mindsets from which climate change has emerged. Special skills called transformative competencies are needed to help address the root of the problem. The aim of this research project was to stimulate or promote these skills in a corporate context to determine the extent to which they are relevant to climate protection and climate change adaptation in companies.

The engagement with transformative competencies took place in the course of a 3.5-day seminar. The relevance of these competences in the context of climate protection and climate change adaptation had been confirmed in advance through literature research. The strengthening of self-efficacy through the seminar was reflected in the participants' commitment to promoting sustainability in their companies. The increased self-efficacy and adaptive capacity enabled participants to identify space for co-creating and developing more hopeful and optimistic visions about the future. In addition, the discussion in the seminar on individual and societal values had an impact on the changes the participants made regarding sustainability in their own lives.

Management commitment to sustainability issues and open structures in the company would foster the implementation of corporate sustainability initiatives. The promotion of transformative competencies in the corporate context was also seen as a strong lever for sustainable change in our society driven by businesses.

Climate fit, climate resilient, climate change adaptation – who proves that and how?

The aim of the project was to identify the requirements and indicators for a climatic assessment on the basis of a literature analysis and interviews and, if possible, to develop a method for the objective assessment of new construction projects (buildings, districts) – applicable in Austria. Most certification methods are related to the building (e.g. "klimaaktiv"), while the open space plays a subordinate role (exception: ÖGNI). In Austria, this certification is often voluntary.

The issue has a large political dimension. What is needed is political will, broad consensus and anchoring in laws and guidelines. The introduction of the EU taxonomy (Annex II) confirms the enormous increase in the importance of the topic of climate change adaptation.

Indicators should be easy to use, of high quality, determinable with just a few entries, meet the EU taxonomy requirements, and be transparent and comprehensible. The dilemma arises that indicators cannot always be of high quality and determined quickly at the same time. Therefore compromises are necessary. In principle, the indicators should be quantitative whenever possible. Where this is not possible, qualitative indicators can be used.

It is crucial that such indicators are widely used and that standardized. They should therefore be created by a standardization body or expert commission (ÖNORM, VDI, OIB). On the other hand, there must be a consensus as to their validity and meaningfulness. We believe that this can be achieved through tests and measurements in practice and through the involvement of stakeholders. This task would be suitable for a further research project.

Measuring adaptation comprehensively

Climate change is unfortunately unavoidable and has become a veritable crisis, with social, environmental and economic consequences that will have a significant impact on people's wellbeing.

So how can we best deal with this dynamic and complex climate crisis? We believe that the first step is for politicians, business and civil society – ultimately all of us – to set realistic goals for a good life and life-friendly environment, even under the given climatic conditions.

In this project, specific climate change adaptation measures were developed with local experts with a view to achieving diverse goals for a good life for all. The adaptation measures were then examined to determine the extent to which the goals were being achieved.

What target values did we use as a basis, what concerns, wishes and/or visions for a good life were expressed by the participants in this process and, above all, what implementation steps were formulated for that purpose?

In this participatory and transdisciplinary project, the participants were local experts who were prepared not only to set their own goals but also to determine the yardstick (indicators) for this themselves.

In order to achieve this, we developed a programme in four full-day workshops in Bad Aussee from February to June 2023 to determine how people in the region wanted to progress together in this direction.

A literature analysis and eight interviews with national and international experts from academia and practice and with regional stakeholders resulted in a detailed, publishable documentation of the

process (in texts and videos), a handbook on how this methodology can be applied in other regions, and a specific system of leading indicators.

The first workshop used art methods (collages and texts) to enable the participants to get to know one another as a basis for further cooperation and to discuss what life might look like in the future for us and future generations. The core question was WHY? The results were picture postcards from the future as qualitative future images and stories.

The second workshop was about HOW. What was the starting situation? With the help of impact diagrams, a common understanding emerged about the dynamics that needed to be considered and also about how the different goals and the actors who pursue them could interact.

The third workshop focused specifically on climate change. How did climate change affect the vision of the future? And how could we know (measure) whether we were getting closer to the goals? So it was about WHAT. How do we measure the success of climate change adaptation projects, where adaptation is understood as the ability to achieve goals of a good life for all.

In the fourth workshop, options for action for the further process and the final result were worked out jointly on the basis of the results developed by the regional participants.

The method tested for the first time in this project is now to be applied and further developed in other settings (also on other topics).

Impact of hail events on agriculture: a remote sensing-based analysis of hail damage in the context of climate change

Hail damage to agriculture causes millions of euros worth of damage in Austria every year. A lot of it occurs in the agricultural and fruit-growing region of south-eastern Styria, one of the areas in Europe with the highest number of hailstorms. Given the expected increase in severe hail events as a result of climate change, the development of robust, efficient and cost-effective methods for determining hail damage in agriculture is highly relevant. An initial assessment of the damage can be made using freely available high temporal- and spatial-resolution remote sensing data, such as the European Space Programme's Sentinel missions. The results could serve as an orientation for insurance experts on site and accelerate and simplify damage analysis after extreme events, especially for large agricultural areas.

In the HAGL project (Impact of hail events on agriculture: a remote sensing-based analysis of hail damage in the context of climate change), we developed an advanced method for efficiently determining hail damage in agriculture by combining optical (Sentinel-2) and radar satellite data (Sentinel-1) and tested and applied it in Austria. The results include a trend analysis of hail events and maps of areas particularly affected by them in south-eastern Styria. The satellite image time series analyses illustrate how agricultural crops change during the growing season and can be used to indicate potential hail damage.

The automated method for determining hail damage in agriculture by combining freely available optical and radar satellite data could be transferred to other regions and could help identify affected agricultural areas and devise adaptation measures and increase the efficiency of insurance work in the event of hail damage.

Climate change impact on triggering rainfall conditions for torrential disasters

Torrential processes (floods, bedload transport and debris flows) represent a severe hazard in the alpine region. The knowledge of event-triggering rainfall is necessary for reliable prediction of torrential processes and potential changes as a result of climate change.

The aim of the project was to identify critical rainfall events, to estimate the change in their probability and to evaluate the need for adaptation strategies. For that purpose, existing data on event-triggering rainfall was compiled from detailed event documentation for statistical evaluation. In addition, all documented torrential events for the period 2003 to 2022 were cross-referenced with catchment-averaged INCA hourly precipitation, and triggering precipitation was determined. From these approximately 3,800 precipitation events, critical boundary conditions (intensity-duration relationship) were derived for the four process types: flood, fluvial sediment transport, debris flood and debris flow. For all four types, it was shown that both the probability and the areas affected by triggering precipitation events will increase significantly in the future, although with clear differences between the emission scenarios (RCPs).

The results of the project should provide a basis for improved event forecasting in a changing climate. In a next step, therefore, other factors associated with torrential disasters, such as terrain, geology and affected infrastructure, have to be considered in addition to triggering precipitation.

City Green – climate change adaptation by greening the city

Based on a survey of urban residents (n = 1,055), this research investigated the conditions under which the development of urban green areas reducing particulate matter, NO2 and air temperature would be supported. The results showed that of the different design types, street greenery was the most popular. If the new green space produced very high environmental benefits, the majority of residents were willing to pay €45 with a 10-minute longer walk home. The willingness decreased significantly if positive effects on particulate matter could not be achieved. A more in-depth analysis revealed four different subgroups (classes):

- Class 1, the “environmentally-sensitive” were particularly interested in a green neighbourhood and would pay more than other respondents for high environmental performance.
- Class 2, the “design-sensitive” focused on the type of greenery and would especially like to see more community gardens.
- Class 3, the “cost-sensitive” were composed of lower-income groups and did not want to have to pay for more green.
- Class 4, the “accessibility-sensitive” also had a high interest in new greenery in the city but did not want parking spaces that were further away from home and therefore caused a longer walk.

A PHysical vuLnerability indeX (PHLoX) for wildfire in Austria as a tool for climate change adaptation

Climate change is expected to significantly change wildfire frequency and magnitude in many parts of the world, including Austria. Nevertheless, socio-economic changes (development of the wildland urban interface for recreational reasons) could also affect the occurrence of wildfires in the future. Recent events have shown that wildfire is an emerging risk for many countries with limited experience in managing them. There is therefore a need to look more closely into the vulnerability of settlements, buildings and infrastructure in the wildland urban interface (WUI), in other words, in areas where our settlements meet the forest. International research on wildfires, however, is clearly oriented toward the wildfire itself (fire ignition, propagation, forecasting, modelling, etc.) and less on its impacts. Studies dealing with the vulnerability of the built environment are limited, especially for countries that have not experienced large wildfires and their catastrophic consequences.

PHLoX focused on the physical vulnerability to wildfire of buildings located in the Austrian WUI. By involving many different Austrian stakeholders and international experts, the project aimed to identify and weight the characteristics of buildings and their surroundings that influence their vulnerability to

wildfires. The final product of the project was a wildfire vulnerability index (WVI) which combined all these indicators in a single index for each building and could be used to support decision-making, risk reduction and climate change adaptation strategies. The index was developed on the basis of a literature review and the expert opinions of Austrian stakeholders (authorities and policymakers, engineers, emergency services) and international experts. The project lays the foundations for future research on vulnerability to wildfire in Austria and for a fruitful collaboration between researchers and stakeholders.

The StartClim research programme

The StartClim climate research programme is a flexible instrument. Because of the short project duration and annual allocation of project topics, it can react quickly to topical aspects of climate and climate change. It is financed by a donor consortium:

- Austrian Federal Ministry of Education, Science and Research
- Austrian Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology
- Klima- und Energiefonds
- Federal Province of Upper Austria

StartClim has been studying adaptation to climate change since 2008. Since StartClim2012, the programme's aim has been to deliver scientific contributions to the implementation of the Austrian National Adaptation Strategy.

The StartClim2022 projects examined different aspects of relevance to climate change adaptation in Austria.

The StartClim2022 report consists of an overview of the results in German and English, along with separate documentation with detailed descriptions of the individual projects by the respective project teams. All StartClim2022 reports and documents will be available for download on the StartClim website (www.startclim.at). Furthermore, a limited number of folders containing a short summary of the results will also be made available.

StartClim2022.A: Children at risk of poverty in the climate crisis: vulnerability, adaptation and social infrastructure

The current IPCC Report once again confirms that the health, psychological and social consequences of the climate crisis are already noticeable in Europe and will increase significantly in the coming years. In Austria, up to sixty heat days per year can be expected by 2085 (APCC 2018). The prevalence and limits to adaptation vary widely, with both financially weak households and children being particularly vulnerable. There are no systematic studies as yet in Austria that consider the impact of the climate crisis, especially heatwaves, on children and their families. Appropriate climate adaptation measures offer far-reaching opportunities going beyond the protection from climate impacts for improving the quality of life of children affected by poverty.

In that context, social workers conducted a survey of poverty-prone families, for whom the questionnaire was especially adapted. Specifically, the questionnaire investigated (1) how the parents of children affected by poverty perceived their exposure to heat and the effects of heat on their children, (2) how they changed their behaviour at home and in public spaces and to what extent they felt informed about heat and (3) what needs they had with regard to their homes, public spaces and the information offered. A total of ninety-nine households were interviewed, in which 190 children aged zero to ten years lived.

About one-third of the respondents reported very strong or strong heat stress for their children. Parents perceived numerous specific health changes (fig. 1). More than half observed more thirst and drinking (85%), poorer sleeping (67%), restlessness, discomfort and increased crying (62%), less motivation to exercise (54%) and aggressive behaviour (51%). More than 40 per cent perceived physical symptoms such as nausea, rashes, headaches and dizziness (45%) or a withdrawal of the children (43%). The statistical evaluation using a t-test showed a significant correlation between the health changes on particularly hot days and the number of heat days observed in the home in 2022. A particularly strong correlation was observed for the items “like to move less”, “withdraw and be alone”, “symptoms of illness (e.g., nausea)” and “cried”.

Heat in the home was perceived as stressful by many. Regarding complaints by children about heat, about 45 per cent avoided staying indoors when it was hot (30% reluctant and 15% rather reluctant). Various strategies were used to deal with the heat stress. The survey listed ventilation, darkening, cooling devices, moving elsewhere and bathing and showering. Almost all households ventilated their homes (91%) in order to be less burdened by heat. However, one-fifth of the households stated that they did not or preferred not to open windows because of noise. Similarly, about one-fifth of the households said that they were exposed to noise or exhaust fumes when ventilating their home. Many darkened their apartments with external blinds (19%) or internal blinds (71%). Not all protection strategies were available to everyone, however. Many of the households indicating a need for air conditioners (70%) or outdoor blinds (30%) were unable to purchase them (30% for external blinds or 49% for air conditioners) because of the acquisition or the running costs (21% for air conditioners).

Another way to reduce heat stress in the home would be to move to another place, which about one-third (31%) of the respondents were considering. This third was made up of households that (1) had not yet considered moving because of the costs involved (13%), (2) had already considered moving despite the costs involved but found it too expensive (11%), (3) were currently looking (6%) and (4) had abandoned their search (1%).

Heat was also strongly felt in public spaces, but they were also used to cool down and escape from hot apartments. Public spaces was also stressful for children. Many children complained about heat in playgrounds or parks (36%) or on the street or when walking with parents (24%). At the same time, more than half of the families surveyed went to public places (56%) or left the home (16%) to escape the heat. Specific questions about the way public space was used revealed its importance for protection against heat. More than half of the respondents said they used swimming pools, parks, (free) bathing

areas and playgrounds. Shopping centres (16%) and water playgrounds (12%) were also frequented. Only a few (6%) visited acquaintances or people from their social networks to escape the heat. One household used the air-conditioned car to cool down the children.

Although public spaces were used by many households, there were many barriers to its use. In general, almost half (45%) of the households said that they would like to go to a swimming pool or lake but were unable to do so, mainly because of the high costs (44%). In pointing this out, numerous households commented that there was simply not enough money for everything. The costs were not always about the entrance fees themselves, but also about additional expenses (such as an ice cream at the swimming pool or a drink when shopping). Money was also saved for language trips for other children in the family.

Regarding the barriers and shortcomings in public spaces, a variety of needs were also cited that would better enable parents to protect their children from the heat.

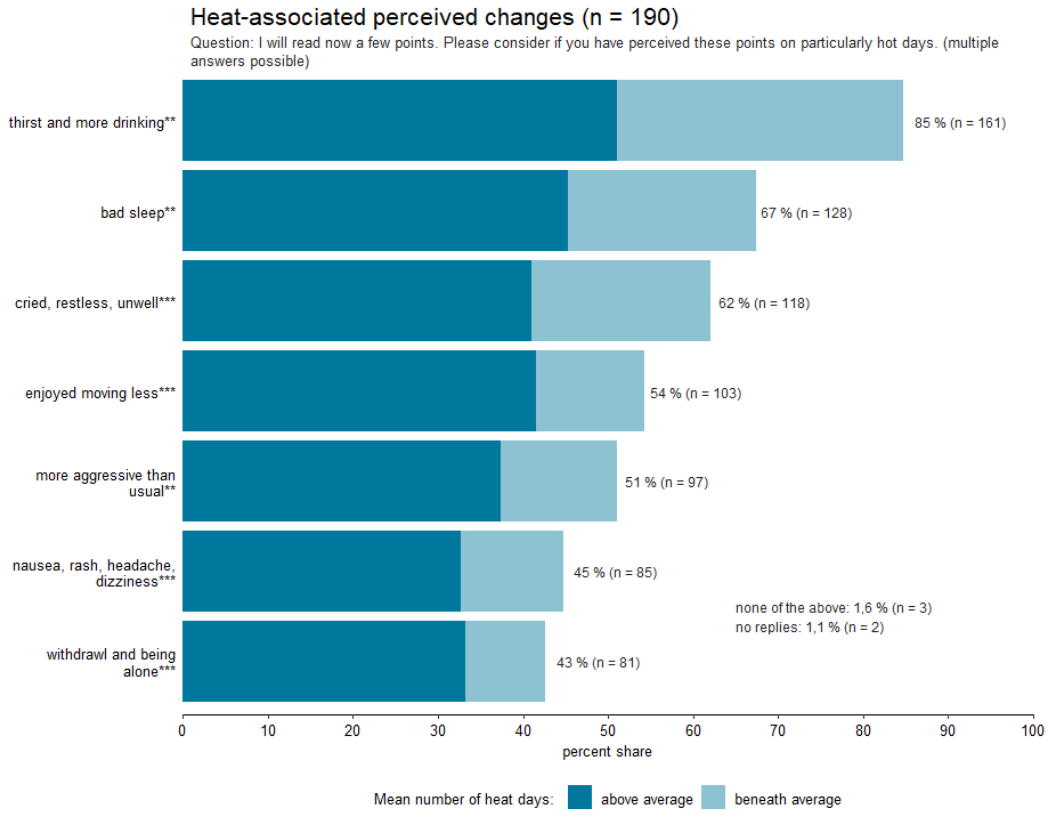

Fig. 1: Perceived heat-associated changes

Three out of four households wanted cooling places with water. About one-third of respondents cited a need for affordable (66%) or free (63%) swimming or bathing facilities or water playgrounds (62%). Shopping centres, shops (30%) or even cafés (14%) were also mentioned as places to cool down. Similarly, three out of four families cited a need for an air-conditioned car. Non-consuming indoor spaces such as libraries, community centres or club premises were only cited by around 10 per cent of households, although a similar number of households (12%) said that these things were available. One parent also explicitly noted that the children had already become accustomed to the situation and therefore did not request activities that the parents could not afford.

It is evident that both climate and social policy measures are good starting points for helping low-income families in general and at the same time better protecting them from heat. A free local public infrastructure is increasingly seen as an essential climate change mitigation measure that would make climate-friendly living easier and more natural (APCC 2023). Social policy research findings indicate

that the extension of such an infrastructure would lead to higher quality than focused measures aimed only at those living in poverty. Böse-O'Reilly et al. (2023, 128) mention the need for measures from a paediatric perspective, such as providing shade in public playgrounds, but also in the open spaces of schools and kindergartens. Planning of events in school or recreational areas "must also be adapted to the new realities" (ibid.). Green spaces in cities foster the physical and mental development of children and contribute to social integration, provided they are accessible to all social milieus.

StartClim2022.B: Promotion of climate change mitigation and adaptation in companies through transformative competencies

Despite the urgent need for measures to mitigate and adapt to climate change, little success has been achieved so far. One possible reason for this is the fact that these efforts do not address the root of the problem: the world views, values and mindsets from which climate change has emerged. This is where the project “Promoting climate protection and climate change adaptation in companies through transformative competencies” (in short: Skills4Change) comes in, as a change in world views, values and paradigms could have a major influence on the transformation of systems. Such a change is necessary to give our society a climate-friendly future.

Skills4Change trained transformative competencies considered helpful in dealing with the climate crisis and in implementing climate change mitigation and adaptation measures. Four organizations with a total of nineteen people participated in the 3.5-day seminar process and the accompanying data collection, consisting of questionnaires, interviews and focus groups. In the seminar, participants were encouraged to engage with transformative competencies in terms both of content and practical exercises. The accompanying data collection served to identify changes in the transformative competencies in the context of climate change mitigation and adaptation.

Fig. 2: Participants in the Skills4Change seminar

A review of the literature demonstrated the relevance of transformative competencies in the context of climate protection and climate change adaptation. The promotion of such competencies contributes to a higher commitment to climate protection and an increased acceptance of climate protection and climate change adaptation measures, and also encourages reflection on individual and societal values, which are seen as the basis for building a peaceful, just and sustainable society.

The project participants were already advanced in developing transformative competencies. Nevertheless, small changes could be generated throughout the seminar, first and foremost regarding the assessment of personal effectiveness, which had hitherto been low in the context of climate protection and climate change adaptation. The work in the seminar on self-efficacy increased the

feeling of being effective. This was evident in the participants' commitment and interest in planning and implementing sustainability measures in their own companies. The focus was on integrating the issue of sustainability into employee discussions, establishing an innovation timetable for sustainability and introducing an innovation award for sustainability.

The corporate structure was cited as a factor that hindered or fostered self-efficacy in companies . Flat hierarchies, freedom of action and a committed and interested management level were seen as conducive to dealing with the issue of sustainability and implementing sustainability measures. In addition to management commitment, a peer group, i.e., a group of interested and committed colleagues, also fostered the approach to sustainability in the company. Peer groups of this nature were formed in the seminar and now work together on sustainability in companies. This also increased motivation to persist with these topics even in the face of difficulties.

The participants' view of the future also changed as a result of the seminar. They are now more optimistic and hopeful. The powerlessness, fear or resignation that is often felt in the face of the climate crisis was reduced by strengthening self-efficacy and adaptability.

Another change was visible in the transformative competence "purpose". Through the seminar, participants explored their own values and were then able to reflect on the extent to which their lives aligned with their values. This led to changes in the actions of the individuals, such as waste separation in the home and participation in clean-up actions in nature.

The data collection revealed that the terms "climate protection", "climate change adaptation", "environmental protection" and "sustainability" were often used synonymously. This was also evident in the discussion of climate protection and climate change adaptation. In addition to nutrition, mobility and energy consumption as individual and operational climate protection measures, waste avoidance in everyday life and at company green events were also often mentioned, as were green events or the establishment of a green team. The building projects in one participating company now include adaptation to natural disasters and climate change.

Companies were seen as a strong lever in the sustainable change of our society, as they have the reach to familiarize many people from different contexts with the topic of climate protection, climate change adaptation and sustainability. In addition, employees can act as multipliers for these issues in society. The discussion of this topic at the management level and open structures in the company were considered to be decisive factors in the integration of sustainability. By bringing together interested people in the seminar, the motivation to integrate sustainability into the company increased.

In the short project timeframe, seeds for ideas and new approaches to sustainability were sown. More research and a longer seminar phase will be needed to effect more far-reaching change. This project can be seen as a starting point in addressing the issue of transformative competencies for climate protection and climate change adaptation in companies. For long-term changes to be made visible, further projects with more financial and time resources will be needed.

StartClim2022.C: Climate fit, climate resilient, climate change adaptation – who proves that and how? (heat related)

Planning and building adapted to climate change has rightly been increasingly demanded in recent years. However, there is little agreement on measurement of the degree of climate fitness or climate resilience of buildings or open spaces. There is also no underlying methodology for how the measurements are calculated. Planners must prove that their project makes a contribution to adapting to climate change (EU taxonomy, competition requirements, certifications such as ÖGNI, klimaaktiv, etc.). There are individual standards, but no interdisciplinary specifications, guidelines and indicators are able to objectively assess the climate fitness of planning projects.

The aim of StartClim 2022C was to identify the requirements for possible assessment indicators and, if possible, to develop a method for the objective assessment of new construction projects (buildings, districts) in Austria. The project focused on the climate fitness of open spaces. The interior comfort with all its structural implications was not part of this research.

The methodology consisted of a combination of theory (analysis of existing literature and concepts) and empiricism (qualitative interviews with relevant stakeholders). Existing assessment systems and indicators in Austria were first researched and identified. In the second step, people from the city administration, certification institutions, real estate companies and scientists dealing with climate change adaptation in their everyday work were consulted about possible solutions.

Most existing assessments are limited to the building and/or use a qualitative classification. Exceptions are ÖGNI, which uses the DGNB system “Microclimate – Thermal Comfort in the Open Space” to evaluate the microclimate in the district. In terms of standards, those of ÖNORM or the VDI (Verein Deutscher Ingenieure, Association of German Engineers) are relevant. ÖNORM ISO 14090 contains a description of what indicators could look like, while VDI 3787/2 shows threshold values for thermal indices. A central result of the project was the following table (extract), which lists some existing indicators and thresholds.

Tab. 1: Indicators to measure climate change adaption

Topic	Indicator	Threshold	Source
Greening	Green and open space factor (Grün- und Freiflächenfaktor, GFF)	-	green.resilient.cities
	Biotope area factor	0.3 ; 0.6	ÖGNI
Solar radiation	Solar radiation winter Dec. 21st (h)	1 /,3 (h) 80% of area	DGNB
	Shade summer (% of open space)	1 / 3 (h)	DGNB
	Treetop canopy	≥ 10/30 (%)	Smart City Strategie Vienna
Wind comfort	Wind speed m/s	Average wind speed exceeding 5m/s	DGNB
Sealing	% of sealed areas in base area number	<40 (++), 40-50 (+), 50-80 (-), >80 (--)	RWTH Aachen 2017
Perceived temperature	PET	VDI 3787/2	VDI
	UTCI	VDI 3787/2	VDI
	perceived temperature	VDI 3787/2	VDI

Building greening	% of facade	-	Smart City Strategie Vienna

Seventeen interviews were conducted with stakeholders (city administration, certification institutions, real estate developers, scientists), three of which were personal and fourteen written. The following main statements were made:

- There are too few meaningful indicators
- There is a demand for simple, fast assessment tools (standardized procedures)
- Legal basis is necessary – this requires political will and a broad consensus
- One effect of the introduction of the EU taxonomy is an enormous increase in the importance of climate change adaptation (Annex II) in practice; there are still uncertainties about the assessment of the required qualities, national instructions for action / interpretation are missing
- There is a desire for increased collaboration between researchers, service providers and local authorities

Research and interviews revealed that indicators should have the following properties:

- easy to use, quick to determine with just a few entries
- high quality
- complying with EU taxonomy requirements
- transparent, comprehensible, based on a clear database and clear state of knowledge

In principle, indicators should be quantitative whenever possible. Where this is not possible, qualitative indicators can be used. Indicators should target the following characteristics:

- sealing: percentage sealed area in the base areas, proportion of unsupported soil
- ground greening: percentage green ground (e.g., green and open space factor)
- greening of buildings: proportion of the total facade and/or roof area
- radiation: percentage shaded open space, tree canopy cover
- overall perception: reduction in the percentage area of certain categories of perceived temperature (e.g. PET category “severe heat stress”) through measures compared with the case without measures
- wind comfort
- rainwater management (Sponge City)

This list shows that the issue is complex and that a single indicator is not enough. To assess whether and to what extent public or private open spaces are adapted to the framework conditions of the changing climate a set of indicators of differing degrees of complexity is required – from the proportion of sealed soil (simple geometric consideration) to the evaluation of heat indicators such as PET (computer simulations and/or relatively complex measurements by experts). Indicators cannot always be of high quality and quickly ascertainable at the same time and design compromises are therefore required to reconcile these two requirements.

During the development of the project, we deviated from the original goal of devising specific indicators. We realized that it was crucial for the indicators to be widely used and for new standards to be defined. They should therefore be created by a standardization body or expert commission such as ÖNORM, VDI or OIB. But there must be a consensus on their validity and meaningfulness. We consider that this point can be achieved through tests and measurements on site, and through the

involvement of stakeholders. This task would be suitable for a further research project. This would allow a meaningful evaluation to determine whether a living space was climate-fit, in the sense of averting possible damage, and climate-resilient, in the sense of being able to maintain its function and at the same time compensate for negative influences as a result of changed meteorological conditions.

StartClim2022.D: Measuring adaptation comprehensively

Climate change is unfortunately unavoidable and has become a veritable crisis with social, environmental and economic consequences that will have a significant impact on people's wellbeing.

So how can we best deal with this dynamic and complex climate crisis? We believe that the first step is for politicians, business and civil society – ultimately all of us – to set realistic goals for a good life and life-friendly environment, even under the given climatic conditions.

Specific climate change adaptation measures were therefore developed with local experts with a view to achieving diverse goals for a good life for all. The adaptation measures were then examined to determine the extent to which the goals were being achieved.

What target values do we use as a basis, what concerns, wishes and/or visions for a good life were expressed by the participants in this process and, above all, what implementation steps were formulated for that purpose?

In this participatory and transdisciplinary project, the participants were local experts who were prepared not only to set their own goals, but also to determine the yardstick (indicators) for them.

In order to achieve this, we developed a programme in four full-day workshops in Bad Aussee from February to June 2023 to determine how people in the region wanted to progress in this direction. A literature analysis and eight interviews with national and international experts from academia and practice and with regional stakeholders resulted in a detailed, publishable documentation of the process (in texts and videos), a handbook on how this methodology can be applied in other regions, and a specific system of leading indicators.

The first workshop used art methods (collages and texts) to enable the participants to get to know one another as a basis for further cooperation and to discuss what life might look like in the future for us and future generations? So the core question was WHY? The results were picture postcards from the future as qualitative future images and stories.

The second workshop was about HOW. What was the starting situation? With the help of impact diagrams, a common understanding emerged about the dynamics that needed to be considered and also about how the different goals, and the actors who pursued them could interact.

The third workshop focused specifically on climate change. How did climate change affect the vision of the future? And how could we know (measure) whether we were getting closer to the goals? So it was about WHAT. How do we measure the success of climate change adaptation projects, where adaptation is understood as the ability to achieve goals of a good life for all. The following figure documents the specific indicators found for this.

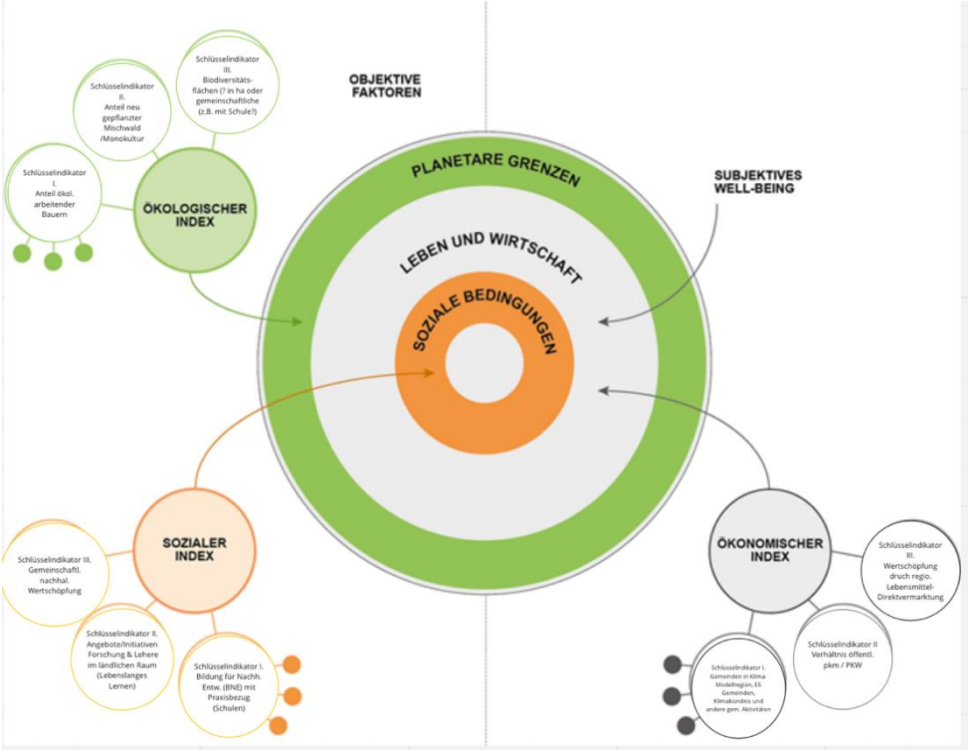

Fig. 3: Schematic representation of the indicators according to the three dimensions of sustainability

In the fourth workshop, options for action for the further process and the final result were worked out together on the basis of results developed by the regional participants.

The method tested for the first time in this project is now to be applied and further developed in other settings (also on other topics).

StartClim2022.E: Impact of hail events on agriculture: a remote sensing-based analysis of hail damage in the context of climate change

Hail damage in agriculture causes millions of euros of damage in Austria every year. A lot of it occurs in the agricultural and fruit-growing region of south-eastern Styria, one of the areas in Europe with the highest number of hailstorms. Experts from Austrian Hail Insurance usually perform a field assessment of the damage caused. A timely assessment and corresponding payment of the insured sum is very important for affected farmers, whose livelihoods may be threatened by the damage. Given the expected increase in severe hail events as a result of climate change, the development of robust, efficient, and cost-effective remote sensing methods for determining hail damage in agriculture is highly relevant.

Satellite image analysis can make this process more efficient and allows an initial damage assessment. The results could serve as an orientation for experts on site, especially in large agricultural areas. Remote sensing methods are already being used successfully in various areas to speed up and simplify damage analysis after extreme events such as flood disasters or forest fires. Satellite data is also suitable for analysing changes in vegetation on agricultural land after hail events. However, the use of optical imagery can be affected by cloud cover if the sky does not clear soon after a storm. Radar satellites, on the other hand, are (nearly) weather-independent active sensors that ensure continuous data availability, regardless of the atmospheric conditions. The combined analysis of optical and radar data has great potential for providing useful information on hail damage and the agricultural areas affected. As part of the HAGL project (Impact of hail events on agriculture: a remote sensing-based analysis of hail damage in the context of climate change), we discussed and evaluated our results and their suitability in practice with potential users, such as Austrian Hail Insurance.

We studied existing approaches described in the literature to develop an advanced method for the efficient determination of hail damage in agriculture by combining optical and radar satellite data, and tested and applied it for the first time in Austria. We conducted a spatio-temporal trend analysis on the basis of the available data from different meteorological services and identified areas in south-eastern Styria that have been particularly affected by hail events in recent years. We then looked at changes in fields in selected areas potentially caused by such events by considering information derived from satellite data that provides insights into plant health and biomass, among other things. We used time series of freely available optical (Sentinel-2) and radar (Sentinel-1) satellite data from the European Space Agency (ESA) and created a workflow for automatically analysing data from the periods before and after a hail event.

Our method is designed to help identify affected agricultural areas as automatically and efficiently as possible. The results include a trend analysis of hail events (2016–21), and maps of the particularly affected agricultural areas in south-eastern Styria. Another important result was a list of vegetation indices derived from Sentinel-2 and Sentinel-1, which provide information about the biomass and water content in plants and soils and are suitable for detecting hail damage in agriculture. The analysis based on these indices showed how vegetation on agricultural land changes during the growing season. Corresponding diagrams and maps for specific fields and types of cultivation were created and a semi-automated process used to identify unusual changes potentially caused by hail. The results were interpreted in comparison with unaffected agricultural areas and validated with data from the hail insurance. Approximately 70–80 per cent of the affected fields were successfully detected.

The automated method for determining hail damage in agriculture by combining freely available optical and radar satellite data could be transferred to other regions and could help in identifying affected agricultural areas and devising adaptation measures to increase the efficiency of insurance work in the event of hail damage. Further development of the method, including a combination of

weather radar data and its application to other extreme weather events and their impact on agriculture, is planned.

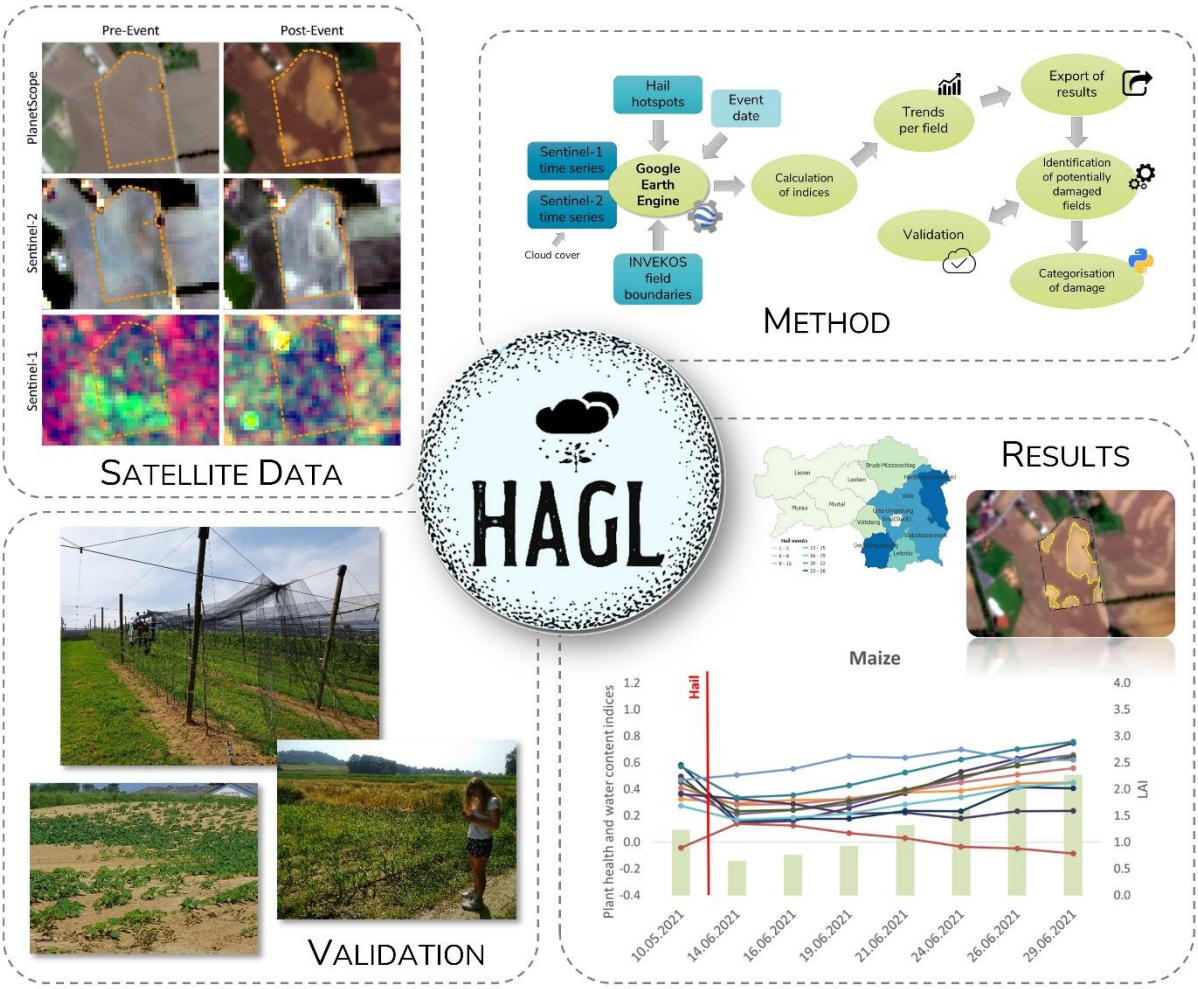

Fig. 4: Schematic representation of the HAGL project

StartClim2022.F: Climate change impact on triggering rainfall conditions for torrential disasters

Debris flows, floods and bedload transport are meteorologically triggered, natural erosion processes in alpine torrential catchments. When the longitudinal gradient in the lower reaches flattens, the eroded and entrained solids are deposited in the alluvial cone. Since the deposition area is mostly occupied by settlements or infrastructure, damage can occur in the event of an incident. A functioning protection concept requires knowledge of when which displacement processes can occur in the catchment area. In the case of heavy rainfall events, debris flows, debris floods and intensive bedload transport can develop into natural disasters, which cause considerable damage and also loss of human life. In extreme cases, they can even exceed local coping capabilities.

The triggers for these torrential processes are primarily intense rainfall events of short duration, but prolonged low-pressure precipitation and snowmelt can also play a role. In the past twenty or more years, threshold curves, mostly in the form of an intensity-duration relationship, have been derived for landslide and debris flow triggering precipitation in many regions of Europe. For Austria, such evaluations in the field of torrent hazards have only been carried out sporadically for event documentation.

In the course of climate change, Austria will experience spatial and temporal changes in temperatures and in the distribution of precipitation. Apart from the geomorphological effects (e.g., change in sediment availability), it can be assumed that the frequency of precipitation triggering torrent hazard processes will change.

Because of the large number of fluviatile and debris flow events in the Austrian alpine region, and thanks to the good database of precipitation information, it is now possible to characterize the prevailing displacement process types as a function of their triggering precipitation. The aim of the project was to identify critical rainfall events that lead to torrential floods or debris flows and to estimate the change in their probability.

For that purpose, twenty-two detailed event documentations by the Institute of Mountain Risk Engineering (BOKU Vienna) were processed, and core information on the events, especially on the triggering rainfall and the prevailing weather conditions, was collected and collated. In parallel, all torrential events of the official event database of the Austrian Forest Service for Torrent and Avalanche Control since 2003 were cross-referenced with the spatially and temporally highly resolved INCA precipitation data. There were 4,016 events in total, which can be classified into the process types “flood”, “fluvial sediment transport”, “debris flood” and “debris flow”. The selected temporal resolution was one hour. Subsequently, the triggering precipitation was determined manually for each event. Derived parameters included total precipitation, intensity, duration and onset, along with maximum one-hour intensity and the antecedent rainfall for one, three, seven and twenty-eight days preceding a torrential event.

The analysis of the event documentation resulted in a database of 168 torrential events, which were listed in an Excel file. It is interesting to note that about a quarter of these events were not included in the event database, indicating that the database cannot be considered complete. Since the data sources for the triggering rainfall events in the ERDOKs were not always homogeneous (monitoring station network with daily or ten-minute data, and INCA data), this limitation must be considered when interpreting the derived thresholds from the ERDOKs. The evaluation of the large-scale weather situations shows that about 34 per cent of the events were triggered in the course of a low-pressure complex, 30 per cent in the course of a high-pressure weather situation and about 36 per cent in the course of a westerly, north-westerly, south-westerly or low-gradient situation.

Evaluation of triggering precipitation from INCA data yielded information on 642 flood events, 2,125 fluvial sediment transport events, 651 debris floods and 651 debris flows. The results of the intensity-duration threshold analysis are shown in figure 1. Fluvial events have a flatter relationship between

critical intensity and duration. All process types show considerable scatter, which could have different causes, but could also be due to different precipitation patterns, among other factors. This should be considered in further analyses and could improve the prediction accuracy.

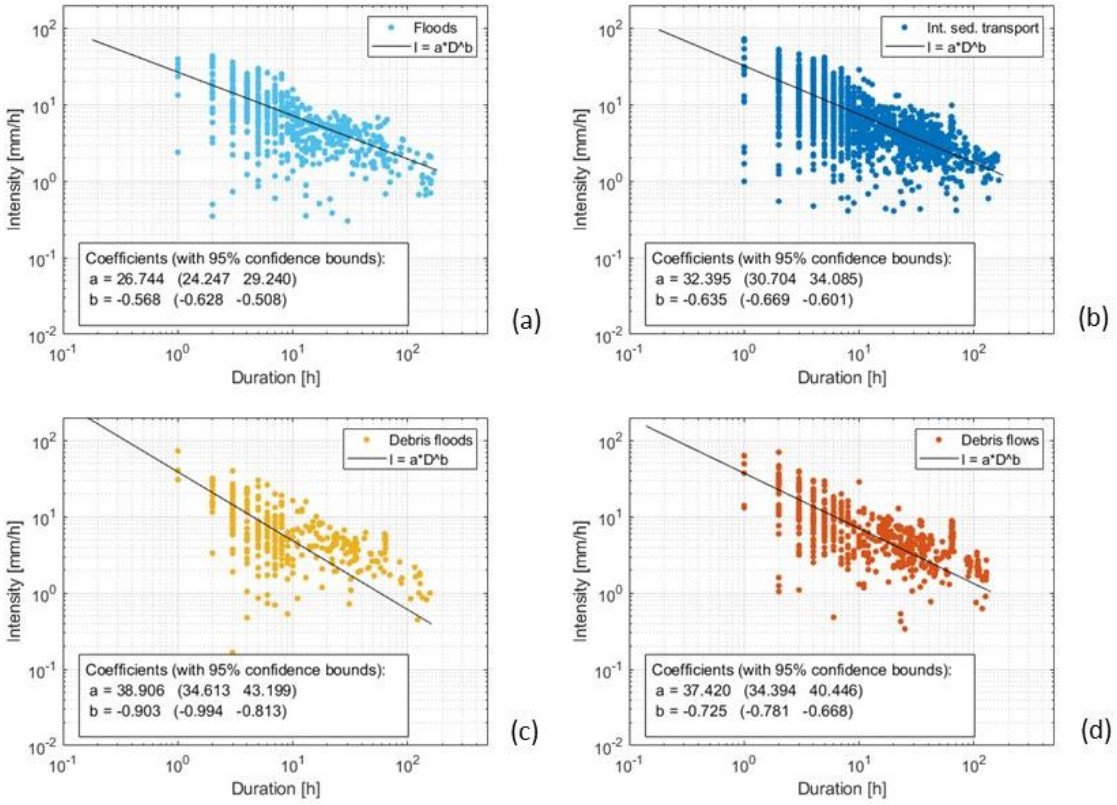

Fig. 5: Intensity-duration relationship and limit curves including confidence interval based on INCA one-hour data for process types flood (a), fluvial sediment transport (b), debris flood (c), and debris flow (d)

For the evaluation of climate change-induced changes in triggering precipitation events, the empirically determined intensity-duration relationships were converted from hourly to daily basis for up to five-day precipitation totals (120 hours). The number of annual exceedances of the respective limits was evaluated using the ÖKS15 ensemble. It was found that both the probability of occurrence and the area affected increased significantly for precipitation conditions of all four process types, albeit with clear differences between the emission scenarios (RCPs). While the frequency of purely meteorological events is also increasing in mountainous areas, the area spread is largely in lowland areas, which is why factors such as terrain shape, subsurface geology, and affected infrastructure must also be considered for further assessment of torrent disasters in climate change.

StartClim2022.G: City Green – climate change adaptation by greening the city

A major goal of many cities in the context of climate change adaptation is to promote urban green space. However, the limited amount of available areas for conversion into green spaces hinders this development. Financing difficulties have also been reported. This study examined the willingness to pay and the acceptance of a longer walk home in favour of new green spaces that contribute to more biodiversity and healthy living conditions.

For this purpose, 1,055 people living in cities with more than 20,000 inhabitants were surveyed. With the help of a special form of questioning, the Choice Experiment, it was possible to query attitudes to the possible performance of new green spaces in reducing temperature, particulate matter and NO2.

The results showed that the majority would be willing to pay €45 per year in the form of a communal charge for high environmental performance (reduction of temperature, particulate matter and NO2), while at the same time extending the walking distance to their homes by up to 10 minutes. However, the results also revealed clear differences between the respondents. Using Latent GOLD software, we were able to distinguish four classes with different preferences, attitudes to climate change, past experience of heatwaves, residential environment and willingness to pay for green space close to home. The following figure describes the proportions of these four classes in urban society and their main characteristics.

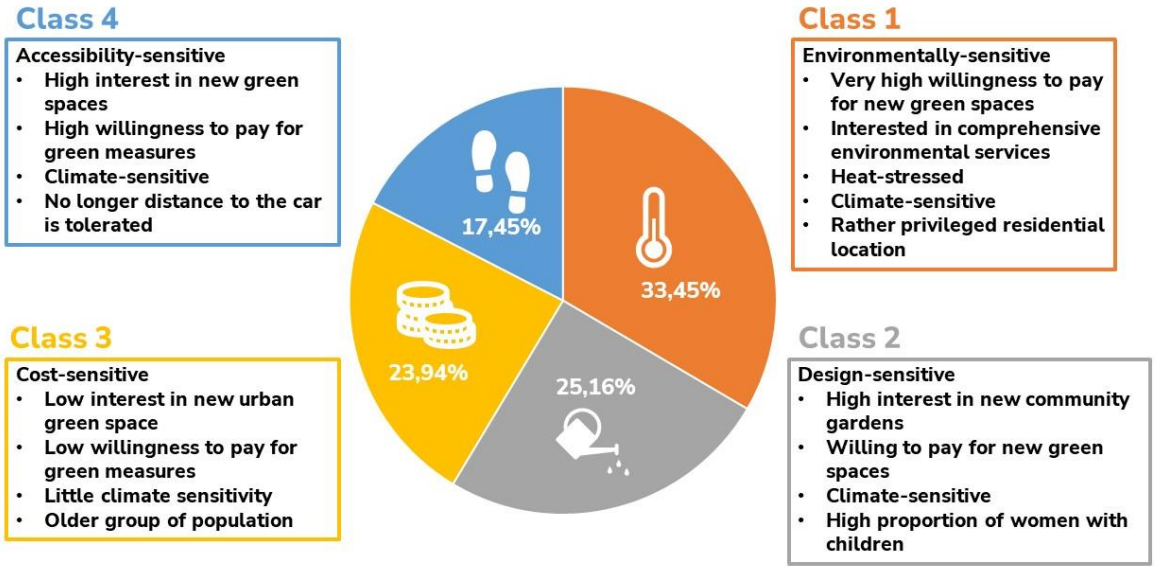

Fig. 6: Within the scope of the representative survey of Austria's urban population, four different classes could be distinguished with regard to support for new green spaces in the city, n = 1,055.

Overall, street greenery proved to be the most popular design, followed by green corridors, green rainwater retention (rain garden) and, lagging clearly behind, community gardens. Differentiated analysis showed that class 2 including many female respondents as well as a higher proportion of people with children preferred this type. Contrary to expectations, biodiversity enhancement did not play a crucial role in the decision-making process. Also surprising was the fact that, in the context of the decision for more urban greening, the level of participation was not a decisive factor.

In the form of model case constellations, different combinations of urban greening, efficiency and possible disadvantages such as refinancing costs and walking distance, were simulated. These case constellations showed that tailor-made solutions could be tested using the available decision support tool (DST). This advantage of this DST was also emphasized by Viennese city planners involved in a

workshop. They stated that such an instrument would be very desirable, especially to convince policymakers to adopt more comprehensive solutions.

StartClim2022.H: A PHysical vuLnerability indeX (PHLoX) for wildfire in Austria as a tool for climate change adaptation

Climate change is expected to change the magnitude, frequency and extent of some natural hazards. As far as wildfire is concerned, burnt area, the number of incidents and the associated costs are on the rise globally and also in Europe. In Austria, fire weather days are expected to rise in the coming years. Recent events (Hirschwang an der Rax in October 2021) have clearly shown that wildfire is an emerging risk for countries and regions that had not experienced significant catastrophic events before. Development on economic, residential, or recreational grounds in the wildland urban interface (WUI), the zone where human development meets the forest, may increase this risk for two reasons. First, wildfires are often initiated as a result of human activities, and secondly, because the more the assets are at risk, the greater the costs and the negative consequences for the communities.

There is therefore a need to lessen this risk by reducing either the possibility of the occurrence of a wildfire or the impact that this might have on the natural and the built environment. To reduce the impact on the built environment, the physical vulnerability of buildings located in the WUI needs to be looked at. Methods for assessing physical vulnerability are often based on empirical data. In countries like Austria and elsewhere in central and northern Europe, however, there is not enough empirical data because of the low frequency and impact of such events in the past. In the PHLoX project, a physical vulnerability index for buildings was developed. This project took a closer look at the characteristics of buildings and their surroundings that made them vulnerable to wildfires, including building features (e.g., the shape of the roof, building material, and design such as windows, doors, shape, and size) but also characteristics of the neighbouring forest (e.g., type of vegetation) and the immediate surroundings (distance to neighbouring buildings or trees).

The first step was to collect these vulnerability indicators by means of a detailed literature review, including a large number of recent international scientific papers. The next step was the involvement of experts from Austria from different backgrounds, ranging from the insurance industry to local authorities and emergency services. Following stakeholder mapping and communication, a panel of international experts was established from universities and research institutes in the USA, Australia, Portugal, Greece, France and Spain. Both sets of experts (Austrian and international) were asked to compare pairwise a number of indicators (thirty-four indicators in three categories). The indicators were weighted using the analytic hierarchy process (AHP) (fig. 1). The last step was to integrate the indicators and weighting in a single wildfire vulnerability index that could be assigned to each building. This index could reveal the spatial pattern of vulnerability and the hotspots and act as a guide for the design of disaster risk reduction and adaptation measures.

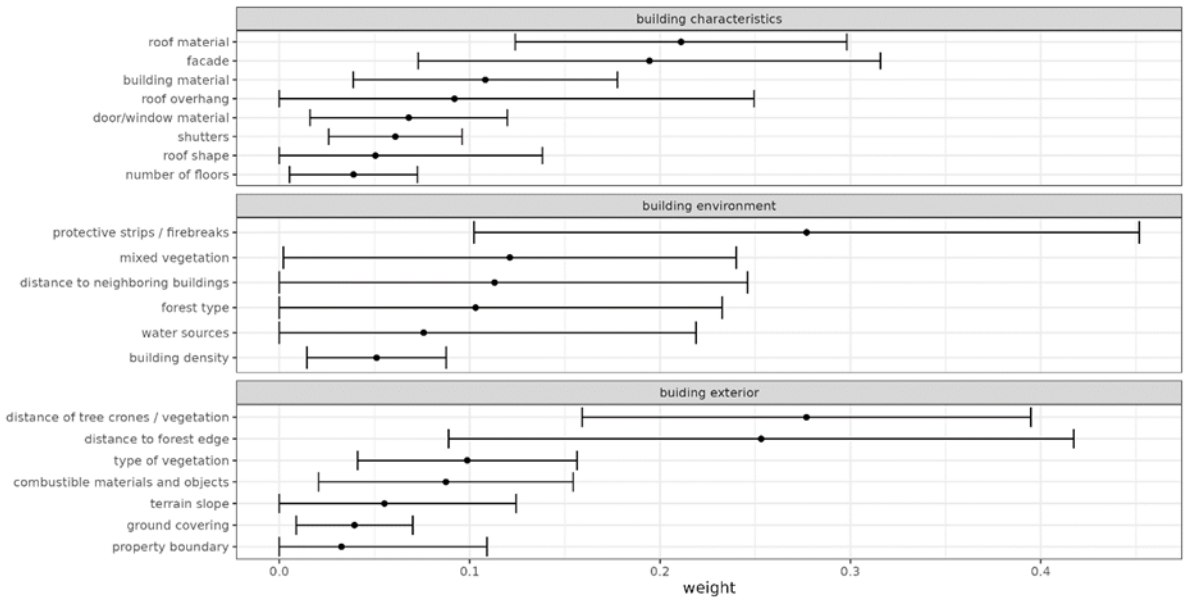

Fig. 7: Results of the AHP based on the answers of the Austrian stakeholders

The weighting and feedback from the experts enabled a number of recommendations for the reduction of vulnerability and hence the negative consequences of wildfires to be made.

1. According to the experts, building material is one of the most important indicators. In areas where the risk of wildfire is particularly high, certain building materials are recommended and others should be avoided.

2. Protective strips and firebreaks were ranked very high as indicators. Firebreaks and similar measures should therefore always be chosen with account taken of neighbouring settlements and prevailing winds to protect large, inhabited areas, save lives and reduce damage to property and costs.

3. Forest type and density were also marked as very important. Residents of settlements next to forests with specific tree types and density should be informed about the dangers that may have to face and prepare their property accordingly (see recommendation 1).

4. The most important indicator in both groups was the distance of the tree crowns from the building. This indicates the importance of cleaning around the building, removing dead wood and leaves and minimizing the contact of vegetation by pruning and trimming trees.

5. The type of vegetation was ranked high. Authorities should inform the residents about tree types that are less dangerous and should be preferred in comparison with others.

6. The degree of preparedness of a building in terms of evacuation possibilities was recommended as an additional indicator. Public awareness, education and training on emergency procedures are therefore very important and should be further developed.

Imprint

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