



The Department of Environmental and Life Sciences

# SELF-EVALUATION

Periodic Research Review

## Summary

The Department of Environmental and Life Sciences conducts research in three areas: (1) Ecology, Evolution and Sustainability, (2) Biology Education, and (3) Geomatics. Research in **Ecology, Evolution and Sustainability** is led by the strong research environment RivEM/NRRV, and it encompasses basic and applied research, with a particular emphasis on solving real-world problems related to ecological sustainability. Successful research on biodiversity, climate change, and ecosystem services (mainly with a focus on freshwater ecosystems) attracts substantial external funding from national and international funding bodies. The group strives to maintain its excellent publication record and strong impact on the surrounding community and engagement in top-quality research education as well as in Bachelor's and Master's programmes. Research in **Biology Education** focuses on practice-based education, development of theory and concepts in subject-specific education and education for sustainable development, with the overarching objective of becoming a top research environment at both national and international level. Biology Education strives to continuously secure external funding for research projects and maintain a strong publication record. The main objective of **Geomatics** is to develop a unique research profile in Sweden that is characterised by cross-disciplinary research within the fields of geoinformation science, sustainability, risk research and transformative human-climate-environment interactions and processes. Strategic recruitments, continuing professional development and establishment of an effective research team, network and environment are key elements. A timeline with consecutive steps towards reaching the goal of becoming a postgraduate discipline has been developed.

## 1. Long-term objectives and strategies

### Ecology, Evolution and Sustainability

The River Ecology and Management Group, RivEM (in Swedish, Naturresurs rinnande vatten, NRRV) has historically encompassed all ecological research at the department. The group strives to conduct top-quality scientific research in basic and applied ecology, with a particular emphasis on solving real-world conservation problems. Our vision for 2021-2025 is to:

- Build upon our successful research initiatives through strengthening our current themes and developing new and innovative projects
- Further broaden our success in attracting external funding from national and international funding bodies, while continuing to develop our already outstanding network of research collaborations
- Maintain excellence in publication success, while increasing the impact of our results through top-tier publications and broader public outreach
- Engage in top-quality research education and maintain close ties with Bachelor's and Master's programmes at Karlstad University (KAU)
- Focus on further developing diversity, equality and democracy within our research group

**Strength:** A well-defined vision for 2021-2025.

**Challenge:** Developing a new vision for 2026-2030 within the next year, aligning with KAU's Vision 2030.

### Biology Education

Research in Biology Education is undertaken within the Centre of Science, Mathematics, and Engineering Education Research (SMEER). The research programme is oriented towards four key areas: (1) practice-based educational research, (2) development of theory and concepts in subject-specific education, (3) representations and language use, and (4) education for sustainable development and the Anthropocene. Our overarching objective is to become a top research environment at both national and international level, contribute to research-informed teacher education and enhance the professional development of educators while fostering student learning. A second pivotal objective is to establish collaborations with schools and other societal partners. These collaborations aim to bolster school development, facilitate teachers' professional development, and contribute to research-based teacher education. The current strategy working towards these objectives predominantly relies on securing external funding, advancing the career development of researchers and exerting influence on the recruitment process for senior researchers.

**Strength:** Membership within the research centre SMEER provides researchers in Biology Education with access to a well-defined and established research infrastructure.

**Challenge:** Increasing external funding in Biology Education.

### Geomatics

The ultimate goal for Geomatics is to evolve into a recognised postgraduate discipline that can provide state-of-the-art education and training at all levels. This transition will involve several sequential steps: (1) recognising Geomatics as a distinct subject at both undergraduate and Master's level, (2) launching a Master's programme, (3) establishing a dedicated research group, and (4) introducing a doctoral programme, solidifying our status as a postgraduate subject. Given that Geomatics will meet the formal personnel requirements for becoming a postgraduate subject (five permanent employees with a PhD, out of which at least two professors and two docents) through strategic recruitment and/or promotions, we anticipate introducing a doctoral programme by 2028.

**Strengths:** (1) A detailed strategy is underway. (2) Support from the department and the faculty.

**Challenges:** (1) Unforeseen changes in personnel/finances that slow down or hinder development. (2) Securing further support from the department and the faculty.

*The research areas at the Department of Environmental and Life Sciences are at various stages of development, but all of them have clear and well-defined strategies for their future growth.*



## 2. Organisation and management

### Ecology, Evolution and Sustainability

The RivEM Research Group, established in 2009, originated from a core team of four researchers in 2000. Initially centred on applied ecology to address real-world river management issues, we have garnered national and international recognition. Over time, our team has expanded to include around 25 researchers. Our research scope has broadened to encompass high-impact studies in biodiversity, global change and evolutionary biology, forming the foundation of our ecological sustainability profile. Numerous RivEM researchers rank among the most highly-cited at KAU, and we maintain an outstanding publication rate, along with a remarkable track record in securing external funding (see Background Data, supplementary file).

We have successfully attracted an increase in national and international external funding, enabling us to expand and diversify with top-quality researchers. Our research environment includes six professors, four docents, 11 doctoral students, two postdocs, and affiliated faculty members. In 2023, we have significantly enhanced our capacity by adding four additional lecturers: two early-career associate senior lecturers and two senior lecturers, covering both Zoology and Plant Ecology.



For more than 20 years, we have been building the infrastructure required for cutting-edge research. National and international guests, our own researchers and doctoral students present and discuss research and current topics at our Tuesday seminar series, as well as in journal papers and book clubs, and we regularly host guest professors and researchers. We have a 250 m<sup>2</sup> state-of-art aquarium lab facility that has resulted in numerous peer-review publications, Bachelor's and Master's projects and is included in our undergraduate and postgraduate programmes. The stream aquariums allow us to simulate the natural conditions of river flow and climate change that are relevant for today's sustainability goals for environmental friendly hydropower and climate change adaptation. In addition, we have a substantial body of field equipment used to investigate river and landscape ecology in situ, as well state-of-the-art ecological modelling computers. We recently added a state-of-the-art lab for the model organism *Drosophila* for our research on eco-evolutionary dynamics. We have also invested in high-tech equipment that enable analyses of gene expression both on an mRNA and protein level and for preparation of samples for DNA barcoding and sequencing.

**Strengths:** (1) RivEM possesses a well-established and widely recognised research profile, with an outstanding track record of securing external funding and a team of highly productive researchers. (2) The research environment is truly international, with representation of 15 different nationalities. (3) A robust and well-developed seminar series features both external and internal presenters. (4) The research profile has expanded, incorporating new expertise in the field of evolutionary biology. (5) Ongoing formal training in research leadership is in progress.

**Challenges:** (1) Historically, all ecological research at KAU was conducted under RivEM. Recent recruitments have bolstered the field of evolutionary biology, and it remains uncertain whether these researchers should form a new parallel research group or be integrated into RivEM. (2) Further formalisation of organisational structure and leadership of the research is required. (3) A lack of collegial review processes before submission of papers and funding applications.

### Biology Education

The Biology Education research environment comprises one professor, one docent, four senior lecturers, two lecturers, and six doctoral students. Given that research activity in Biology Education is primarily carried out within SMEER, it is important to delineate the leadership within the centre. SMEER is overseen by an academic director (the professor of Biology Education). The SMEER Board, consisting of 14 members, comprises seven researchers from SMEER, a doctoral student representative, and seven external members from KAU, other universities and a school teacher. To support the director in day-to-day operations, a working committee of the board has been established, comprising the six research members and the doctoral student representative. Among the members of the working committee, three belong to the Biology Education group. Additionally, one of the committee members organises the SMEER seminar series.

The integration of Biology Education researchers within the SMEER group, funded by the Teacher Education Board, can be viewed as a dual-edged situation. While researchers have access to some

funding (although not substantial sums) from SMEER, it can also serve as a reason for the department management to potentially undervalue Biology Education research.

The Biology Education researchers engage in numerous international research collaborations. Regular participation in international research conferences is encouraged and supported by SMEER, which allocates part of the annual budget to facilitate conference attendance, even when funding is not available via project budgets or departmental funding. Researchers are also encouraged to submit applications for additional research funding from SMEER to enhance existing projects or explore research avenues without external funding. Centre researchers have the possibility to receive funding for the first three years post-graduation to aid the transition from being a doctoral student to an independent researcher, contingent on subsequent employment at KAU.

Biology Education researchers are active in the SMEER seminar series, which hosts sessions approximately every two weeks. These seminars serve as a platform to exchange expertise, assimilate new members and doctoral students, and share ongoing research activities. Both senior and junior researchers are expected to present their work regularly. In addition to this, prominent researchers from other universities are invited to share their work in the seminar series. The seminars also facilitate and strive to improve various aspects of research practices by inviting experts on ethical reviews, publication strategies, open data storage and discussions on how to attract external funding. Prior to submission, researchers can have their funding applications reviewed at the seminars, aiding in refining and improving their work. Hence, the seminars are the most important instrument to develop a joint research culture and promote high-quality work.

The organisation of Biology Education research within SMEER lends itself to multidisciplinary collaborations, involving researchers from various disciplines. Additionally, members are involved in ROSE, a KAU institutionalised academic collaboration that includes researchers from other research centres (CSD –The Centre for Social Science didactics and CSL – The Centre for Language and Literature Education) focusing on subject-specific education.

**Strengths:** (1) Subject-specific education research holds a priority status at KAU, evident in the formation and funding of SMEER. (2) The structured linkage with the biology discipline allows for a close connection to the subject, in contrast to being tied to a teacher education department (as seen in some other universities).

**Challenges:** (1) Navigating the intricate structure where Biology Education researchers are employed at the Department of Environmental and Life Sciences, hosted by the Faculty of Health, Science and Technology (HNT) and members of SMEER, internally funded and supervised by the Faculty Board for Teacher Education. (2) In comparison to subject-specific education researchers at other educational research centres, Biology Education researchers (as well as other SMEER-related researchers) receive relatively little support from our host faculty (HNT) regarding co-funding and interest in educational research.

### Geomatics

Geomatics has begun to establish a clear research profile and vision and has been actively producing scientific output and successfully attracting external funding since 2016. Geomatics is actively working with the establishment and formalisation of a research group. Research efforts are directed towards the fields of sustainable development, environmental monitoring, risk modelling, disaster risk reduction, climate adaptation/mitigation, and spatial machine learning. Two new researchers joined Geomatics during 2022-2023 with fields of expertise strengthening this profile, and we have initiated promising collaboration in the form of grant applications (FORMAS, Horizon 2020, KAU's Centre for Societal Risk Research (CSR), MSB and the Belspo Stereo IV programme) and research papers. One researcher is currently participating in the Research Leader Initiative 23/24 training programme and is, thus, poised to represent the research environment of Geomatics.

We wish to expand Geomatics with one to two new staff members every year, with recruits who are active and experienced in research and education. Geomatics has previously had few employees, and recruiting activities have before the recruitment of the new associate professors 2022 and 2023 (both docents) been directed towards sustaining our undergraduate education. We aspire to grow in diversity regarding research network, language and cultural aspects, broadening the horizon of future research opportunities through international collaboration. We would like to be able to employ doctoral students by starting a PhD programme, as well as attracting more postdocs and guest

researchers. During the autumn 2023, we hosted a guest researcher and another one is joining us in 2024. Recruiting researchers that match the profiles we need has generally been a challenge since the pool of Swedish-speaking academics in the field is limited. There is a possibility to use internal funding for internal professional development, for example, promotions or partaking in specific courses. The group has influence over the distribution of research-allocated funds and can direct efforts towards, for example., continuing professional development or application writing. We discuss strategic investments and the distribution of resources annually.

In the process of establishing a research environment, we can benefit from expertise from research directors and experienced researchers at the department, KAU's Grants and Innovation Office (GIO), and through courses (e.g., REAL). We have improved the outward communication of our research throughout our web presence during the past years, and from 2024, we plan to update our websites substantially and develop a research communication plan, an area that we have not discussed enough.

**Strength:** Structured formalisation of a research environment with clear a profile and leadership in progress.

**Challenge:** Attracting excellent researchers that match our research profile and are experienced teachers.

*We have initiated various transdisciplinary research projects within the department, fostering collaboration among researchers from different groups. For example, there have been successful collaborations between Ecology, Evolution and Sustainability and Biology Education concerning action competence for insect conservation, as well as between Geomatics and Ecology, Evolution and Sustainability on projects related to eel migration and invasive plants. However, there has been no project that encompasses all research groups within the department.*

*In the department, we maintain a continuous commitment to address issues related to gender equality. Our goal is to ensure equal opportunities and responsibilities for individuals of all genders, promoting critical reflection on gender-related matters and equal distribution of tasks and resources. It is worth noting that women professors remain underrepresented at the department, and the gender balance in other categories of academic staff varies across research groups.*

### 3. Expertise profile

#### Ecology, Evolution and Sustainability

Among the most significant local and global challenges that society faces today are climate change and biodiversity loss, as well as the consequent loss of ecosystem services for human well-being. Ecological sustainability aims to contribute to societal transformation by developing win-win solutions for nature and people. We conduct innovative basic and applied ecological research that sets the foundation for sustaining many of the ecosystem services upon which society depends. Key examples of our excellence in research come from our close collaborations with stakeholders in the government and private sector. We work to develop sustainable solutions for fossil-free hydroelectricity, forestry, and management of invasive species. We collaborate nationally and internationally with partners such as the Swedish Energy Agency and the Swedish Transport Administration, and through the European Union's Marie-Curie programme and LIFE Programme. Recently the RivEM group reached a new and significant milestone, greatly strengthening our focal research area and broadening our arena of impact, through a successful award from the Swedish Energy Agency (total amount approx. SEK 280 million) for the establishment of the Swedish Centre for Sustainable Hydropower (SVC), in partnership with Luleå University of Technology (LTU, centre coordinator), Umeå University (UmU), and the Swedish University of Agricultural Science (SLU). We are now positioned to contribute even more to Sweden's efforts to forward the research front through our profile in Ecological Sustainability.

We advertise vacancies nationally and internationally, often leveraging our extensive networks, for academic positions at all levels. Our recruitment efforts primarily target and successfully attract international candidates. In the past, we hired new lecturers primarily to meet the teaching demands of

our Bachelor's and Master's programmes. However, we have shifted our focus in the recruitment process slightly towards emphasising research performance and alignment with our research priorities.

**Strengths:** (1) Extensive national and international research networks. (2) Strong connections with the hydropower industry, Swedish government agencies, NGOs, and other universities, contributing to excellent national and international networks. (3) High academic competence within the research group.

**Challenge:** Sustaining excellence in the field of aquatic ecology, particularly in addressing retirements through professional development and new recruitments. This research area attracted over 80% of external funding in the fields of ecology, evolution and sustainability from 2020 to 2022, and maintaining critical mass of researchers and quality needs to be ensured.

### Biology Education

SMEER plays a pivotal role in the strategy to secure adequate research expertise and staff. We face the challenge of establishing a robust foundation for research across all pertinent areas in teacher education while concurrently maintaining a high international research standard. Additionally, attracting competent external personnel has been another obstacle. To address these challenges, much of SMEER's strategy focuses on financing graduate students for lecturers and fostering expertise among the existing staff. A large portion of SMEER's budget is allocated towards this goal.

As a research centre at KAU, SMEER does not directly employ teachers and staff; this is the responsibility of the departments. Notably, the primary consideration for permanent employment is especially based on teaching requirements rather than research needs. However, SMEER can fund and create temporary research positions within the departments. This has been successfully carried out multiple times, mainly through external funding, but also using SMEER's internal budget. To ensure the relevance of new recruits' research expertise, Biology Education researchers actively participate in the advertising and recruitment process, prioritising both teaching and research needs.

The Biology Education researchers boast numerous academic partnerships, networks, and commitments. Notably, the Research on Subject-Specific Education (ROSE) is a widely recognised and institutionalised academic collaboration at KAU, involving researchers from the research centres SMEER, CSD, and CSL. Within the ROSE collaboration, biology educators contribute to developing a shared theoretical perspective and engaging in comparative research.

Moreover, the ROSE collaboration led to the creation of an international network called "Knowledge and Quality across School Subjects and Teacher Education," supported by the Swedish Research Council. This network unites educational research groups from various academic disciplines at KAU in Sweden, Helsinki University in Finland and the Institute of Education (UCL) in England, aiming to explore how educators and education systems can ensure school-based knowledge building for transformative potential.

Another significant outcome of the ROSE collaboration is the participation in the ULF project (a national investment in practice-based educational research), resulting in the establishment of the graduate school "Knowledge, Subjects and Quality in Teacher Education and Classroom" funded by the Swedish Research Council and in collaboration with University West and Halmstad University. This graduate school includes 14 doctoral students, three of whom are associated with Biology Education.

The most long-term academic collaboration that SMEER has participated in at a national level is the Swedish National Graduate School in Science and Technology Education (FontD). Seven doctoral students from Biology Education have participated in that graduate school, and four of the current full-time teachers/researchers in Biology Education were part of this national program. We have several other international collaborations, in the BriCCS (Bringing Climate Change to School) project we work alongside German researchers from IPN (Leibniz Institute for Science and Mathematics Education) in Kiel. We are active in Horizon 2020 (e.g., the COSMOS project) and are also engaged in a Horizon-CL5-2023 project IMPACT striving to develop an impact assessment framework for climate change and sustainability education.

In addition to these institutionalised collaborations, Biology Education researchers are involved in many national and international networks linked to our different research interests. We have since 2012 been engaged in the academic committee of ERIDOB (European Researchers in Didactics of

Biology) and hosted a European conference for the organisation with 200 participants in Karlstad in 2016. Biology Education researchers are active on the editorial board of the ESERA (European Science Education Research Association) book series and active on many editorial boards of international journals. Further, biology education researchers have been part of the board of Svensk Förening för Forskning i Naturvetenskapernas Didaktik (FND) and organised the national Swedish conference in science education in 2014.

**Strengths:** (1) Profound academic research proficiency in Biology Education. (2) Strong and well-established academic national and international networks, as well as within KAU.

**Challenge:** Recruiting experienced international researchers is notably challenging, primarily as recruitments are initiated to fill teaching vacancies. A prerequisite for teaching in teacher education is proficiency in speaking Swedish or at least a Scandinavian language.

### Geomatics

With the goal of distributing work assignments in the most efficient way, Geomatics regularly maps their staff in terms of competencies, proficiencies and individual preferences regarding their contributions to teaching and research, as well as any shifts in their roles and responsibilities. Historically, recruitments were mostly motivated by the need of staff in education for our two Bachelor's programmes in Swedish, thus limiting the inflow of international researchers. However, with the inception of courses at Master's level converging towards a Master's programme, we have opened up for accessing a larger pool of excellent researchers with expertise that needs to be bolstered at Geomatics. Currently, our core competencies encompass GIS/spatial analyses, earth observation, risk modelling, land change modelling, social-ecological systems and GeoAI/machine learning.

We have initiated a comprehensive mapping of our researchers' active national and international contacts to pave the way for potential collaborations. Our strategic vision is geared towards broadening this network, both geographically and across disciplines, to cultivate inter- and transdisciplinary research that transcends traditional boundaries. Throughout the past 5 years, research undertaken within Geomatics at KAU have been predominantly associated with the Centre for Societal Risk Research (CSR), with additional contributions from Biology and the Centre for Research on Sustainable Societal Transformation (CRS). Our academic collaborations have included esteemed institutions such as Karolinska Institutet, University of Gothenburg and KTH Royal Institute of Technology. The primary areas of research have predominantly addressed natural hazards and disasters, including floods, fires and landslides, as well as the associated risks, exposures, and vulnerabilities for the population. This focus has fostered partnerships beyond the academic realm, incorporating entities like the insurance sector, industrial risk/damage experts, municipalities and the Swedish Civil Contingencies Agency (MSB). Additionally, collaborations have extended to other public authorities.

Recent recruitments have extensive international research contacts and experience in the Global South; one new senior lecturer serves as Secretary-General of the European Association of Remote Sensing Laboratories (<https://earsel.org/>), chairperson of the organisation Special Interest Group in Developing Countries (<https://dc.earsel.org/>) and Sweden's national representative in the organisation, and the second new senior lecturer acts as Research Associate of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. We are, thus, poised to bolster our international research endeavours and broadened our networks, both in terms of collaborations and potential international funding through European and global development grants (e.g., Bill and Melinda Gates Foundation). Future collaborations aim to address pressing societal challenges from environmental change that predominantly align with the Sustainable Development Goals (SDGs) pertaining to Sustainable Cities and Communities, Climate Action and Life on Land, especially Land Degradation Neutrality.

**Strengths:** (1) Overlapping research interest and complementing expertise of present researchers. (2) Growing interest and continued funding opportunities. (3) Extensive international research network.



**Challenge:** Expansion of research activities may be limited because of difficulties in recruitment.

*Historically, our recruitment efforts primarily emphasised meeting the teaching requirements of our undergraduate programmes within the department. While there has been a partial shift in this focus, it remains a challenging aspect.*

#### 4. Research domains and results

##### Ecology, Evolution and Sustainability

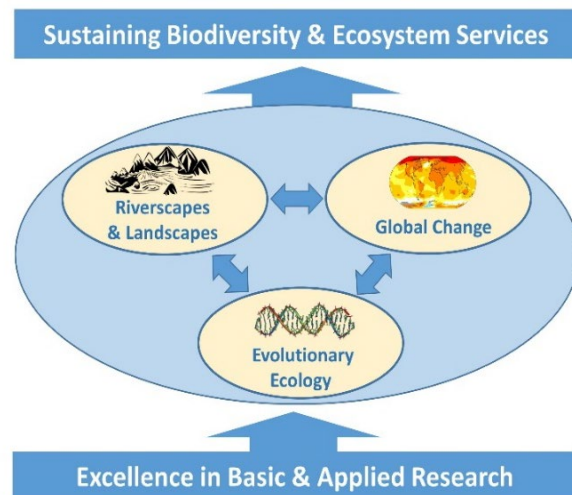
In accordance with RivEM's Vision 2021-2025, we have developed three cross-cutting research themes that position us at the forefront of research in the broader field of Ecological Sustainability:

##### **Theme 1: Sustaining Living Riverscapes and Landscapes**

Historically, our focus has centred on applied ecology, addressing real-world challenges in managing ecosystem services. This theme places a strong emphasis on the preservation of biodiversity and ecosystem services while simultaneously fostering solutions that benefit society. In the context of riverscapes, which encompass river landscapes, our goal is to facilitate the transition to a fossil-free society by ensuring the sustainability of hydropower production while safeguarding biodiversity. The RivEM Group has earned national and international recognition as a leader in developing solutions for fish passage and habitat in hydropower-regulated rivers. We are an integral part of the recently funded Swedish Center for Sustainable Hydropower, and we will spearhead several projects dedicated to sustaining biodiversity and ecosystem services in three key areas.

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**1. Hydropower and connectivity:** *(i) EU projects:* We actively participate in various EU projects focusing on hydropower and connectivity, such as the Marie Curie PhD training network RIBES and two LIFE projects. RIBES, an Innovative Training Network involving eight leading European universities, supports 15 early-stage researchers. In collaboration with consultant companies, public agencies and the hydropower industry, we are developing innovative solutions for sustainable, fossil-free hydropower and ecosystem services. We are also planning a follow-up Marie Curie project to expand further our interdisciplinary expertise. Our EU LIFE Connects project targets ecosystem enhancement by restoring river dynamics and connectivity in southern Sweden, offering valuable insights into reintroduction ecology, host-parasite biology of threatened freshwater mussels and the migration of endangered fish species. Our EU LIFE Ecostreams project focuses on restoring northern Swedish river ecosystems, with a particular emphasis on the endangered freshwater pearl mussel and its host fish species. We are planning follow-up Marie Curie and LIFE projects to expand further our interdisciplinary expertise. *(ii) Swedish Energy Agency and FORMAS – eel research:* We are actively involved in several externally funded European eel research projects, with the overarching goal of contributing new knowledge for successful eel management and conservation. These projects have received funding from organizations such as FORMAS, Energiforsk, the Swedish Society for Nature Conservation and the Swedish Energy Agency. Collaborating with multiple universities, hydropower companies, county boards and municipalities in field and laboratory studies (as well as in a Delphi study), we are committed to advancing eel research and conservation. *(iii) ECOHAB:* A four-year 17 million SEK collaborative project including four Swedish universities (LTU, UmU, SLU, KAU), Energiforsk and Vattenfall AB, and that is funded by the Swedish Energy Agency, HaV and the industry. Here, ecologists and engineers collaborate around connectivity and habitat related questions to improve the ecological status of regulated rivers. Studies in this research area have received much public attention and have been reported on in the mass media, such as national radio (P1), newspapers (DN, Fiskevård, Forskning & Framsteg) and TV (SVT). *(iv) Faunapassages:* We



have one project with focus on hydraulic and habitat conditions for fish passage (PI: LTU) and one on testing diversion techniques to improve passage for post-spawning fish (PI: UmU). A new project, in collaboration with Vattenfall, is starting up, that will use machine learning for improved eel downstream passage design. **(v) Ecological modelling projects:** We have two projects on individual-based modelling for hydropeaking solutions, in collaboration with Humboldt State University, USA (FORMAS and the Swedish Energy Agency), and one project (FORMAS) on state-dependent modelling of an entire river system, incorporating both habitat and connectivity features, done in collaboration with UmU. **(vi) Dam removal:** A collaborative project with stakeholders and industry to identify the impacts of dam removals on freshwater lake ecosystems. The studies will produce novel knowledge about ecosystem processes in regulated waters, knowledge that is largely lacking today. In this research area, we have previously received funding from the KK Foundation.

**2. Invasive Species – minimising harmful societal effects:** Invasive species can negatively affect biodiversity and cause serious damage to crops. Our research on invasive species spans from garden lupines to gastropods and fish. For example, in our projects (funded by e.g., the Swedish Transport Administration and KSLA) we are developing a phenology-driven mowing regime optimised for the control of lupines along species-rich road verges at the landscape scale, as well as exploring the mechanisms affecting the damage caused by invasive snails and slugs. Studies in this research area have received much public attention and have been reported on in the mass media, such as national and regional radio (P1), newspapers (SvD, Aftonbladet, NWT) and TV (SVT).

**3. Forestry and the links between forests and streams:** As part of sustainable forestry efforts, Swedish forest management includes retention of strips of forest along watercourses, referred to as riparian buffers, to protect aquatic ecosystems. We have a FORMAS project, in which we analyse the link between riparian forest buffer width and functional diversity of riparian predator communities to identify optimal buffer zones for conservation of riparian ecosystem functions, based on food web complexity and ecological niches. We use DNA-barcoding and stable isotopes as tools to assess riparian ecosystem functions, and co-construct guidelines with Swedish forestry stakeholders. A second FORMAS project, in collaboration with SLU, addresses how different stressors caused by forestry operations impact small streams and stream networks, and how riparian buffers can mitigate these effects on a catchment scale.

### **Theme 2: Adapting to Global Change**

Our Global Change theme began over 15 years ago with projects to understand the effects of changing winter climate on river ecosystems. Our new partnership with the Swedish Centre for Sustainable Hydropower (SVC) will contribute to this theme (and also to the Riverscape theme), as global change research is an underpinning and fundamental goal of the centre.

**1. Climate-dependent effects of hydropeaking on river ecosystems:** In one project (Energiforsk), we investigated how geomorphology and land use mediate the negative impacts of hydropeaking downstream of hydropower plants. In a second project, conducted within SVC, we study the effects of hydropeaking on river ecosystems during winter along a climatic gradient (a proxy for global change).

**2. Warming winters and fish behaviour and physiology:** The increase in temperature due to global warming is expected to be greater in winter than in summer. As many fish incubate eggs during winter, we study the effect of temperature during incubation on behaviour and physiology of juvenile and adult fish. The Research Council of Norway has supported this research.

**3. Land-based fish farming:** A VINNOVA project focused on developing a sustainable production system for fish as food with little environmental effect, a so-called Recirculating Aquatic System.

### **Theme 3: Evolutionary Ecology**

At the foundation of all our innovative research is excellence in ecological and evolutionary studies. A new theme has been developed following several new appointments within this field. Broadly, the theme covers research into diversity within and between species driven by extrinsic and intrinsic factors (including the action of genes and environment), with the aim of making predictions about natural populations and systems. The most recent appointment works at the interface between ecology and evolution is currently funded by grants from FORMAS, the Swedish Research Council (VR) and the Crafoord Foundation. This theme also includes research within the fields of molecular and genetic analysis in collaboration with Örebro University Hospital and funding from Region Värmland, and evolutionary genetics, funded by VR. The theme also includes research on genomics and population genetics of threatened freshwater mussels.

**Ethical considerations:** *Our research follows the ethical requirements relating to research ethics and animal ethics according to the Swedish Research Council and the Swedish Board of Agriculture. We have all required permits in place, and we maintain an active ethics committee that meets regularly with a veterinarian. All RivEM researchers and students are required to pass an ethics course prior to initiating research.*

**Strengths:** (1) An exceptional record of attracting external funding and excellent publication rate. (2) Strong societal impact.

**Challenges:** (1) Maintaining the critical mass of researchers and quality within the field of applied aquatic ecology, especially after retirements. (2) Addressing the potential decline in the number of doctoral students by prioritising new student recruitments. (3) Advancing transdisciplinary research that encompasses social science aspects of ecological questions.

### Biology Education

Research in biology education is divided into three overarching themes, aligned with segments of the SMEER research program:

#### **Theme 1: Practice-Based Educational Research**

This theme concentrates on improving teaching and learning by fostering collaboration between educational researchers and teachers, both in school and higher education settings. It is centred on developing and applying research in teaching practices, utilising methodologies like design research, action research and learning studies. The majority of biology education research is conducted within the classroom context, with an interest in the conditions for teaching and learning. By conducting research in collaboration between Biology Education researchers and teachers at school, practice-based educational research contributes to the vision of the Faculty Board for Teacher Education of “supporting school development, school-based research, and competence development of teachers in school”. Biology Education researchers have received external funding for practice-based research from the Swedish Institute for Educational Research, where researcher-teacher collaboration is a prerequisite for application. For example, we have conducted a longitudinal study on the implementation of education for sustainable development in collaboration with teachers from five schools in Karlstad municipality.

The Swedish Research Council provides high-stakes funding in Sweden, including in the area of educational research, and Biology Education researchers have been successful in attracting funding from this council in recent years. This includes a project about developing and analysing teaching sequences that introduce epigenetics in upper-secondary biology education in collaboration with teachers. Another example of such a project is BriCCS, in which the third work package of the project includes close collaboration with teachers at three secondary schools in Karlstad municipality.

#### **Theme 2: Development of Theory and Concepts in Subject-Specific Education**

The development of a shared theoretical framework within ROSE has facilitated collaboration and comparative studies across the different subjects of the research centres SMEER, CSD, and CSL. This framework explores applying notions of powerful knowledge and transformation in teaching various subjects, aiming to create a unified theoretical framework for subject-specific research. It has been used as the foundation for the KÄKK graduate school and further explored by graduate students in mathematics and science education linked to SMEER. Delphi studies have been used to identify powerful knowledge in diverse areas such as infectious diseases, epigenetics and, recently, photosynthesis. In this graduate school, Biology Education researchers are involved as coordinators, leaders, course developers and supervisors. Moreover, teachers have been involved in adapting this knowledge for teaching purposes, as seen in projects concerning epigenetics and the creation of a teaching model for photosynthesis.

#### **Theme 3: Education for Sustainable Development and the Anthropocene**

This research area aligns with the overall vision and strategy 2030 of KAU (as well as that of the Faculty Board for Teacher Education) to establish a sustainable society and involves studying environmental education and teaching about climate change. In this research theme, we closely collaborate with schools and school principals to develop impactful teaching practices related to sustainability. It combines practice-based and teacher-oriented research with psychometric and large-scale study methodology. Notably, research on Education for Sustainable Development (ESD) has produced highly influential outcomes, such as the creation of theoretical constructs like Sustainability

Consciousness and Action Competence for Sustainability. These constructs have evolved into widely recognised psychometric research tools, contributing to international research. Moreover, within this theme we have published papers that have had great impact in terms of citing.

Collaborations with schools in the region, especially in Karlstad municipality, have yielded significant projects, such as developing ESD teaching practices and reducing climate anxiety among students in collaboration with climate psychologists. In a project aiming to develop ESD teaching practices, which has been supported by Ljungbergsfonden and the Swedish Institute for Educational Research, 10 preschools, four compulsory schools and one upper secondary school participated collaboratively. In the project, several hundred teachers and school leaders participated in continuous professional development over three years. In another project, funded by the Norwegian Research Council, and led by NTNU in Norway, the aim is to work collaboratively with primary school teachers in Karlstad municipality and several municipalities in Norway to develop critical thinking in sustainability education.

Our research has gained international attention and led to several collaborations across Norway, Denmark, Germany, Belgium and the Netherlands. The research has been integral in participating in global initiatives like the COST-network European Network for Environmental Citizenship Education (ENEC), the Horizon 2020 project COSMOS, and a Horizon-CL5-2023 project IMPACT, striving to develop an impact assessment framework for climate change and sustainability education. Furthermore, an initiative called Education and Bildung in the Anthropocene (EBAN) has been initiated by researchers within ROSE, supported by the Swedish Research Council. Also outside academia, this research has had a great impact on school practice in Sweden and other countries via the development of joint publications and guidelines in the European ENEC network including 39 countries. This work has been conducted in international collaboration with Antwerp University in Belgium, with two researchers employed at KAU part-time for several years and also functioning as co-supervisors of doctoral students at KAU.

**Strengths:** (1) Excellent track record of external funding and impactful publications. (2) Successful international collaborations and high citation record and impact of research, especially in the realm of ESD.

**Challenges:** (1) Balancing the demanding collaboration with teachers and schools alongside maintaining focus on international publication and theoretical development. (2) Unifying diverse research interests and methodologies within the biology education research group to establish a cohesive identity.

### Geomatics

In 2023, Geomatics is engaged in seven research projects with a combined funding of SEK 74.5 million, all of which are directly tied to fostering a more sustainable society. However, out of those seven projects, Geomatics is PI only for one project and thus the projects are not listed in the background data. These projects include evidence-based strategies for combating and monitoring the invasive garden lupine along road verges with high biodiversity (funded by the Swedish Transport Administration/the Swedish Environmental Protection Agency, SEK 4 million), developing assessment methods for cloudburst damages (FORMAS, SEK 3 million), SveDigArk (VR Infrastructure, SEK 66 million), utilising churches as safety points (VINNOVA, SEK 1.5 million), addressing forest and ground fires (CSR, SEK 80.000), improving accessibility to healthcare facilities in 18 Sub-Saharan cities, and studying travel time to delivery wards and maternal outcomes.

The recruitment of two new senior lecturers has strengthened Geomatics' international research impact. Over the past years, our research output included four peer-reviewed papers in international journals, two book chapters, and four reports between 2020 and 2022 (excluding the new senior lecturers' publications). However, as our projects have predominantly been funded by Swedish national bodies, the dissemination of our findings has been primarily through project reports, thus having a more local than international impact. At the international level, with the inclusion of the recently hired personnel, Geomatics is demonstrating significant contributions to international knowledge development. We are contributing to the work of expert groups at global, regional and local levels. Examples here are the Science Policy Interface group of the United Nations Convention to Combat Desertification (UNCCD), the Commission on Ecosystem Management (CEM) of the International Union for Conservation of Nature (IUCN), the Global Land Programme Working Group

on Integration of Rural and Urban Land Systems, the Nature Futures Framework modelling of the Intergovernmental Science-Policy Platform on Biodiversity, Ecosystem Services (IPBES), and the Biodiversity Task Force of the European Geosciences Union. Thus, Geomatics researchers are inter alia contributing to parliamentary debates on the EU Nature Restoration Law at the European Parliament in Brussels.

Geomatics also plays a significant role in addressing SDG 11 by seeking to enhance the well-being of urban residents, especially in the Global South. This effort is reinforced by two proposals related to this subject (Microsoft AI and FORMAS). In 2022, our team was part of large interdisciplinary consortia, contributing to leading journals and books on a diverse range of topics from epidemiology to earth observation and spatial analysis. The field of spatial machine learning is another key research domain where we have made methodological contributions, integrating traditional geostatistics with modern machine learning techniques. Our research, which is both application-driven and methodological, fills critical gaps in the scientific literature. Our international collaborations are part of well-established research consortia that are recognised and supported within the scientific community. All active researchers in Geomatics are well cited with demonstrated impact in their sub-disciplines and a satisfactory amount of research production.

Aligned with KAU's strategic goals for 2030, Geomatics is progressing in expanding doctoral education, increasing its attractiveness to students and staff, and strengthening the synergy between research and education. Our research endeavours are dedicated to KAU's primary objective of contributing to a sustainable society. This includes a broad spectrum of topics, ranging from healthcare accessibility and invasive species management to addressing urban inequalities and enhancing the resilience of smallholder farming systems. Internationalisation in research and education remains an area Geomatics is keen to advance. While international exchanges have not been extensively incorporated into our undergraduate Swedish programmes, preliminary discussions with the Geoinformatics unit at the University of Pretoria in form of a Linnaeus Palme Planning exchange have initiated potential collaborations for our outlined Master's programmes.

**Strength:** Current research impact and interdisciplinary contributions to high-impact areas.

**Challenges:** (1) Improving the balance and maintaining quality and quantity between research production and teaching responsibilities. (2) Attracting large external projects with researchers within Geomatics as principal investigator.

*In general, the prevailing national funding model for research, primarily reliant on external grants rather than core funding, presents challenges in realising long-term strategic research objectives. For instance, many funding agencies support projects with a typical duration of up to three years, whereas doctoral programmes in Sweden typically span four to five years.*

## 5. Collaboration and interaction with the surrounding community

### Ecology, Evolution and Sustainability

The RivEM Research Group is dedicated to applied ecology, which involves providing science-based solutions to society's pressing questions. We also engage in fundamental ecological research, often laying the groundwork for practical solutions. Our emphasis on applied ecology has led to wide-reaching societal impacts and extensive outreach activities. As early as the late 1990s, researchers at KAU Biology began building a strong foundation for broad societal support of our research. By the time RivEM was established in 2009, we had already established collaborations with various entities, including the Swedish Agency for Marine and Water Management (HaV), County Administration Boards and major hydropower companies. More recently, we have formed partnerships with national and international organisations such as the Swedish Transport Administration, the Swedish Energy Agency, the EU Marie-Curie programme and the EU LIFE programme, demonstrating our continued success. Our societal collaboration has taken a significant step forward with our new partnership with LTU, UmU and SLU, known as the Swedish Centre for Sustainable Hydropower (SVC).

Over the past decade, our societal network has expanded significantly, connecting us with stakeholders in various sectors, both nationally and internationally. In addition to our collaborations with government and industry partners, we actively engage with society through outreach efforts. For



example, between 2019 and 2020, RivEM group members were involved in school outreach, served as expert members in the Swedish Land and Environment Court, gave interviews on radio, in newspapers and on online news platforms and hosted webinars. We maintain an active RivEM research blog and have a presence on social media platforms such as X (formerly known as Twitter) and Facebook. Internationally, we supported the First Student Conference on Conservation Science (SCCS), Nordic Chapter, part of a global network of research schools with annual events in different countries. We also serve on editorial boards of scientific journals, such as Ecology of Freshwater Fish.

One outreach initiative was RivEM Week (2020), which also aligns with KAU's strategic goal of closely connecting research and teaching. The RivEM week's seminars provided Master's degree students with opportunities to interact with international experts and national stakeholders from various fields, offering the latest scientific insights and unmatched networking prospects. Another example is our biannual "Green Day", where RivEM researchers, along with societal stakeholders and alumni, discuss future opportunities for Bachelor's and Master's students. Both RivEM Week and Green Day have been very well received by the participants.

**Strengths:** (1) Strong societal impact. For example, our research output directly influencing the relicensing of Swedish hydropower (in Swedish, Sveriges riksdag: Den nationella planen för omprövning av vattenkraft, CU33). (2) Collaboration with a wide range of stakeholders, including industry, governmental organisations, municipalities, county administrative boards and NGOs.

**Challenge:** Expanding collaboration beyond the hydropower industry to sectors such as forestry, wind power and agriculture.

### Biology Education

Interaction between Biology Education researchers and the surrounding community predominantly involves the Swedish school system, while collaborations with schools in Norway and Germany occur through various projects. The primary focus of the research revolves around the teaching and learning of biology, occasionally encompassing other science subjects. Specifically, in the domain of practice-oriented research, access to classrooms and preschools is pivotal, necessitating coordination with school administration and individual teachers to undertake research projects. This coordination is made feasible through formal partnerships between KAU and the municipalities and schools in the region, including bodies such as the regional development centre (in Swedish, Regionalt utvecklingscentrum, RUC).

Almost all research projects within Biology Education display collaboration and interaction with the surrounding community. Often legal agreements are established with schools and municipalities in these projects, with portions of the budgets allocated for teachers' participation. Close collaboration with practicing teachers is evident in graduate schools, fostering the integration of Biology Education research with the broader society. As part of collaborative efforts, researchers aim to develop projects where they work alongside teachers. These initiatives employ methods such as participatory action research, educational design research and learning studies. In these projects, researchers and teachers jointly formulate research questions, design teaching sequences and analyse and report on results. These collaborations have had a substantial impact on the surrounding community. For instance, projects concerning the implementation of Education for Sustainable Development (ESD) in schools in Karlstad municipality involved hundreds of teachers. The municipality of Karlstad initiated these projects, including the BriCCS project focused on climate change education, to enhance teaching quality, reflecting a high level of trust in our research within the community.

One of the Biology Education researchers leads KAU's science centre, Kunskapsgatan, the Children's University project aimed at engaging 10-12-year-old children in science and technology. We are also engaged in a cooperation with the NGO Keep Sweden Tidy (in Swedish, Håll Sverige rent) via a project financed by Vinnova. Additionally, Biology Education researchers actively participate in various media outlets, including specialised and local press. Several practice-based projects have been featured on the web portal Pedagog Värmland, disseminating project outcomes to schools and teachers in the region and nationally across Sweden. Moreover, Biology Education researchers have contributed to curriculum development and the creation of professional development materials for the Swedish National Agency for Education. A Biology Education researcher serves on the editorial board of ATENA Didaktik, a journal targeting researchers and teachers in science and

technology education, published by NATDID, an organisation supporting school development through research.

**Strengths:** (1) Demonstrates a strong societal impact, influencing Biology (and Science) education locally, regionally, nationally and internationally across various school levels. (2) Biology Education researchers have well-established formal and informal networks in collaboration with municipalities and schools in conducting research projects.

**Challenges:** (1) Sustaining collaboration with schools and prioritising their participation in joint research and development activities is challenging. (2) Increasing co-funding from collaborators in the surrounding community is a challenge.

### Geomatics

During the evaluation period, all past research projects sought to benefit society at various scales, from individual households to the national level. With a direct connection to local surroundings in Värmland, the projects engaged local stakeholders in mapping with GIS. The collaborative project together with Biology (study sites located in Värmland) encompasses dialogue with local residents and in-situ data collection. Projects at a national level through the Swedish Civil Contingency Agency (MSB) are mainly related to natural hazards with focus on flood hazard and exposure, contributing to a safer society. This is considered a very important impact on the surrounding community. Two other flood-related projects (SPLASH and DELFI) involved local experts in Värmland and Jönköping from insurance, construction and risk management sectors, as well as local authorities providing flood damage data at the household level. The VINNOVA-funded project “Swedish churches as emergency meeting points” targets the local population in Värmland in terms of a crisis/catastrophe and involves stakeholders from the Church of Sweden, Rescue Services and local authorities, for example, municipalities. Work with MSB in particular has led to a series of projects and continued close relations. All projects are externally funded and closest research collaborator within the abovementioned projects is the Centre for Societal Risks (CSR) at KAU, thus expanding Geomatics research network through the centre’s contacts and broadening research focus to cover diverse topics and environments.

Such a wide range of different research questions and the competence, skills, and experience gained are considered an asset, as Geomatics might have better chances to succeed in trans- and interdisciplinary research participation and external funding. However, realising research ideas without external funding has not yet taken place at Geomatics. Research conducted with internal funding with the advantage of not having to write reports to the funder and somewhat bending ideas to fit a funding call is an area that could be improved at Geomatics aiming to expand research focus from the applied to the more theoretical side. This may improve dissemination in terms of peer-reviewed publications. Focusing on more research depth and expertise in particular fields is considered an important aspect as it complements the breadth already present. We are working with improving this aspect through recruiting excellent researchers that are in line with Geomatics research profile, both strengthening existing capacities and contributing with new competence.

**Strength:** Close interaction with the surrounding community leads to a) continued research and expansion of research network and b) direct societal impact/benefit.

**Challenge:** Maintaining high quality scientific output while a) investing resources in report writing for funders/project partners instead of peer-reviewed publications and b) lack of methodological novelty when state-of-the-art geospatial methods are ‘just’ employed as tools.

*When conducting applied research at the department, a conflict can arise between the desire to publish in high-impact scientific journals and the need to produce technical reports for project partners and funders. Moreover, balancing the focus on local and regional impact with the aspiration for national and international impact may be challenging.*

## **6. Interaction between research and education**

### Ecology, Evolution and Sustainability

We maintain strong connections with both our Bachelor’s and Master’s programmes, a fact recently commended by the reviewers of our Three-Clover programme evaluation. Research findings are

regularly presented during weekly seminars and special events, which actively engage students. Students show enthusiasm in participating in our research projects to gain valuable scientific experience. This opportunity is particularly appealing for Master's projects, where students have access to a wide array of outstanding research projects. Also, in the courses of the Master's programme, there are "mini research" projects, carried out in collaboration with county administrative boards and industrial partners. These projects allow them to contribute to the growth of knowledge and gain insights into the latest innovative research. Furthermore, we arrange Green Day, where Bachelor's and Master's degree students are invited to discuss future opportunities with potential employers, RivEM researchers and societal stakeholders. Furthermore, we teach applied statistics to doctoral students of all subjects within science and technology.

**Strengths:** (1) The Bachelor's and Master's programmes in biology are highly popular, with an increasing number of applicants. The programmes are consistently at full capacity, with a waiting list. (2) The doctoral programme in biology was recently evaluated and recognised for its very high quality. (3) Students are actively recruited (and paid) as research project assistants. (4) All researchers are involved in teaching.

**Challenge:** We have limited experience in securing funding for the development of our study programmes (e.g., seeking support for integrating industry through funding from the KK Foundation and in collaboration with the business sector).

### Biology Education

As subject-specific education is the object of study in Biology Education research, there is an intrinsic connection between our research and education. This connection concerns education at the policy level, in the school system, as well as at KAU, in particular within teacher education. The majority of Biology Education researchers (the only exceptions are postdocs) are active as teachers in the teacher education programmes and are developing courses for teacher education. This gives an immediate opportunity to base the teaching in the courses where the researchers are involved on results from their research, as well as their scholarship in other domains of subject-specific research. The research experience is particularly valuable in the coordination and supervision of independent/degree projects that the teacher students conduct at the end of their teacher education.

Even though most of our research deals with teaching and learning in school or preschool, there is also research within Biology Education that focuses on teaching and learning in the teacher education programmes, for example, pre-service teachers' beliefs about education on climate change and pre-service teachers' use of analogies in biology teaching. We have also recently published a study on pre-service teachers' assessment of argumentation on socio-scientific issues (SSI).

In 2022, a Master's programme in subject-specific education was launched at KAU, focusing on school development and targeting primarily in-service teachers. Biology Education researchers have been part of developing this programme to strengthen the connection between education and research, as well as between KAU and schools in the region. Biology Education researchers are teaching in the programme, which gives new possibilities to connect the participating teacher students' teaching in schools and their forthcoming Master's projects to biology education research. Apart from teaching in the teacher education programmes, Biology Education researchers are engaged in other programmes and courses at KAU. For example, we have developed and given a course in sustainable development for engineering students, to a large degree based on our research in ESD. We are also involved in developing an international joint Master's programme in environmental and sustainability education in collaboration with University of Vechta in Germany, Masaryk University in the Czech Republic and University of Klagenfurt in Austria. Several of the Biology Education researchers teach at the Centre for Teaching and Learning (UPE), which supports the teaching competence of all teachers at KAU by providing qualifying courses in higher education. This provides an example of the high standard and close connection between research and higher education in biology education. However, it has been a challenge to argue for the benefit of educational research at the department and to our host faculty, the Faculty of Health, Science and Technology. Research funding directed to the departments has been focused on research in science and technology, but not so much on educational research. There is a clear area of development to establish collaboration with our colleagues in the departments in teaching courses outside teacher education. Collaboration with teachers of courses

outside the teacher education programmes is one potential way to increase the relevance of biology education research.

**Strengths:** (1) Research on subject-specific (biology) education is intrinsically focused on education, with immediate relevance for teaching and learning of the subjects in focus in the school system and teacher education. (2) All Biology Education researchers are involved in the teacher education programmes and the Department of Environmental and Life Sciences, contributing to grounding the teaching in research.

**Challenge:** There is a challenge in arguing for the view that educational research is an intrinsic part of the HNT faculty.

### Geomatics

Geomatics aims to hold a distinct position in Sweden's GIT (Geographical IT) domain, both in teaching and research. Few universities offer programmes in GIT. Research in GIS and satellite-based earth observation is primarily conducted at KTH, Stockholm University, Lund University and Chalmers. Geomatics at KAU sets itself apart by conducting socially pertinent, multidisciplinary research on the impacts of land system change and climate change, focusing on assessing natural hazards, risks and vulnerability with the goals of contributing to the fields of sustainable development, biodiversity, urban planning and climate adaptation. Essential technical skills that are needed for our research and that are/will be taught encompass Big (geo)Data analytics, classification algorithms (ML/Deep Learning), GIS system enhancement, GeoAI, Python coding, environmental monitoring, modelling/simulation and data gathering, processing and analysis using emerging technologies such as UAVs. The capability to equip our students with the skills and knowledge needed to address present and future societal challenges, particularly in natural hazards and sustainable development, sets our subject focus and expertise apart in comparison to other universities. We aim to encapsulate this distinctiveness in a new Master's programme. Our philosophy is to mutually share expertise, resources, courses and material with other universities and higher education institutions in Sweden to foster a more efficient GIT-education at national level. The development of our research is in harmony with the evolution of our teaching in both structure and content. Over the next decade, our primary objectives are to solidify the foundational field of Geomatics at both undergraduate and graduate levels, introduce a Master's programme that complements our two existing Bachelor's programmes, i.e., the engineering programme Surveying Technology and Geographical IT and the programme in Surveying and Mapping, and to evolve into a field offering postgraduate education in research.

Our course contents and syllabi are reviewed and updated annually in accordance with state-of-the-art research methods and results where applicable. We will continue to enrich our courses with research-related content, both from our own work but also from a broader perspective where it fits and continue to engage students in working with real-world research projects for their thesis work. This approach has been mutually beneficial before and can be seen as an example of how education stimulates Geomatics-tailored research methods and examples are taught in the course Scientific Methods in Geomatics.

Previously conducted analysis of the Swedish labour market has identified elevated needs and shortcomings in the supply of skilled surveyors and GIS/GIT engineers. The launch of distance alternatives of our two existing programmes (among the first in our field in Sweden) has led to a record-high number of students, and the expected number of students in a future Master's programme is considered very high. We have already developed courses at Master's level with high numbers of applicants (Geospatial Python, Introduction to Python for Geomatics and Spatial Statistics in GIS). This is partly because there are too few programmes in Sweden and partly because many students and alumni have already expressed interest in studying further with us. The reason for this has not been related to research at Geomatics in the first place for the undergraduate programmes, but is expected to become so with an upcoming Master's programme that is closely related to our research environment.

**Strengths:** (1) Development of a Master's programme is aligned with the research profile. (2) Uniqueness of programme and research focus will deepen knowledge transfer/exchange within the research community and education domain in Sweden. (3) Offering an international Master's programme with our focus contributes to KAU's internationalisation goals.

**Challenges:** (1) Attracting students to the new programme. (2) Sharing research and teaching responsibilities effectively and fairly among staff.

*All researchers at the department are actively engaged in teaching at various levels, fostering robust connections between research and education. A challenge persists in effectively scheduling teaching to support efficient research and prevent overtime, especially given that the outcomes of grant proposals are typically communicated late in the year.*





The Department of Environmental and Life Sciences

# BACKGROUND DATA

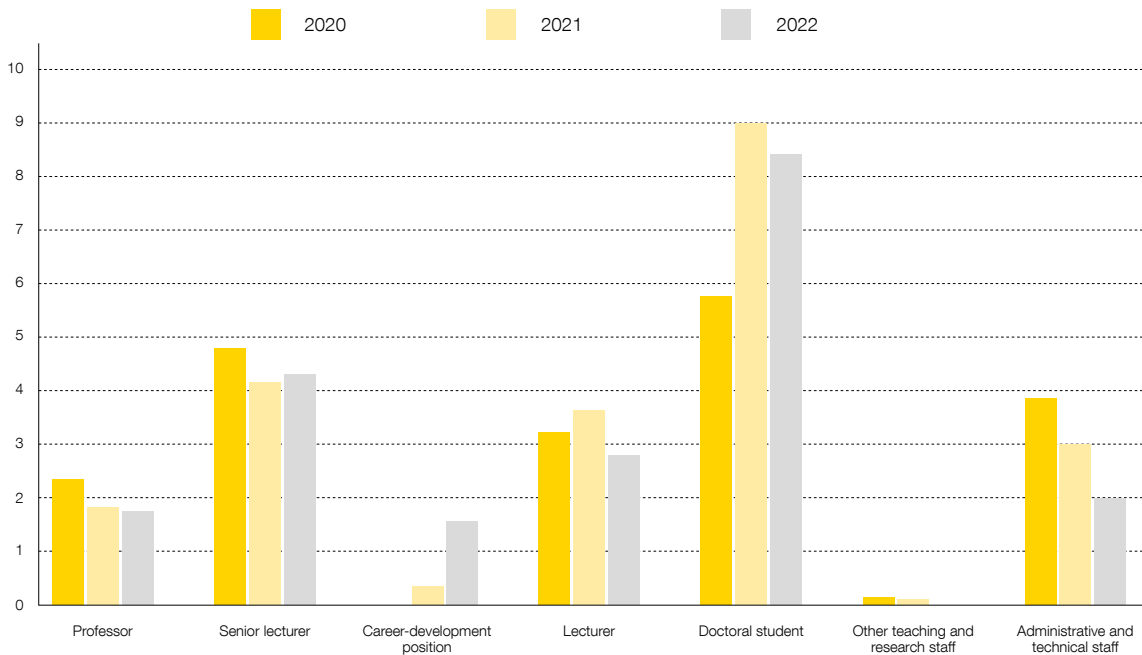
Periodic Research Review

## INTRODUCTION

Background data covers a three year period (2020-2022) and contains information about staff, third cycle studies, financial resources and publishing output.

Data was collected from university administrative systems to provide an overview and illustrate conditions for research at the Department of Environmental and Life Sciences.

## STAFF



**Figure 1.1 Workforce by staff category**

Workforce, full-time equivalents\*, for researchers at the Department of Environmental and Life Sciences over a three-year period. Staff categories are professor, senior lecturer, career-development position, lecturer, doctoral student, other teaching and research staff, and administrative and technical staff. See table 1.2 for individuals in each category.

Source: KULI

\* Full-time equivalent (FTE) is a unit of measurement to illustrate the number of full-time hours spent on research engagement for all employees at the Department of Environmental and Life Sciences. Research engagement includes recorded time covered by internal funding, external research funding and commissioned research funding.

**Table 1.2 Staff at the evaluation unit**

Staff, based on position, engaged in research at the Department of Environmental and Life Sciences (year 2022).

Name	Position	Research subject
Greenberg Larry	Professor	Ecology
Piccolo John	Professor	Ecology
Eckstein Lutz	Professor	Ecology
Österling Martin	Professor	Ecology
Gericke Niklas	Professor	Biology Education
Calles Olle	Professor	Ecology
Erlandsson Ann	Senior lecturer, Docent	Biomedical Laboratory Science
Lind Eirell Lovisa	Senior lecturer, Docent	Ecology
Morrow Edward	Senior lecturer, Docent	Evolutionary Biology

<b>Name</b>	<b>Position</b>	<b>Research subject</b>
Walan Susanne	Senior lecturer, Docent	Biology Education
Watz Johan	Senior lecturer, Docent	Ecology
Andersson Jan-Olov	Senior lecturer	Geomatics
Berglund Teresa	Senior lecturer	Biology Education
Georganos Stefanos	Senior lecturer	Geomatics
Haas Jan	Senior lecturer	Geomatics
Olsson Daniel	Senior lecturer	Biology Education
Thörne Karin	Senior lecturer	Biology Education
de Lisle Stephen	Career-development position, Assistant Senior lecturer	Evolutionary Biology
Lampert Peter	Career-development position, Postdoc	Biology Education
Lovén Wallerius Magnus	Career-development position, Postdoc	Ecology
Abshirini Ehsan	Lecturer	Geomatics
Carlsson Niclas	Lecturer	Ecology
Eriksson Kristina	Lecturer	Biology Education
Lafage Denis	Lecturer	Ecology
Preece Anna-Sofia*	Lecturer	Public Health, Global Health, Social Medicine and Epidemiology
Eriksson Anders	Doctoral student	Biology Education
Marker Jeffery	Doctoral student	Ecology
Gal Raviv	Doctoral student	Ecology
Addo Louis	Doctoral student	Ecology
Motyka Roman	Doctoral student	Ecology
Filipsson Karl	Doctoral student	Ecology
Rydin Mikael	Doctoral student	Biology Education
Shry Samuel	Doctoral student	Ecology
Hoppenreijs Jacqueline	Doctoral student	Ecology
Hansen Henry	Doctoral student	Ecology
Blomqvist Elin	Doctoral student	Ecology
Rock Sebastian	Doctoral student	Ecology
Orlikowska Ewa	Administrative and technical staff	Ecology
Elmlund Anna	Administrative and technical staff	Other Biological Topics
Hajiesmaeili Mahboobeh	Administrative and technical staff	Ecology
Ekman Johanna	Administrative and technical staff	Ecology
Nordström Emil	Administrative and technical staff	Ecology

Source: Primula

\* Employed at another department, participating in research projects at the evaluation unit.

## THIRD-CYCLE STUDIES

**Table 2.1 Doctoral students at the Department of Environmental and Life Sciences**

Doctoral students by discipline, year of admission and activity-level during year 2022.  
Industry/collaboration/external doctoral students are marked with (I).

Name	Admission Subject	Degree of activity 2022	Year of admission	Industry/Collaboration/External (I)
Anders Eriksson	Biology	81	2020	
Anna-Clara Rönner	Biology	85	2020	(I)
Annika Forsler	Biology	90	2020	(I)
Annika Thyberg	Biology	37	2019	(I)
Barbro Kristina Eriksson	Biology	43	2019	
Elin Blomqvist	Biology	100	2021	
Florian Eggers	Biology	100	2020	(I)
Harald Raaijmakers	Biology	34	2018	(I)
Henry Harold Hansen	Biology	100	2020	
Jacqueline Hoppenreijis	Biology	79	2019	
Jeffery Duane Marker	Biology	85	2019	
Karl Filipsson	Biology	23	2017	
Louis Addo	Biology	80	2020	
Mikael Rydin	Biology	50	2020	
Raviv Gal	Biology	63	2019	
Roman Motyka	Biology	96	2019	
Samuel Joseph Shry	Biology	70	2020	
Sebastian Lorenzo Rock	Biology	80	2020	
Velizara Stoilova	Biology	100	2020	(I)

Source: Ladok

**Table 2.2 Graduate licentiate and doctoral students at the Department of Environmental and Life Sciences**

This table show students completing a Degree of Licentiate or Doctor 2020–2022.

Name	Subject	Degree	2020	2021	2022
Anna Mogren	Biology	Degree of Doctor	1		
Harald Raaijmakers	Biology	Degree of Licentiate			1
Karl Filipsson	Biology	Degree of Licentiate	1		
Karl Filipsson	Biology	Degree of Doctor			1
Kristine Lund Bjørnås	Biology	Degree of Licentiate	1		
Teresa Berglund	Biology	Degree of Doctor	1		
<b>Total</b>			<b>4</b>	<b>0</b>	<b>2</b>

Source: Ladok

## FINANCIAL RESOURCES

**Table 3.1 Research funding**

The table shows research funds spent at the Department of Environmental and Life Sciences for the period of 2020–2022. Amounts in SEK 1000.

Funding	2020	2021	2022
Faculty funding (governmental funding)	8 731	9 691	12 990
External funding <sup>1</sup>	11 430	15 433	13 680
Internal income <sup>2</sup>	5 424	2 839	831
<b>Total</b>	<b>25 585</b>	<b>27 962</b>	<b>27 500</b>
Percentage external funding	57%	61%	51%

Source: KULI/Raindance

<sup>1</sup> Includes revenue from fees, other reimbursements and funding which can include grants from Councils, other public research funding agencies, municipalities, regions and research foundations.

<sup>2</sup> Internal income includes, for example, grants and/or compensations from other parts of the university.

**Table 3.2 External research funding**

Distribution of external research funds spent during the period of 2020–2022. Amounts in SEK 1000.

Funding source	2020	2021	2022
EU and foreign organisations	1 604	3 618	4 452
Swedish research councils <sup>1</sup>	2 695	4 360	2 280
Swedish Foundations <sup>2</sup>	4 486	5 346	6 191
Industry, company etc.	2 613	2 079	765
Other public organisations <sup>3</sup>	32	30	8
<b>Total</b>	<b>11 430</b>	<b>15 433</b>	<b>13 680</b>

Source: KULI/Raindance

<sup>1</sup> Research Councils include the Swedish Research Council, Forte and Formas.

<sup>2</sup> Swedish Foundations include The Knowledge Foundation, Vinnova, The Swedish Energy Agency etc.

<sup>3</sup> Other public organisations include Country Councils, municipalities etc.

## EXTERNAL RESEARCH FUNDING STATISTICS

**Table 4.1 External research funding statistics**

Table shows number of grant applications submitted to external funding bodies and amount applied for and granted. Amounts in SEK 1000.

Funding source	2020	2021	2022
Number of grant applications	24	27	17
Number of granted applications	8	11	6
Amount applied	58 249	99 726	38 560
Amount granted	12 662	17 025	7 179
Success rate*	33%	41%	35%

Source: Raindance

\* Success rate is calculated on the number of granted applications in relation to those submitted.



## BIBLIOMETRIC ANALYSIS AND REFERENCE LIST

The research activity at Karlstad University is expressed, among other things, in scientific publications. This report aims to map the publishing activity and its development over time for the Department of Environmental and Life Sciences. The report also shows the proportion of internationally co-authored publications where at least one of the authors is affiliated with a university outside Sweden as well as the proportion of publications that are open access, i.e. freely available online.

## METOD

To get a complete coverage of what is published within the unit, the following tables are based on registered publications in DiVA (Digital Scientific Archive), the local publication repository where researchers, teachers and students register their research publications and essays. It covers all subject areas and publication types

Publication extraction for the years 2020–2022 has been based on the researchers individual Kau: ID, which links them with their respective publications. The list of researchers that are included in the analyses was provided by the HR department and includes also researchers that are no longer part of the unit but were employed during 2020–2022.

The analysis includes all publications where at least one of the authors is affiliated with Karlstad University. The publication subcategories presentation, entries, abstracts and “other” have been omitted from the analysis because these entries are registered to a very varying extent by the researchers. Doctoral dissertations and licentiate theses are reported in detail in other parts of the evaluation and have therefore also been omitted here.

## PUBLISHING OUTPUT

Counting the total number of publications is the simplest bibliometric measure for reporting publications over a period of time for a research-producing unit. During 2020–2023, 80 individuals from the Department of Environmental and Life Sciences published 167 publications.

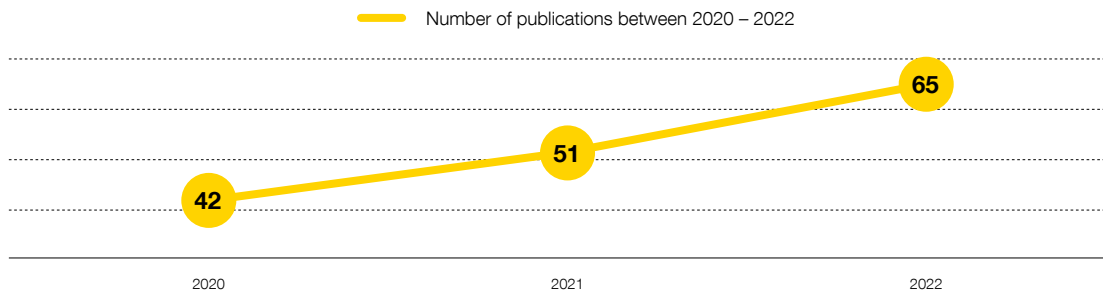
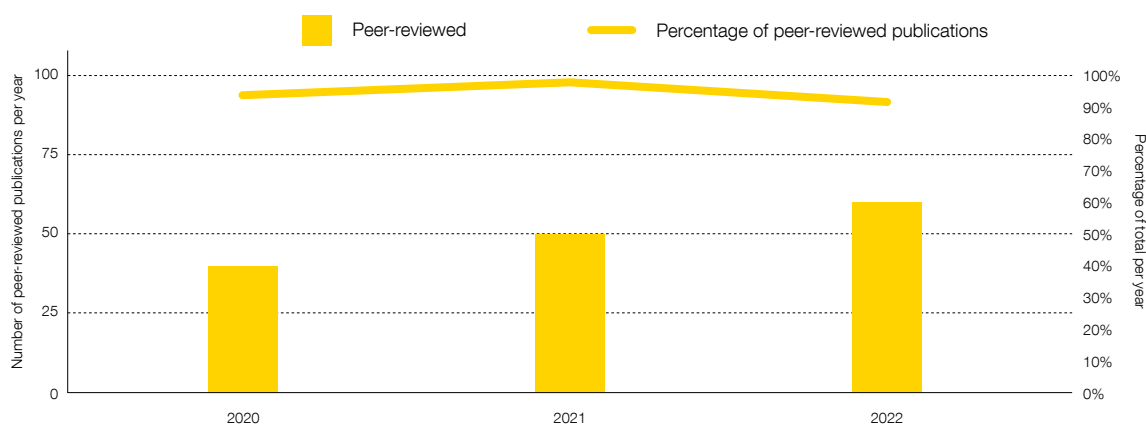


Figure 5.1 The annual total number of publications during 2020–2022



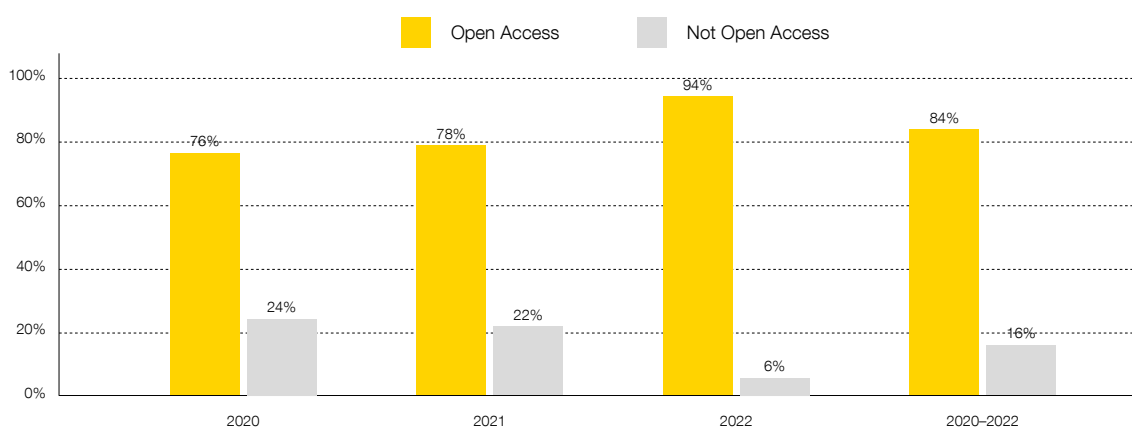
**Figure 5.2 Refereed/peer reviewed publications per year**

Number of peer-reviewed publications per year for the unit (bars). Percentage of peer-reviewed publications of the total annual number of publications (line).

**Table 5.2.2 Number of publications for each publication type**

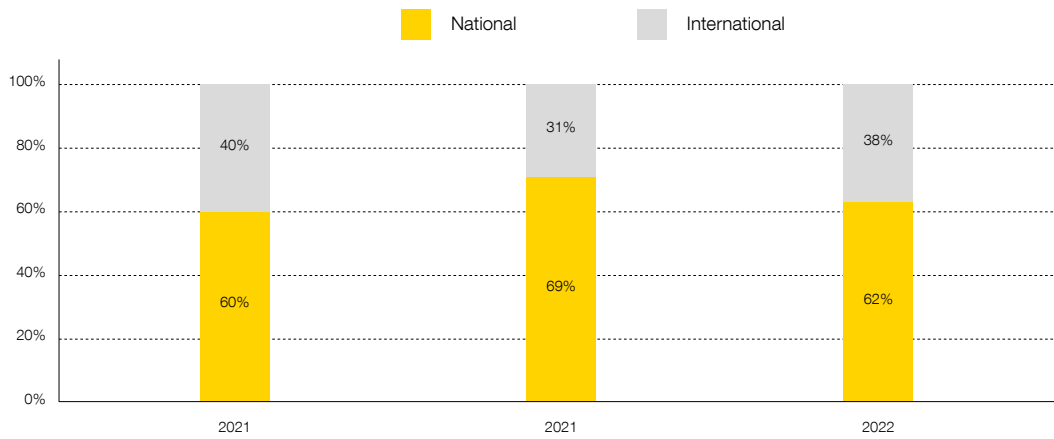
The unit's publications sorted by publication and content type for the years 2020–2022.

	Peer-reviewed	Scientific but not peer-reviewed	Other (popular scientific, debate)
Article in journal	123	1	2
Article, review/survey	6		
Book	1		
Chapter in book	14	3	
Collection (Editor)	3		
Report		5	



**Figure 5.3 Percentage of peer-reviewed articles that are open access vs. articles behind paywalls**

Comparison of the percentage of peer-reviewed articles that are open access and the percentage that are not.



**Figure 6.1 National and international co-authorship 2020–2022**

Proportion of the unit's publications with an international profile and publications where all authors were affiliated to Swedish organizations.

## PUBLICATION LIST

### Article in journal

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# Assessment report

## 0. Brief summary

Research at the Department of Environmental and Life Sciences covers three research areas: Ecology, Evolution and Sustainability; Biology Education; and Geomatics.

The area Ecology, Evolution and Sustainability has its base in the River Ecology and Management Group, RivEM, which conducts top-quality scientific research in basic and applied ecology. More recently the area has expanded towards evolutionary ecology. A current challenge is how to grow in terms of research subjects and management structure.

The Biology Education area is part of the SMEER research centre but also part of the department. This dual identity seems to work fine and the connection to SMEER is important in terms of research and funding. The area has diverse research interests and is looking for a “cohesive identity”; not necessarily a desirable aim since there is a strength in diversity.

Geomatics is a new and small research area, now expanding. Their current aim is to be recognised as a postgraduate discipline. For this they need to employ senior researchers, and their challenges lie in obtaining funds for this expansion through external funding and strategic investments from the department/university.

As a whole, the department is successful when it comes to scientific publications and obtaining external and university funding. The department is particularly strong in applied research with clear societal impact. However, all areas currently strive to also expand on their fundamental research. A challenge for the department is to achieve this without compromising the strength in applied research and keep the current good linkage between research and teaching.

# 1. Research and scientific development

The Department of Environmental and Life Sciences has three research areas: Ecology, Evolution and Sustainability; Biology Education; and Geomatics, where the first two belong to the subject Biology but Geomatics is its own subject. Geomatics is a new and still small research area which sees a need to grow, whereas the first two are well established.

Overall, the department has been successful when it comes to scientific publications and obtaining external research funding, something which has also led to increased university funding - due to the “formula” for distribution of faculty funds according to metrics of success in e.g. research.

The department is particularly strong in applied research, typically done in collaboration with stakeholders, and with clear societal impact (see section 4). However, all research areas currently strive to also expand on their fundamental research, presumably because results from such research may be of more general scientific interest and hence publishable in higher-tier journals. Strong merits from fundamental research could in turn increase the chances of obtaining external grants from new sources (agencies funding more curiosity-driven research, such as VR-NT open calls), make it easier for PhD students from the department to find postdoc positions and make the department more attractive for external recruitments. A common challenge for the department is to achieve this goal without compromising the strength in more applied research.

Much of the research occurs within the three research areas, but some joint projects cross the borders. We see a clear potential for increasing such scientific integration, in that all areas have a common interest in issues such as sustainability, climate change and biodiversity.

## **Ecology**

Research within the area of Ecology, Evolution and Sustainability is a strong and important component of research within the Department of Environmental and Life Science. There are three main themes of research in this area: (1) Sustaining living riverscapes and landscapes, (2) Adapting to global change, and (3) Evolutionary ecology. The first two themes, which are primarily associated with the River Ecology and Management (RivEM) group, consist mainly of diverse river-related ecological research that deal with e.g., hydropower, climate change, and invasive species, and the impact on stream organisms. Historically, research in this area was associated with the RivEM group, but recent recruits have broadened this area to include topics such as (i) invasive terrestrial species (e.g. lupin), (ii) aquaculture, and fundamental ecological and evolutionary questions less reliant on aquatic organisms as models (i.e. theme 3).

Researchers in this area have been very successful in securing external research funding, and the societal impact of the research is obvious and high. Because of this “external” success, and because internal funding is positively correlated with external success, there has been room for recruitment in this research area. By recent hiring of evolutionary ecologists, the research scope of the department has subsequently broadened. It is important that this research group comes to a consensus on a recruitment strategy, that ensures that (i) the RivEM group remains strong, (ii) that new recruits staff members will support and enhance the current research, without being artificially squeezed into the current RivEM research. If the scope of this research area is to be broadened further, it may be best to confine the expansion to a field of research that can run parallel to and/or support RivEM, and vice versa.

## **Biology education**

The overarching research themes for Biology Education are: 1) Practice-based educational research; 2) Development of theory and concepts in subject-specific education and 3) Education for sustainable development and the Anthropocene. Researchers in the area have in recent years published impactful and highly cited publications in these areas and successfully attracted VR funding for educational research and other external funding. They mention in writing that unifying these diverse research interests to establish a “cohesive identity” is a challenge. However, this need not necessarily be a desirable aim, as there is also strength in diversity.

The Biology Education research area has an intricate structure, in that it is a part of the SMEER research centre (Science, Mathematics and Engineering Education Research; evaluated separately), but also an integral part of the Biology subject at the Department. The staff sees some challenges navigating this structure when it comes to e.g. financing, employment of staff and recruitment, but also advantages (see also section 3), and our impression is that they do not want it to change. The SMEER connection furthers development of more general theory and concepts in

subject-specific education. On the other hand, membership in the Biology subject provides close access to biology research and teaching, and opportunities for collaborations.

This research area mentions as its particular strengths that they have a profound academic research proficiency in Biology education and strong national and international networks, and we can only agree. The challenge identified is primarily increasing didactics research at the department, since permanent staff is employed by the department rather than by SMEER. The primary consideration has thus been to fulfill teaching requirements rather than research.

### **Geomatics**

Until recently the geomatics staff was mainly a few teachers that taught two bachelor programs. The staff members were hired based on teaching needs (and Swedish language was a requirement). Recently, two new international and younger researchers were employed, which has increased the research activity substantially. These researchers have both started up new research directions and enhanced the previous research (with e.g. joint successful applications).

The geomatics research area plans to expand further in the coming years. The first milestone is the start of an international master program in 2026. The next step is to create an own research profile, among others to meet the requirements to establish a PhD program. Ideally, this could be achieved in 2028, but this would require: (1) a good start of the master program, and (2) that the permanent staff requirements for an own research profile is met (2 professors, 2 docents and 1 senior lecturer). To meet the latter requirement the geomatics research area needs to recruit several new senior researchers (e.g., currently there is no professor). This, in turn, would require that the geomatics research area obtains strategic support from the department/faculty/university and/or that they are successful in attracting research grants. So far, Geomatics has been successful in being a partner in several research projects, but they have not been the main partner and partly therefore not been able to attract the larger financial resources needed to support further recruitments.

The geomatics field is in rapid development due to an increasing amount of geospatial data and improved analysis methods, including GeoAI methods. The geomatics research area has potential to be a national, and some niches also international, player in this rapid development. To accomplish this it is important to have a strategy for the (possible) recruitment in the coming years. On the other hand, it is also important that the recruitments support the teaching duties in the department, which make the recruitment a balancing challenge.

## 2. Academic qualifications and ensuring competence maintenance in the short and long term

There are two types of recruitments: (1) positions mainly targeting teaching needs, which are in many cases retirement replacements and often with a requirement of Swedish language skill, and (2) positions more related to research needs. KAU has traditionally had the focus on bachelor and master education, and hence the first type of recruitment has dominated. But the research side is increasingly important at KAU, a trend that is also visible in the Department of Environmental and Life Sciences. The research areas Biology Education and Geomatics have earlier only recruited in the first category, but have more recently started to internationally recruit more research-oriented staff.

For both categories the initiatives for the new positions are taken by the departments. Then the final decisions are made by the dean (vice chancellor in case of professors), based on whether the department can show that they have resources for the new positions (mainly based on teaching and external funding). All three research areas at the Department of Environmental and Life Sciences have recently employed new staff and are also planning to grow in the near future. Currently, there seems not to be any internal disagreement about resources for the new positions.

KAU announced 15 new career development positions a couple of years ago using saved governmental money (swe: *myndighetskapital*). Two of these positions were given to the research area Ecology, Evolution and Sustainability that enabled them to extend the group in the field of evolutionary biology.

There are large differences between the research areas in the possibility to attract new staff. The Ecology, Evolution and Sustainability research group has always received many applicants. It has been more difficult to find good applicants in the other two research areas, partly because Swedish language knowledge has most of the times been a requirement. Recently, the geomatics research area hired two younger international researchers. Hopefully, these new researchers can make geomatics at KAU more well-known, also internationally, which potentially will give more applicants to new positions in the future.

Most staff in the Biology Education research area have a background from their own department. Moreover, several of the senior lectures have been recruited directly from the PhD education. This is not the case in e.g. the Ecology, Evolution and Sustainability research group where a postdoc period is required for the permanent positions. One reason for this situation is that many of the PhD students in Biology education has teaching experience from e.g. high school before going back to the university environment, and therefore they are older when defending their PhD thesis and at that age not so inclined to e.g. go abroad for a postdoc position.

There is no specific startup package for newly recruited staff including e.g. a PhD student and technicians. But there is an informal rule that the new staff should not initially be overloaded with teaching to provide them with time to develop their research, learn Swedish (if necessary) and apply for external funding.

There is a guideline document to support the new staff at the department. The department has not had any formal mentorship program, but there is an unofficial "buddy system" in place, especially for PhD students.

### **PhD education**

There are around 20 PhD students within the department and all of them are within the Biology study plan. This study plan is written so that it should fit both the ecology and biology education PhD students. There is no PhD program in geomatics; it is within their long-term goal to establish such a program. There will be a new PhD student supervised from the staff in geomatics but this PhD student will formally be in a social science PhD program.

The PhD students feel that there are enough PhD courses to choose from. Some of them also point out that it is good to attend PhD courses at other universities to get a broader perspective and to extend the research network.

Many of the PhD students conduct undergraduate teaching, and at least the ones we met during the online site visit were very positive to teach up to the maximum allowed limit of 20%. Five PhD students have a very low activity grade (substantially below 80%); the reason for this was stated as other department duties, paternal leave, and personal circumstances. In Biology education there are some teaching staff that perform PhD studies in parallel with other (teaching) duties in schools.

Several of the PhD students in Biology education are linked to graduate schools, e.g. the graduate school "Knowledge, Subjects and Quality in Teacher Education and Classroom" funded by VR (three PhD students from BE) and the Swedish National Graduate School in Science and Technology Education.

### 3. Organisation, leadership and management

The Department of Environmental and Life Sciences is organized into three areas: (1) Ecology, Evolution and Sustainability, (2) Biology Education, and (3) Geomatics, where research in (1) and (3) fall directly under the department, but research in (2) falls under SMEER, which provides an infrastructure for education research in different disciplines across the university. This provides an interesting and somewhat unique structure, where faculty associated with Biology education are employed by the Department of Environmental and Life Sciences, hosted by the Faculty of Health, Science and Technology (HNT), but also funded internally and supervised by the Faculty Board for Teachers Education. Importantly, Biology Education members contribute significantly to SMEER, which is overseen by a director (from Biology Education), who is assisted by a working committee, of which three out of seven members are from Biology Education. Although this complex structure may cause some difficulties (e.g. reported limited support for Biology Education from HNT, and the potential for this area to be undervalued in the department), the presence of Biology Education within the Department of Environmental and Life Sciences provides a platform for collaboration, and can strengthen the relationship between education and research, e.g. in the fields of biodiversity and sustainability.

In spite of the differences among the three research areas, both in terms of emphasis and presence/size, there appears to be general respect among staff and Ph.D. students across the areas. The head of the department position is rotated, at least to some degree, among the research areas, and the sense is that irrespective of their area, past and present heads of the department have worked toward improving and serving the department as a whole. Another contributing factor to the apparent “harmony“ within the department, may be that all research areas are housed in the same building (albeit not on the same floor). This proximity stimulates interaction (i) between staff and graduate students, and (ii) among different research areas. A new shared lunch/coffee room will likely promote departmental cohesion even further. Although most research projects occur within the three research areas, a departmental management group, which includes people from different areas, does exist. Perhaps a more formal group or committee, that includes faculty and students from all research areas, could promote further collaboration and unity among the areas. An informal Ph.D. student group exists across research areas, but is dormant at the moment; the plan is to activate the group again.

Physical resources, facilities, and laboratories appear to be sufficient for the current research at the department. Of the three research areas, Ecology, Evolution and Sustainability requires the most on-site laboratory space, which includes e.g. 250 m<sup>2</sup> aquarium lab facility and a recent laboratory facility for eco-evolutionary research on *Drosophila*. Further development of any of the three research areas in the department should not be hindered by logistics in the near future.

Because all research areas have a goal of either maintaining or increasing the number of staff contributing to research, there is some potential for conflicts among research areas for future funding. Decisions on recruitments are primarily taken at a departmental level, and are apparently invariably backed up by the Dean of the faculty. In general, the Department of Environmental and Life Sciences has done well in securing external funding, which has yielded increased internal funding as well. According to the Dean, an increase in staff numbers in Geomatics, which is in the research area in the greatest need for expansion, will rely on an increase in external funding, which again can lead to more internal funding. The distribution of funding within the department also follows some general rules, which are not completely clear to us, or to all faculty members. It is important that the processes underlying the generation and distribution of funding within the department are clear or at least accessible to all faculty members. One financial issue that was brought up in the discussion was whether the department pays the fourth year for a PhD student (if the funding organisation only pays three years, which e.g. Formas does). The staff was uncertain whether such a rule did exist, or if it was handled case by case.



## 4. Collaboration, utilization and impact of research

### **Ecology**

The ecology, evolution and sustainability research area has a long history of collaboration in applied and fundamental research, which extends to numerous academic and governmental institutions, as well as major companies and stakeholders. The list of collaborators extends to a range of local, national and international entities such as the Swedish Agency for Marine and Water Management (HaV), County Administration Boards, hydropower companies, the Swedish Transport Administration, the Swedish Energy Agency, the EU Marie-Curie programme, and the EU LIFE programme. The research unit has also established a recent partnership with three other universities in the Swedish Centre for Sustainable Hydropower (SVC). The research area has also participated in various social outreach projects in relation to education and social services (e.g. serving as experts in court), as well as making efforts towards reaching the public. Although the research area does not seem to contribute much to popular scientific journals, information is disseminated e.g., through radio interviews and events such as the RivEM week and the biannual “Green day”.

As an example of utilisation and impact, the main emphasis of the RivEM research group has been to apply ecology to increase the understanding of, and solving problems arising from pressing ecological issues, such as the sustainability of hydroelectric structures, climate change, and threats to biodiversity. For example, output of the research group can directly influence the relicensing of hydropower development in Sweden.

### **Biology education**

The Biology education research area has a strong network of academic national collaboration. The university-wide ROSE collaboration at KAU led to participation in the national ULF project on practice-based educational research, and subsequently in a VR-funded graduate school together with University West and Halmstad University. PhD students from the area can also participate in the Swedish National Graduate School in Science and Technology, and this national program has in turn fostered four of the current full time senior staff.

The research in the theme on Practice-based educational research is primarily conducted within the classroom context, and as such is performed in close collaboration with teachers at schools, furthering also school development and teacher competence development. Teachers are also involved in the research theme on theory and concepts in subject-specific education, adapting the research results for teaching purposes (e.g. epigenetics and photosynthesis projects). Finally, Education for sustainable development (ESD) and the Anthropocene involves close collaboration with schools. Project outcomes have included the development of practices for teaching ESD and how to reduce climate anxiety among students (in collaboration with psychologists). Research from KAU and collaborating partners in the ESD area has evidently had a clear societal impact on school practices in Sweden and other European countries.

A clear challenge is to balance these important but demanding collaborations with teachers and schools in the vicinity with maintaining the focus on international publication and theoretical development.

### **Geomatics**

Geomatics research is often interdisciplinary in the context that geomatics theories and methods are applied to solve research questions and real-world problems in other domains. Therefore, geomatics researchers often cooperate with other research groups, which is also the case in Karlstad. There are established cooperation with the Centre for Societal Risk Research (CSR) and Centre for Research on Sustainable Societal Transformation (CRS). The joint research projects have been applied on applications such as natural hazards, disasters and sustainability. But they have also worked in other areas such as archeology..

The geomatics research area has also worked together with organizations outside academia, such as the Swedish Civil Contingencies Agency (MSB), local rescue services, local authorities and the Church of Sweden.

In the self-evaluation it is noted that there are some challenges with too many cooperation projects, especially with organizations outside academia. These projects often require that technical reports are written and that there is not enough time to write scientific papers. Furthermore, in some projects there is no possibility to formulate adequate research questions required for scientific publications. Therefore the geomatics research area strives to complement the applied cooperation projects with more research projects, where they also are the main applicants (see section 1).

## 5. Internationalisation, gender equality, research integrity and multidisciplinary collaboration

### **Internationalisation**

The ecological research area has a particular internationally recognized strength in applied research regarding solutions for fish passage and habitat in hydropowered-regulated rivers, and this has led to several international collaborations. This includes participation in a Marie Curie PhD training network (RIBES) including eight European universities, and a modeling collaboration with Humboldt State University, USA. Researchers in the area have also attracted international funding, such as for two EU LIFE projects.

For Biology education the internationally strongest research theme is the Education for sustainable development. A project on critical thinking in sustainability education funded by the Norwegian research council involves primary school teachers in Karlstad municipality and several municipalities in Norway. Researchers from KAU also participate in initiatives such as the European Network for Environmental Citizenship Education (including 39 countries), the EU Horizon 2020 project COSMOS, and the Horizon-CL5-2023 project IMPACT. As a result of such projects, co-publications with international researchers have become much more frequent.

The Geomatics research area has not participated much in international research projects and the dissemination of findings has been primarily local and national (often in the form of project reports) rather than international publications. However, due to the new recruitments this is now changing, and Geomatics publishes internationally as well as contributes to international knowledge development through several expert groups, contributing to EU parliamentary debates. Plans are ongoing to further strengthen internationalisation of research as well as education, for instance connecting a student exchange program to the outlined Masters programme.

### **Gender**

The department is unbalanced in terms of gender equality when it comes to staff positions, in that six out of seven professors are male. The gender balance is more equal at more junior levels of permanent researcher staff, but again most PhD students are male. Staff at the department is evidently aware of the unbalance, and are taking steps to change it. There are attempts to identify strong female candidates for positions and contact them personally, a practice that should be further encouraged. There is also an ongoing and positive discussion regarding the problems that can be associated with gender unbalance, where female staff may be overloaded with duties because of the desire to have both genders represented. Besides positions, there seems to be a clear awareness of other aspects of gender, such as a striving to have a gender balance in invited speakers, authors of papers to be discussed, faculty opponents etc.

### **Research integrity and ethics**

There are obligatory courses regarding the ethical handling of research animals (in particular fish) and humans (biology education). There is also an obligatory ethics PhD course, evidently university-wide. This is important, but since the concrete ethical aspects vary considerably across subjects the department should also consider giving PhD courses more tailor-made to the research at the department (if this is not already done). This should include possible ethical conflicts arising from the many collaborations with stakeholders outside of academia at the department.

### **Multidisciplinary collaborations**

The department has a strong track record when it comes to multidisciplinary collaborations. The ecological research area participates in RIBES (see above), along with experts in environmental fluid mechanics and hydraulic engineering. The two EU LIFE projects are also of an interdisciplinary nature. However, the research area mentions as a challenge that they would like to advance transdisciplinary research to also encompass social science aspects. This seems natural, given that the research frequently has a strong societal impact. Research in Biology education frequently is of an interdisciplinary nature, for instance the collaboration with psychologists (see above), and perhaps in particular participation in the VR-supported initiative EBAN, where researchers from several disciplines (and countries) will come together. Geomatics is an interdisciplinary subject by its very nature, and as such is part of several large interdisciplinary consortia. Researchers from the area have contributed to publications on a range of multidisciplinary sustainability topics such as invasive species, cloudburst damages, epidemiology, accessibility to healthcare facilities and the well-being of urban residents.

## 6. Connection between education and research

KAU is foremost a teaching institution, even though research has become increasingly important. All permanent staff, including professors, are required to teach at least 20% (according to a previous vice-chancellor decision). This means that the students will meet active researchers as teachers.

The teaching is an important factor that decides much of the economy at the departments. The bachelor and undergraduate programs at the Department of Environmental and Life Sciences have many applicants, which has enabled programs with many students. This has, in turn, been one of the main reasons that the department has grown in recent years (the other main reason is the increase in external funding).

Within the Ecology, Evolution and Sustainability research area findings are regularly presented during weekly seminars and special events, where students are present. These seminars also work as an information for the students to define their master thesis projects, which they often conduct in co-operation with a research project. The research area also has a supportive role for the students' future careers. Among others, they arrange the Green Day, where Bachelor's and Master's degree students are invited to discuss future opportunities with potential employers, researchers and societal stakeholders.

In the Biology Education research area there is a strong, and natural, link to education. Much of the research concerns didactic methods which are evaluated on teaching on all levels. With few exceptions the researchers are active as teachers in the teacher education programs and are developing courses for teacher education. This facilitates a transition of research results directly to the teaching students, which is especially valuable in the end of their studies (in e.g. the independent/degree projects).

Previously the staff in Geomatics had almost exclusively worked with the two bachelor programs. In recent years, the research activities have been extended, which also have been a support to the bachelor program. This is especially seen in the planning of the new master and PhD programs. Since the Geomatics research area is planning to extend their staff in the coming years they have good opportunities to formulate the announcements so that the new staff supports the new master program. To realize this, it is important that the direction of the master program is decided (a discussion which has already started).

Many of the students within the biology and geomatics programs are given on distance (where the students only are required to be at KAU at certain events). This seems to be a good alternative to attract new student groups, and raise the total number of students. However, it is uncertain to what extent this will affect the connection between research and education. Here the content of the distance courses is not the challenge (it is likely the same as on campus), but that the distance students do not get much experience of being in an academic environment and meeting researchers.

## 7. Concluding assessment and recommendation for continued development

Overall, the research at the Department of Environmental and Life Sciences is of a high quality. Below we list major recommendations to maintain and further strengthen this quality. Note that minor recommendations are also interspersed throughout the report.

The department has been quite successful when it comes to scientific publications and obtaining external funding for its research, something which has also resulted in increased university funding. The historic “core” of research concerns River Ecology and Management as well as Biological education. The ecological research area has recently expanded towards evolutionary ecology as well as other topics, and the Geomatics research area has been added and is expanding. A primary challenge for the department lies in handling these expansions without compromising the historical strengths. We note that the department seems to have a good “quality culture”, where discussions on such potentially divisive subjects can take place without too much conflict. It is important to safeguard and if possible further promote this culture, ensuring that there are avenues for inter-departmental strategic discussions. PhD students should be included in this process.

Much of the research is performed within the three research areas, but some joint projects cross the borders. We see a clear potential for increasing such scientific integration, in that all areas have a common interest in issues such as sustainability, climate change and biodiversity. Avenues for further increasing joint projects across the department should be promoted.

The department is particularly strong when it comes to applied research, typically in collaboration with stakeholders, and with clear societal impact. From a management perspective it is important to support such cooperation. However, all research areas currently strive to also expand on their fundamental research. This goal should be furthered, but another challenge for the department is to achieve this goal without compromising the strength in more applied research. The two types of research do not necessarily stand in opposition.

The ecological and educational research areas have a strong track record when it comes to international collaborations, and the plans for increased internationalisation in Geomatics should be encouraged, including plans for student exchange. All three research areas have a clear and commendable multidisciplinary approach in their research. Ecology aims to advance this further, towards including more social sciences aspects - a natural and positive development considering the societal impact of their research topics.

For recruitments, there should preferably be a healthy mix of “homegrown” staff and external recruitments. There should be a career plan for younger researchers, and a mentor system in place. Criteria for promotion should be clear and well communicated.

Issues concerning gender and research integrity seem to be handled quite adequately at the department, although there is always room for improvement in these areas. Strong candidates of the underrepresented gender should always be personally contacted for recruitments. Departmental PhD course(s) on research ethics and research integrity, tailor-made for the department’s research, should be considered.

There are clear links between research and education at the department for two reasons: First, all researchers teach at least 20%, and this “rule” should be kept. This is important both so that the whole staff actively supports the teaching (e.g. with new research findings) and so that the bachelor and master students meet researchers. The teaching perspective should always be included in the decision of new staff. This is especially important in Geomatics, where the planned new positions will decide the direction of the forthcoming master program.

Second, the inclusion of Biology education as a research area within the department not only ensures strong ties to education for researchers *within* the area, but also provides the potential for researchers in the other areas to form such ties. Future expansion of the links to education is planned for Geomatics, where a Masters programme is now being formed and a PhD programme is planned. For the latter goal recruitments are needed, and this may necessitate support from both the department and from the university. This would be a step to meet KAU's strategic goal of expanding the PhD education.

The department has a strong profile towards distance teaching. There is a risk that this weakens the link between research and education in that students do not truly meet an academic environment, and these effects should be evaluated.