

Knowledge for a climate transformation

Strategic agenda for the National Research Programme on Climate



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R7:2021

ISBN: 978-91-540-6141-9

Cover photo: Sara Winsnes, Scandinav Bildbyrå AB.

Forskningsrådet för miljö, areella näringar och samhällsbyggande, Formas

The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning

Box 1206, SE-111 82 Stockholm, Visit us: Drottninggatan 89

Phone: +46 (08) 775 40 00, E-mail: registrator@formas.se

www.formas.se/en

Stockholm, April 2022

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Foreword

We at Formas would like to thank everyone who has contributed in various ways to implementing the National Research Programme on Climate. Since the programme's inception in 2017 and through September 2021, the programme has initiated and announced 19 calls. Of these, decisions were taken in 12 calls through which the programme has funded more than 100 projects. In addition, the programme offered a variety of activities that promoted knowledge-building and dissemination with the aim of meeting the climate challenges. For up-to-date information about the programme's calls, projects and other activities, please visit the Climate section under national research programmes on Formas' website. Many thanks to all of you who were involved.

We would also like to extend a warm thanks to all of you who provided insightful input and reflections during the revision of this strategic agenda, which aims to guide the efforts of the National Research Programme on Climate.

Specifically, we would like to thank these programme committee members: The Swedish Energy Agency, Formas, Forte, the Swedish Agency for Marine and Water Management, Mistra, the Swedish Environmental Protection Agency, the Swedish Polar Research Secretariat, the Swedish Space Agency, Sida, the Swedish Research Council and Vinnova, as well as the programme's working group, of course, with representatives from most of these organisations.

Our thanks also go to the researchers and experts who reviewed the strategic agenda during the revision, as well as all the stakeholders involved in the substantial efforts that laid the foundation for the first version of the climate programme's strategic research agenda.

We'd also like to extend a big thank you to Anders Wijkman, the chairman of the programme committee during 2018–2021.

We very much look forward to continuing our broad collaboration.

Stockholm, December 2021

Ingrid Petersson
Director General of Formas

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Summary

The National Research Programme on Climate stems from a government commission received by Formas and spans the period 2017–2026. The climate research programme, which is one of thirteen national research programmes, was established by the government to meet its goal of addressing societal challenges posed by climate change in Sweden and around the world. The programme's aim is to provide knowledge for a profound transformation of society that addresses climate challenges. This will be done by funding research and innovation that can help to achieve rapid emission reductions, adapt societies to a changing climate, and promote climate efforts in line with long-term sustainable development.

In this strategic agenda, we present the objectives, thematic orientations and work methods of the National Research Programme on Climate. This is a revised version of the original agenda, which was published in 2018 in connection to the establishment of the programme. The revision has been made in light of the lessons learned during the first years of the programme and the additional funding provided by the government starting in 2021. The revision was carried out in 2021.

In addition to meeting society's global and national challenges and needs, national research programmes are expected to coordinate and pool research in one area as well as to enable interdisciplinary and cross-sectoral collaboration.

To promote synergies among different stakeholders who complement each other in terms of knowledge, expertise and mission, the National Research Programme on Climate has an advisory committee and a working group that consist of research funders relevant to the field. The committee is headed by a chair.

This strategic research agenda identifies six key themes and four cross-cutting perspectives, which together create a framework of priority areas that will guide the research programme's activities. The six themes are based on analyses of the challenges surrounding, and the goal context of, the national programme as well as on analyses of knowledge gaps in society on climate transformation. These starting points have subsequently been related to current investments in climate research and innovation, so that the national programme can supplement current climate research.

The six themes and their focus areas are as follows:

- **Sustainable innovations for climate efforts**, focuses on the next generation of social, organisational, policy and technological innovations that have the potential to make an impactful contribution to transformation and to climate adaptation in Sweden and beyond, while taking into account other global sustainable development goals.
- **System-integrated knowledge of climate change, ecosystems and society**, highlights the need for in-depth knowledge of the human-nature relationship, the complexity of the climate system, the effects of climate change, and the links between climate change and biodiversity. The theme also includes a risk perspective.

- **Production and consumption in line with climate goals**, focuses on changing production and consumption patterns and on promoting sustainable resource use in a broader sense. This theme includes entire value chains, climate ethics, and shifting norms and behaviours related to consumption.
- **Governance for meeting climate challenges**, is about governance, institutions and leadership that can promote the transformation needed to achieve the climate targets, including decision-making at different levels and organisations, power aspects and the impact of actions.
- **Economic and financial drivers for climate action**, is about how the financial system and different types of investments can contribute to the transformation, as well as the role economic instruments and the economic system have for climate change.
- **A democratic and just climate transformation**, addresses issues of justice and democracy in the transformation linked to emission reductions as well as to climate adaptation. Ethical issues are also included, as well as questions of representativeness, power and accountability.

In addition to these themes, four cross-cutting perspectives have been identified that provide valuable approaches to the agenda's themes. These perspectives are: **International climate efforts, Digitalisation, Synergies and conflicting goals in the sustainable development agenda**, and **Gender equality, equity and diversity**.

In the implementation of the programme, we will initiate research and other activities that combine the themes and perspectives. This is part of capturing the systemic challenges of climate change and the holistic view needed in the transformation. Because of this system view, the programme also interacts with other national research programmes in areas that have especially strong links to climate change. In order to contribute knowledge for a profound transformation that addresses climate challenges, the calls in the programme span a broad repertoire of research approaches and research perspectives as well as offer various types of grants including research support, innovation support and collaboration support. Working methods, calls for proposals, and other activities will be continuously developed during the ten-year programme period and adapted in pace with knowledge development and society's needs for climate transformation.

1. A national research programme on climate

Climate change is often described as the defining issue of our time. In its assessment report published in August 2021, the Intergovernmental Panel on Climate Change states: “It is unequivocal that human influence has warmed the atmosphere, ocean and land.”¹ It points out that several of the observed changes are at a rate unprecedented in many centuries and, in some cases, millennia. The report also notes that many changes due to past and future greenhouse gas emissions are irreversible for centuries to come. Examples include changes in the ice sheets and global sea levels. The IPCC assessment report, which refers to over 14,000 scientific papers, underscores that comprehensive, rapid reductions in emissions of carbon dioxide and other greenhouse gases are necessary to limit global warming and thus reduce the impact on communities and ecosystems worldwide.

Climate change is already having significant impacts around the world, which all additional emissions are driving even more. Some of the consequences of a changing climate include temperature increases, shifting precipitation patterns, glacier melting, sea level rise and extreme weather. Their effects depend on a variety of factors that play a key role in the resilience of communities and ecosystems and their adaptation potential. Examples of such factors are geographical conditions, land use, economic resources, institutional capacity, and the policies that are pursued. Because these factors interact, a single effect such as an increasingly drier climate can have drastically different consequences depending on where it occurs and a specific community’s ability to withstand and manage the stresses. In addition, there are significant differences within communities where certain groups, such as children, the elderly and women, are often more vulnerable than others. Consequently, the adaptation measures taken to address climate change make a huge difference in the consequences they bring.

The challenges of climate change ultimately depend on how extensive climate change will be and how the changes will be addressed. As part of limiting global temperature increases and supporting those who are impacted by climate change, the world’s countries signed a global climate agreement in 2015 called the Paris Agreement.² This agreement stipulates that the global temperature increase should be kept well below 2°C above pre-industrial levels and strive to limit it to 1.5°C. The global average temperature increase is 1.1°C so far, and in its latest assessment report the IPCC estimates that the 1.5°C average temperature rise could be reached as early as within a few decades.³ The world thus faces a major challenge, and the commitments presented so far in the global climate negotiations must be strengthened dramatically. The Paris Agreement also stresses

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1. §1, Intergovernmental Panel on Climate Change’s 2021 report “The Physical Science Basis”. See also IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.
 2. The Paris Agreement, UNFCCC (25 August 2021).
 3. IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

that significant efforts need to be made to adapt communities to a changing climate. An important point of departure in the Paris Agreement, as well as in the long-running global climate negotiations, is that the countries with the best conditions for the transition should take the lead, and industrialised countries should provide support to developing countries.

Sweden has a stated policy goal of being a leader in the global effort to achieve the goals of the Paris Agreement. In addition to the Swedish parliament's adoption of a climate act stipulating that the climate goals should guide the government's efforts, the government has also expressed the goal of becoming the world's first fossil-free welfare nation.⁴ The government has stressed that this goal will require decisive action entailing "a long-term, systemic change that takes into account the different conditions that prevail in cities and in different rural areas, for different income groups and other individual circumstances."⁵ The government has also emphasised that all sectors must contribute to Sweden's achievement of the climate goals, which means that climate policy must be integrated in all relevant policy areas. This has also been an explicit strategy for EU climate action, in which the idea of integrating climate change in other policy areas is intended to be further developed within the framework of the Green Deal and the current multiannual financial framework for 2021–2027.⁶

In "A coherent policy for the climate – climate policy action plan" (Govt Bill 2019/20:65), the government stressed that climate policy should enable a transformation that leads society towards a fossil-free future without compromising the ability to achieve other sustainable development goals, in Sweden or in other parts of the world.⁷ Integrated perspectives, innovation and knowledge are essential components of this shift, and the government has emphasised the importance of research. It is against this background that the government's investment in the national research programmes can be understood.

In its 2016 research bill, the government proposed establishing ten-year national research programmes, each focusing on major cross-sectoral challenges.⁸ Seven programmes launched in 2017, and with the 2020 research bill the number of national research programmes rose to a total of thirteen.⁹ The national research programmes are intended to complement the research and innovation system as a whole. This does not mean that all research in a particular field is concentrated in the programmes, but rather that the programmes involve a concerted effort in priority areas. The programmes are expected to meet the government's goals of addressing society's challenges both in Sweden and around the world. Because of the systemic nature of the challenges, the national research programmes also interact with each other in funding calls and other activities in areas that are tightly interlinked.

One of these programmes is the National Research Programme on Climate, which Formas was tasked with establishing in 2017. The programme runs for ten years and will be conducted in close collaboration with other research funding

4. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan.

5. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan, p. 8.

6. Climate Mainstreaming EU, 2021 (2 September 2021).

7. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan.

8. Govt. Bill 2016/17:50: Collaborating for knowledge – for society's challenges and strengthened competitiveness.

9. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden. The thirteen programmes address these topics: Antibiotic resistance, workplace research, crime, the social consequences of digitalisation, oceans and water, sustainable spatial planning, climate, food, migration and integration, mental health, segregation, applied welfare research, and viruses and pandemics.

organisations in Sweden. The government commission, which is contained in its entirety in Appendix 1, has provided key input for formulating the programme's goals and purpose.

1.1 Programme goals and purpose

There are high expectations for the National Research Programme on Climate. The goals of the programme can be divided into two types: those related to climate challenges and those of a more structural nature related to research policy.

The programme's goals are to provide knowledge for the following:

- A profound transformation of society that addresses the climate challenges
- A rapid reduction in emissions to net zero and, in the long term, negative emissions
- Climate change adaptation with increased robustness and reduced vulnerability to the consequences of climate change
- Climate actions that are undertaken in line with long-term sustainable development where no one is left behind.

In addition, the climate programme will contribute to the following:

- Renewal and innovation through high-quality research and innovation of excellence
- Interdisciplinary and cross-sectoral collaboration
- The real-world impact of research results
- Synergies and collaboration among funders, research-performing organisations and users of climate research
- Increased internationalisation of research
- Gender equality
- Research ties to higher education
- An efficient use of research infrastructure.

The National Research Programme on Climate cannot, of course, endeavour to realise these ambitious goals alone. Instead, they must be understood in a broader societal context and the programme must be carried out in collaboration with others. As the government stressed in its first climate policy action plan from 2019, policies should be an enabler for a transformation, and climate policy should be integrated in all relevant policy areas.¹⁰ Accomplishing this also requires new research-based knowledge. The National Research Programme on Climate is a vital initiative in this respect, yet it is only part of Sweden's overall research and innovation initiatives that are relevant for the climate transformation. In this strategic agenda for the National Research Programme on Climate, the aim is thus to describe the context in which the programme operates and to present the programme's focus areas and activities for implementing the programme.

10. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan.

1.2 Developing the agenda

A first version of the agenda was developed in 2017–18. It was titled Research for meeting the challenges of climate change: *Strategic agenda for the National Research Programme for Climate*. It was developed by Formas in consultation with the research funding organisations that are part of the programme committee and in dialogue with stakeholders and research-performing organisations.¹¹

Prior to developing the first version of the agenda, an extensive analysis was carried out. An external analysis of international experiences from challenge-driven research programmes served as key input. To ensure the relevance of the research programme, Formas also conducted a workshop on knowledge needs with civil society organisations, the public sector and the private sector. The largest government funders also shared data about research funding in the field of climate change. In parallel, relevant reports and publications were analysed. A first version of the agenda was submitted for consultation to higher education institutions (HEIs) and research institutes, as well as to the stakeholders who participated in the workshop discussions on knowledge needs. Representatives from the HEIs and research institutes were invited to continue a dialogue to further ensure that the programme's efforts and activities during the programme period could create added value and synergies for the sector's progress. The first version of the agenda was finally approved by Formas' Research Council in September 2018.

From the outset of the programme, regular revisions were planned during the implementation in order to address any changes in the external environment that could affect the programme. A first revision was initiated in the autumn of 2020 and completed in 2021, resulting in this strategic agenda. The revision took place within the context of three main inputs: the research bill *Research, freedom, future – Knowledge and innovation for Sweden*, which provided the programme with a significant budget increase,¹² the EU's launch of Horizon Europe, and an evaluation of the programme's organisation and governance undertaken in 2020.¹³ In conjunction with the revision, Formas conducted a review of the programme's process descriptions, level of ambition, communicability and direction. In alignment with language from the research bill, the initial focus of the programme has been preserved while adding enhancements and clarifications.

The revision was carried out by Formas in dialogue with the programme committee and working group. The committee discussed the programme's direction, and the working group contributed explanations of the role of funding organisations in research and innovation. Research-performing organisations and stakeholders were also involved in submitting the chapter on themes and perspectives for consultation. In addition, we consulted with other national research programmes that had also revised or developed their strategic research agendas in order to learn lessons.

11. Research for meeting the challenges of climate change: Strategic agenda for the National Research Programme on Climate, Formas 2018.

12. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden.

13. Evaluation of Formas' national research programme, Ramboll 2020.

1.3 Outline

Chapter 2 describes the context that underpins the goals of the programme and their attainment. In Chapter 3, we provide a brief overview of Swedish climate research and a global outlook focusing on the EU framework programme for research and innovation, Horizon Europe. This chapter also describes the programme's strategic direction relative to key trends in Swedish climate research. Chapter 4 presents the challenges the programme focuses on, which consist of six thematic areas and four cross-cutting perspectives. Essentially, the themes and perspectives have strong synergies among each other and can be combined in different ways in calls for funding for research and innovation, as well as in other activities the programme initiates. Chapter 4 is therefore a key chapter of this agenda and is followed by a description of the programme's implementation and organisation in Chapter 5.

2. Context of the programme goals

The National Research Programme on Climate will support efforts to achieve the national, European and global goals around the climate challenges Sweden has pledged to take action on, as well as efforts to achieve the objectives of Swedish research policy. The programme's own goals are therefore designed in light of policy objectives and agreements of great importance to climate studies, as well as several research policy objectives. In this chapter, we describe the policy objectives the programme wishes to contribute to and how the programme's goals relate to them. Although the programme intends to support policy objectives, a vital research task also entails critically examining, complementing and thinking beyond today's policy goals. The programme's calls and other activities therefore encourage a broad repertoire of research approaches and perspectives.

2.1 Goals for meeting the challenges of climate change

Several policy agreements have guided the formulation of the programme goals that offer a response to meeting the climate challenges. These include global and national goals as well as agreements and strategies that address emission reductions, climate adaptation and sustainable development from a broader perspective. They are often interlinked, and the Swedish government aims for Sweden to be a global role model and leading country in efforts to realise the goals of the Paris Agreement and the 2030 Agenda.

The 2030 Agenda

The 2030 Agenda offers strong guidance for domestic and international sustainability efforts, and it has been called the most ambitious agenda for sustainable development that the world's countries have ever adopted.¹⁴ The agenda was adopted in 2015 and consists of 17 sustainable development goals (SDGs). Goal 13, Climate action, aims to "take urgent action to combat climate change and its impacts".¹⁵ The 2030 Agenda also states that the goal should be implemented "while acknowledging that the UN Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change".¹⁶ Although Agenda 2030 has a specific climate goal, the links are clear between this goal and several of the other SDGs. It is therefore important to explore synergies and conflicts among goals in all sustainability efforts.

The Paris Agreement

In December 2015, virtually all the countries of the world agreed on a new global climate agreement – the Paris Agreement – under the UN Framework Convention on Climate Change. The goal of the agreement is to keep the global temperature increase at well below 2°C above pre-industrial levels and strive to

14. (25 August 2021) See also UN 2015, Transforming our world: The 2030 Agenda for Sustainable Development.

15. Goal 13: Climate action – The sustainable development goals, www.un.org/sustainabledevelopment (25 August 2021).

16. Goal 13: Climate action – The sustainable development goals, www.un.org/sustainabledevelopment (25 August 2021).

limit the increase even further to 1.5°C. The agreement also aims to increase climate adaptation capacity and to address the damage and losses caused by climate change. The agreement states the need for all countries to have a climate plan with their own goals in place. Low-income countries should receive support from the other countries to take climate action, including adapting their communities to a changing climate. This support can take the form of financing, technology transfer or capacity-building. The efforts will be evaluated regularly with the aim of raising the ambitions.

EU's Green Deal and Climate Law

In December 2019, the European Commission presented the European Green Deal, which aims to make the EU the world's first climate-neutral continent. The Green Deal is a growth strategy for transitioning to an economy where there are no net greenhouse gas emissions in 2050, economic growth is decoupled from resource consumption, and no people or places are left behind. The Green Deal will be integrated in all policy areas and ensure a just transition for all.¹⁷

In June 2021, the Council of the European Union adopted the European Commission's proposal for a European climate law, which had been approved by the European Parliament earlier in April.¹⁸ The Climate Law makes the Green Deal's climate neutrality target legally binding. In addition, the Climate Law contains a 2030 target of at least 55% lower net emissions compared with 1990. It recognises the need to increase EU carbon sinks through land use change and forestry, as well as a commitment to negative emissions after 2050 and stricter regulations on climate change adaptation. A scientific advisory board will also be established to provide independent scientific advice. The Climate Law, with its stricter climate targets, will be followed by a comprehensive package of measures and legislation that goes under the moniker "Fit for 55".

Climate adaptation strategies of the EU and Sweden

The European Commission adopted a new climate adaptation strategy in February 2021, building on its 2013 strategy. The new strategy emphasises that EU climate adaptation measures need to encompass all parts of society and all levels, both within and beyond the EU. The aim is to "build a climate-resilient Europe", which will be done by increasing our understanding of the effects of climate change and of climate adaptation solutions, improving adaptation planning and climate risk assessments, and accelerating adaptation measures in Europe and globally.¹⁹ Among other issues, the strategy highlights the need for a system perspective that recognises integration of climate adaptation into macroeconomic fiscal policy, nature-based solutions and local adaptation measures as important cross-cutting priorities.

In 2018, the Swedish government presented a national strategy for climate adaptation.²⁰ The government's goal for climate adaptation is to develop a sustainable and robust society for the long term that proactively addresses climate change by reducing vulnerabilities and leveraging opportunities. The strategy represents a way for the government to meet its commitments under the Paris Agreement and in the EU's climate adaptation strategy. To support Sweden's climate adaptation

17. A European Green Deal, European Commission (europa.eu) (2 September 2021).

18. Regulation (EU) 2021/1119 of the European Parliament and of the Council establishing a framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (European Climate Law) on 30 June 2021.

19. EU COM (2021) 82 final, Forging a climate-resilient Europe – the new EU strategy on adaptation to climate change.

20. Govt. Bill 2017/18:163: National strategy for climate adaptation.

efforts, the government in 2019 established the National Expert Council for Climate Adaptation, which is tasked with evaluating climate adaptation efforts in Sweden and proposing action measures.²¹ PAs tasked by the government, the Swedish Meteorological and Hydrological Institute SMHI also runs the National Knowledge Centre for Climate Adaptation, which acts as a hub for knowledge around climate adaptation efforts.²² On 1 January 2019, a new regulation on climate adaptation for public authorities also entered into force. Under this regulation, 32 central government agencies and 21 county administrative boards must initiate, support and evaluate their climate adaptation efforts within their respective areas of responsibility and scope of their mandates.²³

The climate policy framework

In June 2017, parliament decided on a national climate policy framework for Sweden. It took effect 1 January 2018, and consists of a Climate Act, new national climate targets and a climate policy council. Under the long-term climate act that was passed, Sweden is aiming for net-zero greenhouse emissions by 2045 and thereafter negative emissions. Under the Climate Act, every four years the government must present a climate policy action plan describing how climate policy efforts should be conducted during its electoral period. The first action plan was presented in December 2019.²⁴

The climate policy framework includes five interim targets to be reached between 2020 and 2045. Four of the interim targets address greenhouse gas emission levels for 2020, 2030, 2040 and 2045, compared with the reference year 1990. In addition, there is a sector-specific objective for reducing emissions from domestic transport. The long-term goal for 2045 includes Sweden's total emissions occurring within its borders, called territorial emissions.

A complementary way to measure Sweden's emissions is to start from consumption-based emissions, which take into account the climate impact caused by Swedish consumption both in Sweden and in other countries.²⁵ Consumption-based per capita emissions in Sweden in 2018 were approximately 8 tonnes per person, compared with roughly 5 tonnes per person per year when calculating territorial emissions.²⁶ To achieve the Paris Agreement's goals, global emissions should average no more than 1 tonne per person per year by 2050.²⁷ Reducing emissions from Swedish consumption is thus an important step in helping to reduce global greenhouse gas emissions. In October 2020, the Cross-Party Committee on Environmental Objectives received an additional directive to propose a comprehensive strategy for reducing climate impact from consumption.²⁸

21. National Expert Council for Climate Adaptation (klimatanpassningsradet.se) (2 September 2021).

22. Swedish Meteorological and Hydrological Institute SMHI (2 September 2021).

23. Ordinance (2018:1428) on climate adaptation efforts by public authorities, SFS 2018:1428.

24. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan.

25. The size of consumption-based emissions in other countries depends on how much we import, how emissions-intensive the goods or services are, and how large the emissions intensity is in the country of production. Three-fifths of total emissions arise as a result of household consumption, and the remaining two-fifths from public consumption and investments. Public consumption corresponds to the goods and services that organisations like schools, hospitals and government authorities buy to conduct their operations. Investments correspond to emissions linked to the construction of buildings, the manufacture of machinery and computers as well as assets and inventory investments. Approximately 57 percent of consumption-based emissions occur in other countries (Swedish Environmental Protection Agency, report 6945 on an in-depth analysis of the Swedish climate transition for 2020, "Klimat och luft i fokus", December 2020).

26. "Konsumtionsbaserade utsläpp av växthusgaser", Swedish Environmental Protection Agency (naturvardsverket.se) (25 August 2021).

27. An in-depth analysis of the Swedish climate transition for 2020, "Klimat och luft i fokus", Swedish Environmental Protection Agency, December 2020.

28. Committee terms of reference Dir. 2014:165, supplementary terms of reference for the All-Party Committee on Environmental Objectives (M 2010:04), "Strategi för minskad klimatpåverkan från konsumtion".

Sweden's environmental objectives

Sweden's environmental objectives framework consists of one generational goal, 16 environmental quality goals and several interim targets.²⁹ The environmental objectives were established by parliament in 1999, and since then have been guiding Swedish environmental policy. Since the 2030 Agenda was decided on in 2015, these environmental objectives have become Sweden's way of implementing the environmental part of the agenda.

The "Climate action" SDG is intended to stabilise greenhouse gas concentrations in the atmosphere in accordance with the UN Framework Convention on Climate Change "at a level that would prevent dangerous anthropogenic interference with the climate system".³⁰ In addition, this goal must be achieved in such a way that "biological diversity is preserved, food production is assured and other goal of sustainable development are not jeopardised".³¹ The generational goal is an overarching goal for environmental policy to "hand over to the next generation a society in which the major environmental problems have been solved, without increasing environmental and health problems outside Sweden's borders".³²

2.2 Sweden's research policy objectives

The government's objective for research and innovation policy is that "Sweden should be one of the world's foremost research and innovation countries and a leading knowledge economy, where high-quality research, higher education and innovation lead to the development and welfare of society, competitiveness of the business sector and respond to the societal challenges we face, both in Sweden and globally".³³ The policy's goal is to safeguard independent research while responding to global and national challenges and needs throughout society.

The 2020 research bill focused on five global challenges, of which "Climate and the environment" is one. The national research programmes represent one of the fundamental instruments for fulfilling the government's goal of meeting the priority challenges both in Sweden and around the world. The programmes aim to "coordinate research in a single field, create ties with higher education and provide a link to international research partnerships".³⁴ The programmes also intend to enable interdisciplinary, cross-sectoral collaboration. In addition, the national programmes, like all other research funding in Sweden, are expected to improve the quality of research, promote gender equality, and increase collaboration and real-world impact.³⁵

Further instructions on the national research programmes' contributions to research policy are set out in the mandates to the relevant implementing public authorities. In Formas' commission from 2017 to establish a national climate research programme, it was emphasised that the level of ambition must be raised in terms of compiling existing research, communicating research results and

29. <https://www.sverigesmiljomal.se/miljomalen/> (2 September 2021).

30. Reduced climate impact – Sweden's environmental objectives (sverigesmiljomal.se) (25 August 2021).

31. Reduced climate impact – Sweden's environmental objectives (sverigesmiljomal.se) (25 August 2021).

32. Generation goal – Sweden's environmental objectives (sverigesmiljomal.se) (2 September 2021).

33. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden, p. 13.

34. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden, p. 65.

35. These areas were highlighted and received follow-up interim targets for the period 2017-2026 in Govt Bill 2016/17:50: Collaborating for knowledge – for society's challenges and strengthened competitiveness.

ensuring real-world impact.³⁶ Climate research was also identified as an important foundation for achieving climate policy goals.

As the government underscored in its 2020 research bill, the national research programmes should serve as a link to international research collaborations. For example, the programmes can take into account and leverage the opportunities available to seek synergies with EU cooperative initiatives. These include Horizon Europe's missions, for example, which aim to support research and innovation that can promote profound transformation.

2.3 Links between policy objectives and programme goals

Climate policy objectives in Sweden, the EU and around the world share several common features involving rapid emission reductions, a shift away from fossil fuels, negative emissions and climate adaptation, and a belief that climate efforts must take place in harmony with broader sustainability efforts in an inclusive way. Ideas for a profound transformation can be found in the 2030 Agenda, in Swedish climate policy documents such as the bill "A coherent policy for the climate" and in research policy through Horizon Europe. These ideas have laid the foundation for developing the programme's goals (see section 1.1, "Programme goals and purpose").

We have crystallised these goals into six key themes and four cross-cutting perspectives which represent the programme's focus. They are described in more detail in Chapter 4. The types of activities for achieving the programme's goals are described in more detail in Chapter 5.

36. Government decision M2017/01282/Mm, Commission to establish national research programmes on climate and on sustainable spatial planning.

3. Swedish climate research – an overview

Climate research is a broad field. It encompasses the climate system and climate changes, impacts and adaptation, as well as the reduction of greenhouse gas emissions. Climate research is funded not only by several Swedish research funding organisations and expert agencies, but by municipalities, county councils, private and public foundations, and private financiers from industry and the EU, as well as by other international organisations. A comprehensive description of Swedish climate research is thus not easy to produce, either in terms of content or funding. This chapter aims to highlight the role and direction of state research funders in particular and to provide a global outlook focusing on Horizon Europe, the EU framework programme for research and innovation. We conclude the chapter with a reflection on trends in climate research that are important to the strategic direction of the National Research Programme on Climate.

3.1 Swedish climate research funders

One of the programme's goals is to actively encourage synergies and collaboration among funders of climate research and innovation. The programme's committee includes a number of Swedish research funding organisations identified as especially relevant to the field, all but one of which is state-owned.

This section provides a general description of the role of these funders in the research and innovation system, with a focus on their funding activities for climate research. The scope of their activities is therefore much broader than in our descriptions.

We begin by describing the largest Swedish state funding organisations. These funders are also responsible for other initiatives that the 2020 research bill identified as vital for the national research programmes to relate to, such as the government's strategic collaboration programmes, the strategic innovation programmes and other national research programmes. Next, we offer an overview of other government agencies and research foundations that play a key role in funding Swedish climate research. Our selection focuses on organisations that are part of the programme committee established to support the programme's activities and that can promote synergies and coordination of Swedish climate research.

The Swedish Research Council is Sweden's largest research funding organisation and provides support for research of the highest scientific quality across all scientific disciplines. It supports Swedish research by providing 6.8 billion kronor in annual funding.³⁷ Most of the funds go to basic research projects whose focus can be freely chosen by the researcher. The Swedish Research Council's funding for climate research is distributed primarily through open annual calls for research projects but also through subject-oriented and career-oriented support, as well as in calls for environmental and collaboration funding and bilateral research collaboration. To offer the best conditions for Swedish climate research, the Swedish Research Council funds infrastructure both in and outside Sweden, such as research facilities,

37. Appropriation directions for budget year 2021 for the Swedish Research Council, Ministry of Education and Research, U2020/06608 (partially) U2020/06666, 17 December 2020.

measuring instruments, databases and large-scale computational tools. The Council established two national research programmes in 2017 (one on migration and integration and one on antibiotic resistance) and was tasked with establishing four additional national research programmes with the 2020 research bill (on viruses and pandemics, crime, segregation, and the consequences of digitalisation).

Vinnova is Sweden's innovation agency and is tasked with bolstering Sweden's innovation capacity and contributing to sustainable growth. For 2021, Vinnova's block grant for research and innovation is 3.4 billion kronor.³⁸ As of 2021, the majority of Vinnova's activities take place in ten priority areas. Five of these address priority challenges and the rest concern innovation capabilities. The 2030 Agenda is a benchmark for all ten areas, with a special focus on aspects of climate change. Vinnova is the national contact authority for the EU's framework programme for research and innovation, and it is tasked with strengthening Swedish participation in the programme including within the climate field. It is one of three agencies that run strategic innovation programmes, and it is responsible for 14 of 17 programmes. The agency has also been tasked with leading and coordinating the government's strategic collaboration programmes, one of which addresses industry's climate transition. In addition, Vinnova is involved in several other relatively broad programmes, such as Challenge-Driven Innovation, and a research mission in financial markets that includes climate change and sustainable development.

Formas is a government research council that provides nearly 2 billion kronor in annual funding for research and innovation within the environment, spatial planning and land-based industries. Across all of Formas' activities, the research is assessed on the basis of both scientific quality and real-world impact. In addition to the National Research Programme on Climate, Formas also funds much climate research through its biggest call – the annual open call. In this call, which is fully research-initiated, researchers themselves propose their own research ideas within Formas' areas of responsibility. The review panel in the annual open call that assesses climate research proposals predominantly funds research in the natural science research, but also in technology, the social sciences and humanities. Climate change is often a focal point in other Formas calls. The agency also funds innovation through the strategic innovation programmes and other initiatives. Formas has established three additional national research programmes for sustainable spatial planning, food, and oceans and water.

The Swedish Energy Agency pursues society's transition to a sustainable energy system. It has both a governing and expert advisory role. Its annual energy research appropriation is about 1.5 billion kronor, and the agency supports research, innovation and business development in energy-related areas, conveys facts, knowledge and analyses, produces statistics and forecasts, runs networks and participates in international climate efforts.³⁹ The Swedish Energy Agency is involved in strategic innovation programmes with representatives from Viable Cities and RE:Source. The agency is also in charge of the Green Industry Leap and research programmes with close ties to the field of climate change, such as Human, Energy Systems and Society (MESAM) and Research and Innovation for a Sustainable Bio-Based Society (Bio+).

38. Appropriation directions for budget year 2021 for Vinnova, N2020/03087, N2020/03061 (partially), N2020/00489, etc., 17 December 2020.

39. Swedish Energy Agency's 2020 Annual Report.

Forte promotes and supports research in the areas of health, working life and welfare. Its research areas are central to socially sustainable development, which must be integrated in the climate transformation and build knowledge for the implementation of the 2030 Agenda. Each year, Forte provides approximately 800 million kronor in funding for both basic research and needs-driven research. The agency is also responsible for the national research programmes on working life, applied welfare research and mental health.

There are also several government agencies with smaller budgets for research funding that have an important role to play in the system and that serve as valuable partners in the programme's efforts to achieve synergies in the field of climate change.

The **Swedish Environmental Protection Agency** develops and implements environmental policy. Through its environmental research appropriation, it funds needs-driven, evidence-based research of high scientific quality and practical environmental application with an annual budget of 94 million. These funds support both the Swedish Environmental Protection Agency and the Swedish Agency for Marine and Water Management. The **Swedish Agency for Marine and Water Management** participates in the EU research project Banos, which has developed a new research agenda for the North Sea and the Baltic Sea that focuses on climate change, as well as in other maritime and water-related partnerships under the EU's research programmes. The agency also conducts a regular survey of research gaps resulting from its missions. **Sida**, the Swedish International Development Cooperation Agency, works to build up research capacity in low- and middle-income countries, supports regional and global research institutions, and promotes research that can improve the conditions of people living in poverty by participating in funding calls that researchers in low- and middle-income countries can apply for. The Swedish Polar Research Secretariat coordinates and promotes Swedish polar research by arranging and supporting research expeditions to the polar regions and by being responsible for research infrastructure and conducting calls. The **Swedish National Space Agency** also funds research relevant to the programme, such as atmospheric and climate research, as well as infrastructure that enables national and international space activities in Sweden.

The government has also established several research foundations, including **Mistra**, the Foundation for Strategic Environmental Research, which is especially relevant for the climate programme. Mistra funds long-term investments of four or eight years through programmes for interdisciplinary research collaboration and for public–private partnerships, with an annual budget of roughly 200 million kronor.⁴⁰ In addition, climate research is financed through a wide range of other public and private research foundations as well as by county councils and municipalities.

3.2 Global outlook with a focus on Horizon Europe

Climate research is often conducted in global partnerships and is funded by various international organisations and funders. Globally, the Belmont Forum is a vital multilateral network where research funders, national science councils and regional

40. www.mistra.org/en/about-mistra/how-we-work

associations work together to support transdisciplinary research that can address global climate and environmental change. For researchers operating in Europe, the EU Framework Programme is one of the main sources of international funding for research and innovation. In the Nordic region, collaborations are run within NordForsk and Nordic Forest Research (SNS). In light of the EU's significance for funding Swedish climate research, this section will focus on the EU's ninth framework programme, Horizon Europe, to be implemented during 2021–2027.

Horizon Europe builds on Horizon 2020, although some important changes have been made to promote greater impact on research and innovation, the strengthening of international cooperation, and increased openness and citizen participation.⁴¹ To promote these objectives, the EU has made some changes that allow more stakeholders to receive funding, for example. It has also launched a new initiative around missions. All in all, these changes are expected to help Horizon Europe fulfil the vision of a prosperous, just and sustainable society.

Horizon Europe's overarching goals are to help strengthen sustainable growth and competitiveness in Europe, tackle climate change and promote sustainable development worldwide. It has a planned budget of 95.5 billion euros for the period 2021–2027.⁴² Of this, 35% is earmarked for contributions to the climate transition.

Horizon Europe has three main pillars: (1) Excellent Science, (2) Global Challenges and European Industrial Competitiveness, and (3) Innovative Europe. Most of the partnership programmes and missions fall under pillar 2. Pillar 2 has six clusters that focus on broad global challenges, two of which are specifically linked to the climate: cluster 5 on climate, energy and mobility, and cluster 6 on food, bioeconomy, natural resources, agriculture and environment. In addition, pillar 2 includes a horizontal element focusing on broadening and strengthening the European Research Area (ERA).

Missions are a new instrument in Horizon Europe whose goal is to help solve major global challenges. Five missions have been established, and two of them – climate adaptation and climate-neutral cities – are closely linked to the climate, as are the missions for ocean protection and food security.⁴³ Each mission will include various activities ranging from research to policy measures and legislation. They aim to contribute to meeting policy objectives such as the EU Green Deal and the 2030 Agenda.⁴⁴

In Horizon 2020, Sweden was one of the ten most successful countries in the framework programme. During that year, Swedish organisations received 3.4% of all funding awarded in Horizon 2020 and were especially competitive in the climate sub-programme, with a grant award share of 4.2%.⁴⁵ The Swedish government has high expectations on Sweden continuing to be a successful nation in Horizon Europe. The government also stressed in its 2020 Research Bill that the challenges clusters and missions focus on are well-aligned with the challenges the government has identified as central. The National Research Programme on

41. "Gathering power for Horizon Europe: Proposal for a national strategy for stronger Swedish participation", Vinnova report VR 2020:12, p. 8.

42. Horizon Europe, European Commission (europa.eu) (20 June 2021).

43. The five missions are: (1) Cancer, (2) Adaptation to Climate Change, including societal transformation, (3) Climate-Neutral and Smart Cities, (4) Restore our Ocean and Waters and (5) A Soil Deal for Europe. See Horizon Europe on the European Commission website at europa.eu. (2 September 2021).

44. Missions in Horizon Europe, European Commission (europa.eu) (20 June 2021).

45. Horizon 2020 – Yearbook 2020: Swedish participation in European programmes for research and innovation, 2021, Vinnova report VR 2021:07.

Climate therefore monitors opportunities and seeks synergies with initiatives at the EU level.⁴⁶

3.3 Trends in Swedish climate research

In the first version of the agenda for the National Research Programme on Climate, a review of Swedish climate research was performed that included previous surveys, analyses and reviews of Swedish climate research.⁴⁷ Since climate research is a broad and complex field that defies easy categorisation, estimates of past funding for climate research are rough ones.

However, the first agenda pointed to a number of trends in Swedish climate research funding that laid the groundwork for the programme's focus. In its 2020 research bill, the government states that the programme's initial focus should be maintained and expanded upon. This agenda is therefore also based on these trends, which can be summarised in three key points: (1) the need for more interdisciplinary science, social sciences and humanities, (2) the need for a holistic perspective on the climate transformation, and (3) the exploration of challenge-driven research and innovation. Since the first agenda was written, a fourth trend has emerged that focuses on transformative change.

1. Need for more interdisciplinary research, social sciences and humanities

Science and technology research has long dominated the broader research landscape, and climate research is no exception. Of the climate research funded in 2010, 90% was assessed to be science and technology research.⁴⁸ In recent years, demands from politicians both in Sweden and the EU have intensified for strengthening interdisciplinary and cross-sectoral collaboration as well as the humanities and social sciences.⁴⁹ For example, the Swedish Research Council has been tasked with providing funding for Swedish graduate schools in the humanities and social sciences, areas that are seen as vital for addressing global challenges and for interdisciplinary research and innovation.⁵⁰ The importance of the humanities and social sciences as well as interdisciplinary research was also highlighted in the report Formas produced for the government in 2015, which served as input to Sweden's research policy for the period 2017–2027.⁵¹

2. Need for a holistic approach to the climate transformation

When the programme's first agenda was produced, a survey of ongoing climate change efforts was conducted. The results revealed that an estimated 70% of funding from eleven major Swedish research funding organisations was used for initiatives that focused on emission reductions. Emission reduction efforts had primarily taken place within transport and energy. The remaining 30% had been distributed relatively evenly between climate adaptation and climate processes or

46. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden; "Gathering power for Horizon Europe: Proposal for a national strategy for stronger Swedish participation", Vinnova report VR 2020:12.

47. Research for meeting the challenges of climate change: Strategic agenda for the National Research Programme on Climate, Report R6:2018, Formas 2018.

48. "Swedish climate research – what are the Swedish costs and effects?", Swedish National Audit Office, RiR 2012:2.

49. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden; Horizon Europe Strategic Plan (2021–2024), European Commission 2021.

50. Govt. Bill 2020/21:60: Research, freedom, future – Knowledge and innovation for Sweden, pp. 58–9.

51. En hållbar framtid genom stark forskning och utveckling: Ett underlag till Sveriges forskningspolitik 2017–2027, Formas 2015.

models.⁵² These estimates were also in line with the Swedish National Audit Office's review of Swedish climate research from 2012.⁵³

In the work on the agenda, requests were put forward to emphasise a holistic perspective on the climate transformation. This includes system perspectives that take into account interactions among different kinds of natural and societal systems. In the climate efforts, the entire sustainability agenda and 2030 Agenda need to be considered. Synergies can also be sought between emission reduction measures and climate adaptation.

3. Exploring challenge-driven research and innovation

Funding for research and innovation has become increasingly challenge-driven in nature. This means that the issues are based on an identified challenge facing society. Major broad research programmes, which were previously rare in Swedish research policy, have been given even greater scope in the 2020 research bill. The Swedish national research programmes are one example. The trend towards challenge-driven research is also evident in the EU's new Horizon Europe framework programme, with its clusters and five key missions. Challenge-driven research has made its way along the entire traditional scale, from basic research to applied research, development and innovation. For example, in its review of scientific research, the Swedish Research Council notes that research-initiated basic research is increasingly focused on major global challenges, a trend particularly clear in climate research.⁵⁴ Även Formas also describes a trend towards more theme-based financial instruments rather than disciplinary-specific ones.⁵⁵

Since the first agenda was written, a fourth major trend on **transformative change** has had an impact on sustainability issues, policies and research funding. Transformative change includes ideas about profound shifts in individuals and communities to sustainable development. Transformation is ultimately about reshaping society and the way it is organised – socially, culturally and in practice. Working towards transformative change requires continuous, integrated processes for knowledge-building, innovation and reflection. In the 2019 Climate Policy Action Plan, the government states that the climate issue will require decisive actions and will entail a long-term, controlled systemic change,⁵⁶ which aligns with the ideas of transformative change.

3.4 Strategic direction of the programme

Climate research is funded by several Swedish and international research funding organisations. Because of this diversity, the funding system can be perceived as fragmented.⁵⁷ However, it can also be seen as a consequence of the different research funders' various roles and focus areas, some of whom primarily focus on basic research, needs-driven research or innovation, while others span the entire scale. Either way, there is a need for coordination in Swedish research funding, which the national research programmes are expected to support. The

52. Research for meeting the challenges of climate change: Strategic agenda for the National Research Programme on Climate, Report R6:2018, Formas 2018.

53. "Swedish climate research – what are the Swedish costs and effects?", Swedish National Audit Office, RiR 2012:2.

54. Research overview 2019: Natural and engineering sciences: trends, impact and challenges, Swedish Research Council, VR1905, s.7.

55. En hållbar framtid genom stark forskning och utveckling: Ett underlag till Sveriges forskningspolitik 2017-2027, Formas 2015, p. 13.

56. Govt Bill 2019/20:65, A coherent policy for the climate – climate policy action plan, p. 8.

57. En hållbar framtid genom stark forskning och utveckling: Ett underlag till Sveriges forskningspolitik 2017-2027, Formas 2015.

national research programmes can thus help to mobilise forces in urgent areas, while serving as complementary components of the research system as a whole.

The programme also relates to the four above-mentioned trends in Swedish research funding. These trends underpin the overall orientation of the programme and its themes and perspectives described in the next chapter.

The programme aims to do the following:

- Promote interdisciplinary research, the social sciences and humanities
- Support a holistic perspective on the climate transformation through, for example, system perspectives and linkages between climate change and the 2030 Agenda
- Explore challenge-driven research and innovation, using different forms of financial instruments and encouraging a diversity of research approaches and perspectives that promote a broad understanding of the complexity of the climate challenge
- Design actions that stimulate transformative change.

4. Programme themes and perspectives

This strategic research agenda is based on analyses of previous research funding in the field of climate change, the knowledge needs of stakeholders, and climate policy and research policy objectives. During the process of developing the agenda, we established an overall direction for the programme. This direction intends to stimulate interdisciplinary research, the social sciences and humanities in order to gain a holistic view of the climate transformation and a diversity of research approaches and perspectives, as well as to promote transformative change. These main features are the basis of the themes and perspectives that set the direction of the National Research Programme on Climate. Figure 1 illustrates the programme's goals, themes and perspectives.

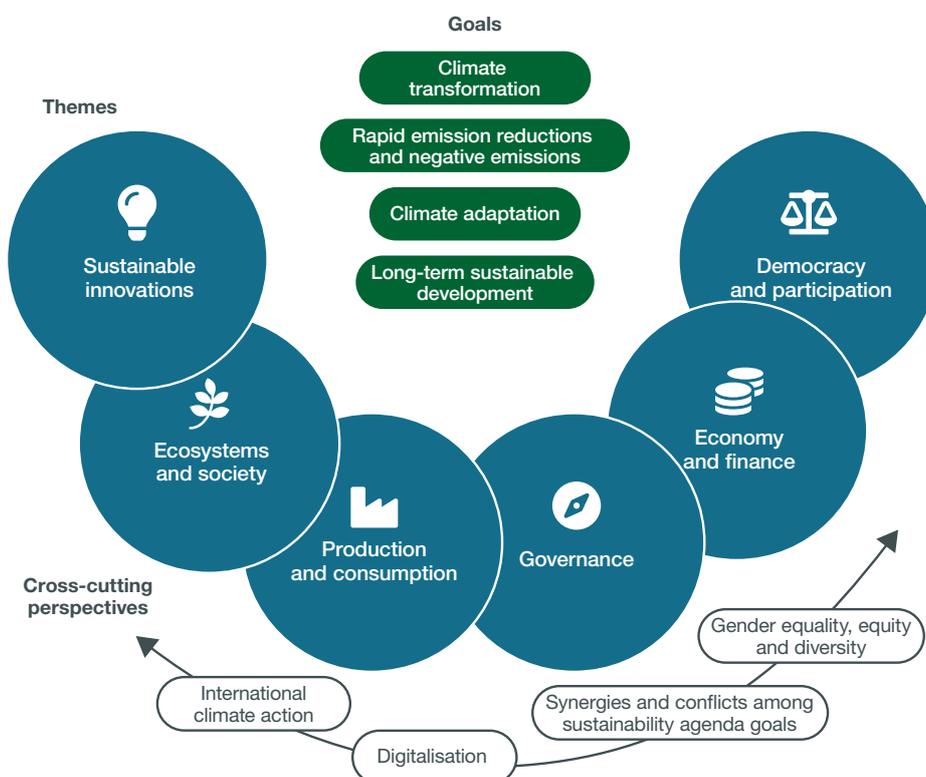


Figure 1. The programme's goals, themes and perspectives.

The six themes have been identified as crucial for the agenda, while the four perspectives were highlighted in the government's commission to set up the programme and are of a more general nature for sustainability efforts. The six themes and the four perspectives should be viewed as parts of a whole with strong synergies and links among them. These links will be used in various ways when designing programme activities, including research and innovation funding calls. For each theme, there are subheadings that describe the expected effects of knowledge-building in the area. A description under each subheading states the challenges identified in each area.

Some themes include challenges that closely relate to those in other national research programmes. For example, the national research programmes for sustainable spatial planning and for food also address issues around climate adaptation and sustainable production and consumption, respectively. This is intentional and reflects the systemic nature of the challenges. In areas with particularly strong links, the programmes interact in calls and other initiatives.

The themes relate to the programme goals presented in Chapter 1 and are relevant from both a national and a global perspective. Overall, the programme's themes and perspectives are expected to help meet the overarching goals of the National Research Programme on Climate.

4.1 Theme: Sustainable innovations for climate efforts

This theme is about innovations in a broad sense, whether organisational, policy-oriented, social or technological. Research on support and conditions for climate-related innovations, such as policy decisions and early involvement of users in the innovation process, is also included. System perspectives and a contextual understanding of where, when and how different types of innovations can make an impact are included, as well as the short- and long-term effects of different measures.

Sustainable innovations for emission reductions

Innovation can play an important role in the climate transformation. This is true both for innovations that aim to reduce emissions in new and faster ways and for innovations in other areas that integrate climate considerations and can achieve a major impact. Innovation and advances in technology take place in a broader context of culture, politics and economics, as well as in an ecological context. The nature of these innovations can vary and can be organisational, policy-oriented, social or technical. Research is needed on these different types of innovations and how they interact with each other. Future scenarios, visions and risk perspectives around innovations are also included, for example as linked to policy innovations or technologies for carbon uptake, negative emissions or other challenges. The significance of other crises for climate innovations is also covered in this theme, as well as how innovations for emission reductions interact with broader sustainability efforts.

Communities preparing for climate change

Preparing cities, communities and individuals for inevitable climate changes, such as shifting precipitation patterns, heat waves and rising sea levels, requires research on innovations and ecosystem solutions within the built environment, infrastructure, and agriculture and forestry, as well as more streamlined work-flows and processes in both the public and the private sectors. We also need new ways to communicate with citizens and get them involved in the processes of developing, testing and learning from different activities. Solutions developed in countries that have long lived with extreme weather can be leveraged by other countries that will have to adapt their own communities to a changing climate. Research on a contextual understanding of where, when and under what circumstances different types of innovations are adequate is also included.

4.2 Theme: System-integrated knowledge of climate change, ecosystems and society

This theme highlights human–environment interaction, complexity in the climate system and the effects of climate change as well as the links between the climate goals and other sustainability goals, both in Sweden and worldwide. Risk perspectives and strengthened preparedness for addressing climate risks are also included in the theme. System perspectives, feedback mechanisms and long-term effects need to be included, as well as the link between climate change and biodiversity loss on land and in water.

Increased understanding of climate change and its effects

We need to better understand the effects of climate change and climate action on habitats, from both a national and a global perspective. Research describing the functioning of the climate and the effects of climate change in ecological and social systems is needed to understand questions like how regional changes link back to the climate system and how these effects drive or mitigate further change. This can also provide knowledge about the effects of climate change on ecosystems, human living conditions, and the built environment and critical infrastructure, and how these effects relate to social, cultural, economic, environmental and political processes as well as feedback mechanisms between them.

Strengthened preparedness for climate-related risks

Different geographical areas and diverse groups in society are impacted in various ways by climate change. Research is needed about the direct and indirect effects of climate change on ecological and social systems, how risks and vulnerabilities interact with social and economic structures in society, and how risks are understood, defined, valued and prioritised. This research can provide a basis for spatial planning, crisis preparedness, nature conservation and international efforts. Research is also needed on the links between climate-related changes, peace and security, and climate-driven migration. Links between climate change and health issues in Sweden and abroad are also included, such as the increased spread of infectious diseases and health risks related to extreme weather events like heat waves, floods, droughts and water shortages. Contextual perspectives are vital for understanding the vulnerability and exposure of different groups to the direct and indirect effects of climate change as well as climate action.

Climate efforts around biodiversity and ecosystems

Biodiversity loss and human-induced climate change raise fundamental questions about the relationship between humans and nature, which includes aspects such as norms, cultures and history. There is also a complex interaction between biodiversity and a changing climate, so we need more knowledge about central feedback mechanisms and how they can be managed, ecosystem services, the effectiveness of different measures and other topics. Research needs in this area include how to understand and manage goal conflicts regarding the role of forests in the climate transition, how carbon is captured and stored in natural environments like forests, agricultural land and wetlands is related to biodiversity, and how to design measures and incentives to increase carbon sequestration. We also need more knowledge about how efforts to achieve the climate goals can be linked to the goals of biodiversity and well-functioning ecosystems on land and in water, and what this means for long-term sustainable development.

4.3 Theme: Production and consumption in line with the climate goals

This theme addresses the need for a shift in production and consumption patterns in order to respond to climate challenges, reduce emissions and contribute to a sustainable use of resources. It addresses how different actors, from both the private and public sectors, are addressing and contributing to the transformation, as well as climate ethics, changing norms and consumption behaviours.

Reduced emissions through resource efficiency and a circular economy

Limiting greenhouse gas emissions in line with national and global climate goals demands a radical change in people's use of resources. Goods and services generate emissions not only when a product is used but over its entire life cycle – from product design and extraction of raw materials through to waste management. Production and value chains are often complex and extend beyond national borders. There is a need for in-depth knowledge about what these production and value chains look like as well as how emissions and production resource use can be reduced, potentially through circularity, longer product lifespans, and the switch from product ownership to shared services. This theme includes studies of entire systems as well as studies of organisations, policy instruments and behaviours. Research on rebound effects, by which resource efficiency frees up financial resources that can generate additional environmentally damaging consumption, is also included. Also under this theme are notions and beliefs about resource-efficient communities and the pathways to achieve them.

Strengthened resilience to the effects of climate change on production and consumption

In parallel with efforts to reduce emissions, a climate adaptation perspective on consumption and production issues is needed. Resilience and crisis preparedness must be strengthened to address production disruptions potentially brought on by climate change that can impact supply chains for food and other essential goods and services. The climate transformation can entail a major restructuring of society. We thus see a need for more knowledge about the direct and indirect effects of climate change on production, distribution and logistics, as well as how they can be predicted, prevented and managed. Knowledge is also needed about how different actors and organisations, both private and public, national and international, can develop their capabilities to address and adapt to climate change's direct and indirect effects.

New consumption patterns in line with the climate goals

Both private and public consumption make a major impact on the climate through the production of the goods we consume. Changing our consumption patterns and overall consumption levels requires an understanding of the needs and functions that different actors believe they should fulfil. Research is needed on how climate and environmental impact can be reduced from the goods and services procured by the public sector and purchased by private-sector players. There is also a need for research on the importance of private consumption and marketing to people's perceived needs, health, well-being and perceptions of a good life, which can include questions about climate and altered views of consumption. Here, it is important to examine the role of norms, values,

attitudes and habits, both in consumption behaviours and in the choice not to consume. The theme also includes questions about the impact of the platform economy on the climate and measures that enable people and organisations to make sustainable choices regarding food, travel and transport as well as residential, retail and office spaces.

4.4 Theme: Governance for addressing the climate challenges

This theme involves governance, institutions and leadership that can promote the transformation needed to achieve the climate goals. It includes research on decision-making at different levels and organisations and on the effects of climate actions and power structures, as well as instruments and supporting institutions, formal and informal, that can help society achieve the established climate goals. The theme also involves the study of policies and mechanisms that hinder the climate transformation, goal conflicts, and the effectiveness of measures taken.

Decision-making for societal change

Decision-making that has a bearing on the climate transformation takes place at all levels of society, from local and regional to national and global, and involves many different actors, public as well as private. Synergies and conflicts of goals within and between different sectors and policy areas must be analysed and followed up in order to achieve an effective transformation that can realise the climate goals while taking into account other sustainability goals, such as biodiversity. This includes research on roles and relationships between governmental and non-governmental actors, and on the opportunities for, and effects of, institutional reforms nationwide and worldwide. A better understanding of leadership, decision-making and various forms of support and mechanisms is needed that can ultimately also promote change among actors. Research in this area also includes how the climate challenge is described, explained and understood in different contexts, as well as how different actors and interests put knowledge of our climate challenges into practice or oppose it.

Targeted measures for climate action

Within the theme there is also a need for more knowledge about climate-related decision-making processes and various policy measures – individually or in combination – that can contribute to emission reductions and to society's adaptation to a changing climate, both nationwide and worldwide. This includes research on new kinds of policy instruments and the effectiveness of various measures for meeting the requirements for emission reductions from a system perspective. There is also a need to follow up and evaluate measures, and to study how different sectors and social groups support or oppose measures taken. We also need research into the new forms of legislation that are emerging and the impact of various legal processes aimed at supporting the climate transformation and biodiversity conservation. Cost-benefit analyses of different policy instruments and their added value are also part of the theme, as are analyses of redistribution effects and other consequences of different possible choices and policy instruments for limiting carbon dioxide emissions.

4.5 Theme: Economic and financial drivers for climate action

This theme is about how the financial system and different types of investments can contribute to the transformation, as well as the role of economic instruments and the entire economic system in climate change. The theme includes research on investment patterns in the public and private sectors as well as the allocation of climate risks, rights and obligations. The critical examination of perspectives on the economic system's role in climate efforts is also included.

Shifting financing and investment patterns

The world needs to shift away from investments that cause major greenhouse gas emissions and instead steer financial flows towards investments in zero-carbon technologies and other emission-reducing measures. For example, there is a need to better understand the financial market's willingness to invest in zero-carbon operations, green financial instruments and the EU taxonomy for sustainable investments. A need also exists to better understand how the portfolios of financial players match evidence-based climate goals. Investment patterns in other areas of the public and private sectors must also be better understood, as must the allocation of climate risks, rights and obligations in order to bring about the investments needed. Here, economic instruments can play a vital role, as well as the effects of various subsidies on transition efforts, as both an enabler and an aggravating factor. Research on economic climate action, both existing and not yet proven, is important with regard to topics like emissions trading, climate tariffs, the removal of fossil fuel subsidies and incentives to increase carbon sinks. In addition, issues related to the financing of measures that reduce vulnerabilities and increase resilience in communities and ecosystems will become increasingly important. Examples here include how funding and division of responsibilities are designed for Sweden's climate adaptation efforts and how financial resources for climate adaptation are mobilised and distributed globally.

The economic system enables a fundamental climate transformation

The relationship of the economy to climate change is complex. It can involve all or part of an economic system and its consequences for the climate. Economic activity often entails an environmental and climate burden, but various actors can also use profitability and growth as driving forces for achieving the climate transformation. Economic policy instruments can play a key role in correcting market failures and removing other barriers that hinder the transformation, and they need to be understood in their social, political and institutional contexts. Analysing combinations of economic and other types of instruments and their consequences is especially important. Furthermore, uncertainties arising from climate change, such as potential threshold effects, should be integrated in economic models and decision-making. An economic evaluation of climate benefits can be part of the theme, but research is also needed that critically examines and highlights the economy's basic assumptions, methods and approaches and its role in society's climate efforts and the sustainability goals in general. This includes reassessing and proposing alternatives to existing assumptions that can enable the climate transformation and long-term sustainable development.

4.6 Theme: A democratic and just climate transformation

The theme of a democratic and just climate transformation deals with issues of fairness and democracy, including efforts to reduce climate-impacting emissions and to adapt communities to a changing climate. The theme includes both ethical issues and issues of representativeness, power and accountability. Intergenerational perspectives are also included.

Climate justice between and within countries

There is a need to better understand how efforts to achieve the climate goals can be shared fairly both between and within countries. This includes questions about how the countries that have emitted the most carbon dioxide so far – historically and in the present – can support other countries that are already heavily impacted by the effects of climate change, how high-income countries and emerging economies can take responsibility for and reduce their emissions, and how global cooperation can be designed to promote fairness in global climate action. Questions here include how justice is understood and can be promoted, as well as power, representativeness and accountability. The effects of transformation efforts from a system perspective should be studied, as well as how negative side effects can be avoided. Ethical issues of global justice, human security and ecosystems are also included. The underlying reasons for conflict and migration can be highlighted in this theme, which includes analyses of unequal distribution of resources, institutional capacity and vulnerability to the effects of climate change.

Democracy and justice in climate efforts

There is a need for research on the differences between different individuals and groups in terms of accountability for greenhouse gas emissions, vulnerability to the effects of climate change, and opportunities to influence one's own situation and the surrounding community. This can cover research on individuals' emissions linked to income, how climate risks and disasters affect different groups and individuals differently as a result of, for example, economic inequality, gender and age, or research on which groups' experiences and perspectives that are represented in climate efforts. The theme also encompasses research on various challenges for urban and rural areas in terms of emission reductions and climate adaptation, as well as how measures affect different groups and how support, acceptance and legitimacy are understood and can be obtained. Power perspectives are also included, as well as the role of expert authorities and democratic decision-making.

4.7 Cross-cutting perspectives

In addition to the six themes already presented, four perspectives have been identified as particularly relevant for the themes of the National Research Programme on Climate. The perspectives can provide valuable insights into the agenda's themes. In the activities initiated by the National Research Programme on Climate, studies combining themes and perspectives will therefore be encouraged. Examples of such studies include applying a gender perspective to climate action innovations, an international perspective on production and consumption, or a digitalisation perspective on justice and democracy in the climate transformation. The four perspectives are: global climate efforts; digita-

lisation; synergies and conflicts in the sustainability agenda; and equity, gender equality and diversity. They are described below.

Global climate efforts

The climate transformation takes place across many levels of society: globally, on an intergovernmental basis, nationally, regionally and locally. Climate change research should thus not be limited to Swedish research subjects, but should examine the interactions among these levels. An example would be how Swedish and European measures can have consequences in other countries. Knowledge is also needed about how global climate efforts affect Sweden or other parts of the world, how climate efforts can be promoted in different parts of the world, or how different countries affect and will be affected by climate change as well as the climate transformation. This can both provide new insights around the agenda's themes and enable mutual learning among actors and levels of society.

Digitalisation

The rapid advance of digitalisation in different sectors and areas of society creates opportunities as well as challenges for the climate transformation. Research on the programme's different themes should therefore take into account the drivers, potential and risks of digitalisation for achieving the climate goals. By taking into account the impact of digitalisation in society – social, cultural, legal and technical – good conditions for accelerating the climate transformation can be promoted. For example, there is much to explore due to the vast amounts of data generated today both in terms of opportunities and risks. The theme also involves the role of machine learning and artificial intelligence in climate efforts.

Synergies and goal conflicts in the sustainability agenda

Climate adaptation and the shift away from fossil fuels in Sweden must take place in interaction with the social and economic dimensions of sustainable development, and with the environmental dimensions that do not directly concern greenhouse gas emissions. Climate research therefore needs to study and address synergies and conflicts with the other sustainability goals in the 2030 Agenda, both in Sweden and worldwide. This also includes exploring how other sustainability goals will be affected if the climate goals are not reached. Research on synergies and conflicts in the sustainability agenda should take into account different temporal and spatial perspectives, including intergenerational perspectives

Equity, gender equality and diversity

Equity and gender equality based on factors like age, nationality, ethnicity, geographic location, income and function, are pivotal issues in the efforts to achieve the climate goals and other sustainability goals. Diversity and broad participation in climate efforts, with representation from more voices and interests, can influence how the work on adaptation and emission reductions is done. It can also be important for acceptance and mutual learning. Equity, gender equality and diversity are central tenets of a democratic, well-functioning society. Gender equality is a cross-cutting perspective in the agenda, in addition to being its own goal.

5. Programme implementation

This chapter describes how the National Research Programme on Climate is organised and how it is managed, followed up and evaluated. We also describe how funding calls are developed, how we approach communication and real-world impact, and what other kinds of activities are conducted within the programme.

The national research programmes are ten-year initiatives, and the strategic research agenda is regularly updated during the programme period. We regularly evolve the way we work through continuous learning in line with the instructions in our commission, which stipulate that the national research programmes should be conducted in a flexible format. The entire programme is conducted in collaboration among research funding organisations, research-performing organisations and other stakeholders, and is involved in a variety of grant forms and activities.

5.1 Organisation for collaboration

After Formas was tasked with establishing the National Research Programme on Climate, a programme committee was formed in 2017. The committee includes research funding organisations that are relevant for the programme's area. Most are government agencies with research funding mandates, but one non-governmental foundation is also included. The composition of the committee can change as necessary. The committee, which has an advisory role, assists Formas in its long-term programme planning, proposes and recommends the implementation of calls, provides access to expertise in the field, and helps to promote the visibility of the programme. The committee is led by a chair who is appointed by Formas' Director General. Up-to-date information on the committee members and chair is available under the Climate section of the Formas website.

A working group has also been formed for the programme. It consists of representatives from several, but not all, of the research funding organisations that are members of the programme committee. The working group supports the programme's ongoing activities. Dialogues with the working group can be about the calls or ongoing research relevant to the field in order to better coordinate operations, related government mandates or different areas in the programme's missions.

In addition to the programme committee and working group, a regular dialogue takes place between government officials and the funders who have government mandates to establish national research programmes, Formas, Forte and the Swedish Research Council. This dialogue takes place at both the strategic and operational levels.

In addition to these formalised types of collaboration, there is also a needs-driven dialogue with research-performing organisations and other stakeholders to support the programme's development efforts. Societal relevance is always a requirement in programme calls, but we also create calls that, for example, specifically aim to stimulate mobility between academic researchers and practitioners

and to promote the real-world impact of research results.

The programme works particularly closely with the other national research programmes that Formas is responsible for, including programmes for a sustainable spatial planning, food, and oceans and water. Through regular dialogue and a coherent development process, we have enabled mutual learning and method development in our initiatives and our calls. We conduct a lively dialogue and joint calls with other national research programmes and within the framework of international collaboration.

We have also produced a roadmap to support the programme's implementation. The roadmap describes the challenges that underpin the programme, the initiatives that must be implemented to meet these challenges, the expected results and long-term effects of these initiatives, and the goals these effects can help to achieve.

5.2 Programme activities

The programme's funds are distributed primarily through calls. The calls can be carried out within the programme or in collaboration with other Swedish or international organisations. We offer various forms of funding such as research grants, innovation grants or collaboration funding. The programme committee is involved in developing the focus for calls carried out within the programme. Formas' Research Council takes the decision to announce calls and determines the allocation of funds.

We regularly invite awarded project members to conferences and other events to help build knowledge and reach out to the broader society. Events can include kick-offs at the start of a group of projects, seminars during or after the projects, theme days and theme weeks. We also initiate and compile research reviews to highlight the state of knowledge and knowledge needs in key areas.

The programme implements activities in order to monitor and link the programme to international research funding, such as Horizon Europe and the Belmont Forum. We also work in collaboration with the other national research programmes to promote gender equality, research ties to higher education and the efficient use of research infrastructure.

5.3 Follow-up and evaluation guide future choices

In accordance with our commission, Formas follows up the programme each year and reports its status to the Government Offices. We continuously monitor the initiatives and activities implemented, including calls, projects and communication activities. Projects that are awarded programme funding become part of a project portfolio that serves as input for analysing which research has been funded and what priorities should be made in future initiatives. Funded projects are categorised according to the agenda's themes and perspectives.

Because the programme is long term, Formas conducts several formative evaluations during the programme period. An initial evaluation of Formas' three national research programmes starting in 2017 was conducted in 2020 to provide a basis for

streamlining and developing the programmes. Ramboll was tasked with investigating the suitability and effectiveness of Formas' three national research programmes in terms of organisation and governance since their inception.

Their evaluation reveals the following about the programmes.⁵⁸

- They are well on their way to being established as nationally unifying platforms in each research field.
- They have identified relevant research needs in collaboration.
- They have helped to improve research coordination and create relevant calls.

In order to enhance and continue these efforts, Ramboll recommends the following to Formas:

- Clarify roles, responsibilities and key processes in the programmes for all collaborating programme parties.
- Support and leverage the different roles of funders in the research and innovation system and create a learning experience around how this type of collaboration can be conducted.
- Find clearer models for involving the different stakeholders and end users.

The Swedish Research Council, Forte and Formas plan to carry out a mid-term evaluation of seven national research programmes for 2021–2022. The evaluation will review the potential of the programmes to achieve expected results and impacts as set out in each programme's strategic research agenda. This includes assessing how well each programme's design and initiatives correspond to its mission and objectives, as well as the added value the programmes bring to the research and innovation system. The evaluation is formative and is expected to make recommendations to further develop the programmes.

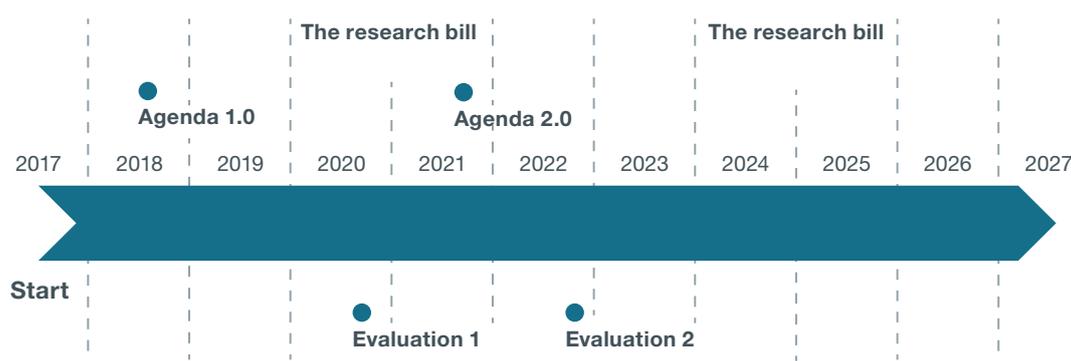
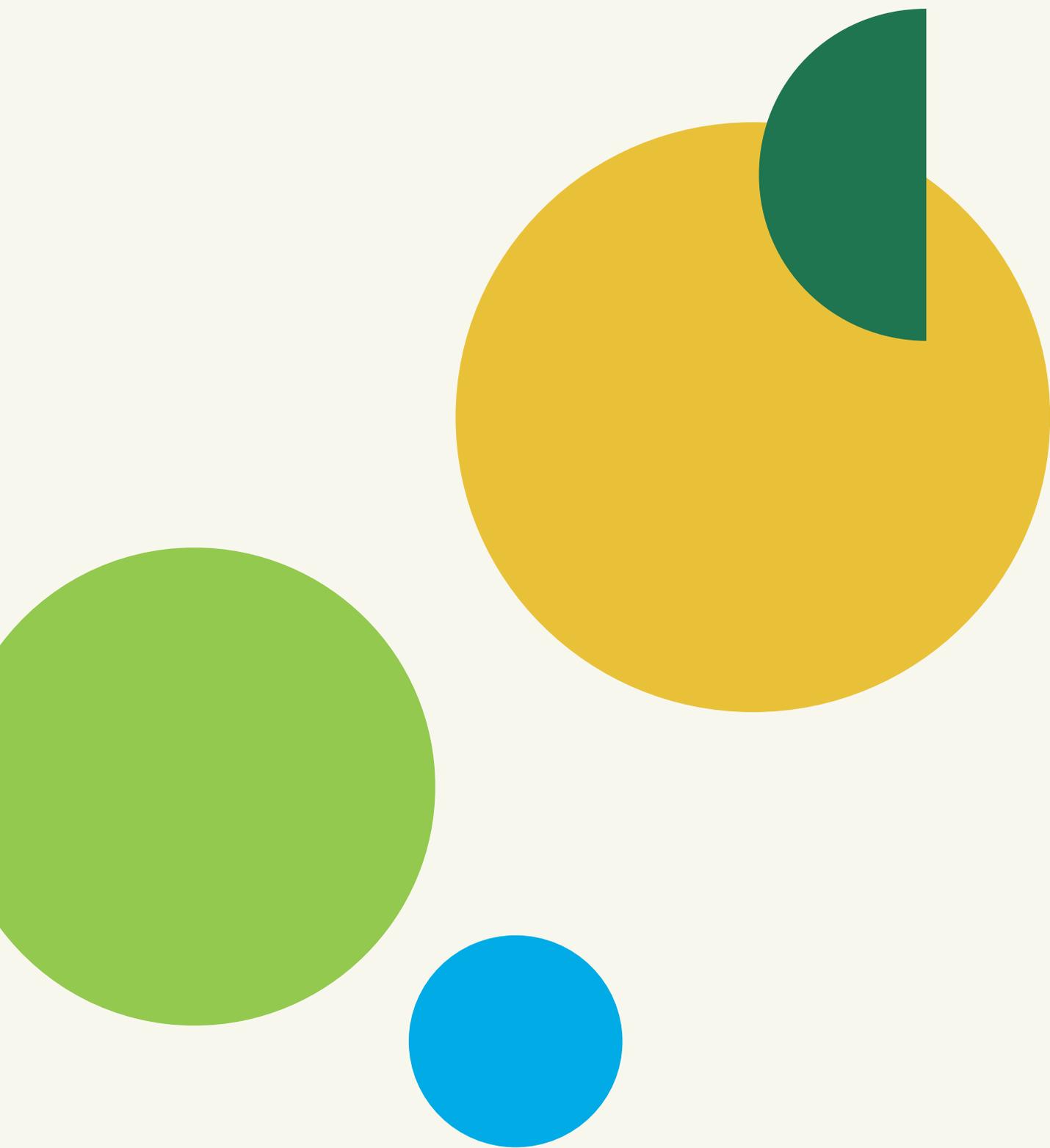


Figure 2 The overall timetable of the programme for establishing a new and revised agenda, and evaluations, in relation to research bills.

In the long term, a final evaluation is planned, with a focus on the impacts the programme has had on society's climate transformation and on the Swedish research system.

The strategic research agenda and programme roadmap will be revised during the programme period. Evaluations, research proposals, or major changes in the national or global business environment can be cause for making reprioritisations and revisions within the programme. When the agenda is revised, the research-performing organisations and stakeholders should be made aware of this. Formas' Research Council approves the revised agenda.



Appendix 1. Formas' commission

Excerpt from: Government decision I:12, 2017-05-18, Ministry of the Environment and Energy, Commission to establish national research programmes on climate and on sustainable spatial planning

The government's decision

The government tasks the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) with establishing national research programmes for climate and sustainable spatial planning, in accordance with the government decision of 18 May 2017 (ref. no. U2017/02404/F). The commission runs for ten years, through 2026. Formas shall also announce calls for special three-year grants to support research on social housing policy. Formas must annually report progress on the implementation of the national research programme commission to the Government Offices (Ministry of the Environment and Energy) when it issues its annual report.

Background

National Research Programme on Climate 2017–2026

Climate change is one of humanity's greatest challenges. It is also one of the government's top priority issues. As a result of climate change, the global temperature increase is estimated to be 3.2–5.4°C towards the end of this century compared with preindustrial times. The consequences of such a temperature increase are expected to be dramatic, with adverse effects on people, communities, ecosystems and the economy. In Sweden, the challenge of reducing emissions is particularly pressing in the transport, agriculture and base industries. Reducing human impact on the climate requires extensive transformation in Sweden, within the EU and globally. Research efforts are also needed to strengthen society's adaptation to a changing climate. We need more knowledge about carbon flows and carbon sinks in forests and farmland. Research and innovation efforts are needed in the energy system, industry, agriculture, forestry and aquaculture, land use, marine and coastal ecosystems, transport and the built environment, and production and consumption.

The need is great for research that has practical application, especially concerning how society can reduce emissions and adapt to climate change in an effective and inclusive way, while taking into account the individual's place in society. We must strengthen interdisciplinary research that considers user perspectives and studies of people's behavioural patterns, as well as the research and evaluation of policy instruments including their cost-effectiveness, not least at the EU level. We need a better understanding of the roles of different actors in driving the transition to a fossil-free society. Research is also needed to better understand climate-related processes, both nationally and globally. Swedish climate research continues to be well positioned to contribute to future IPCC reports, a vital contribution for Sweden as a research nation.

More about the commission

National Research Programme on Climate 2017–2026

Formas shall establish and launch a ten-year national research programme for climate research. The government believes that climate research represents an important basis for achieving climate policy objectives. The need for research

and innovation efforts to meet the climate challenge is set out in Bill 2016/17:50, “Collaborating for knowledge – for society’s challenges and strengthened competitiveness”. We need to increase our knowledge and develop solutions to enable Sweden to become a fossil-free welfare society and to be a leader in the global effort to realise the Paris Agreement’s ambitious goals and the 2030 Agenda sustainability goals. We also need research efforts to strengthen society’s adaptation to a changing climate. Achieving this requires both empirical scientific and interdisciplinary research, where science and technology are linked with research and knowledge in other sciences. We must also raise the ambition level when it comes to compiling existing research, and communicating and using research results. The programme can span the entire spectrum – from research, innovation and technological development to demonstration, market introduction and dissemination.



Ett forskningsråd för hållbar utveckling
A Research Council for Sustainable Development

Formas is a government research council for sustainable development. We fund research and innovation, develop strategies, and conduct analyses and evaluations. Our areas of activity are the environment, agricultural sciences and spatial planning. We conduct systematic reviews that aim to make it easier for Sweden to achieve our environmental goals. We also communicate about research and research results.

Forskningsrådet för miljö, areella näringar och samhällsbyggande, Formas
The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
Box 1206, SE-111 82 Stockholm, Drottninggatan 89
Phone: 08 775 40 00, E-mail: registrator@formas.se, www.formas.se