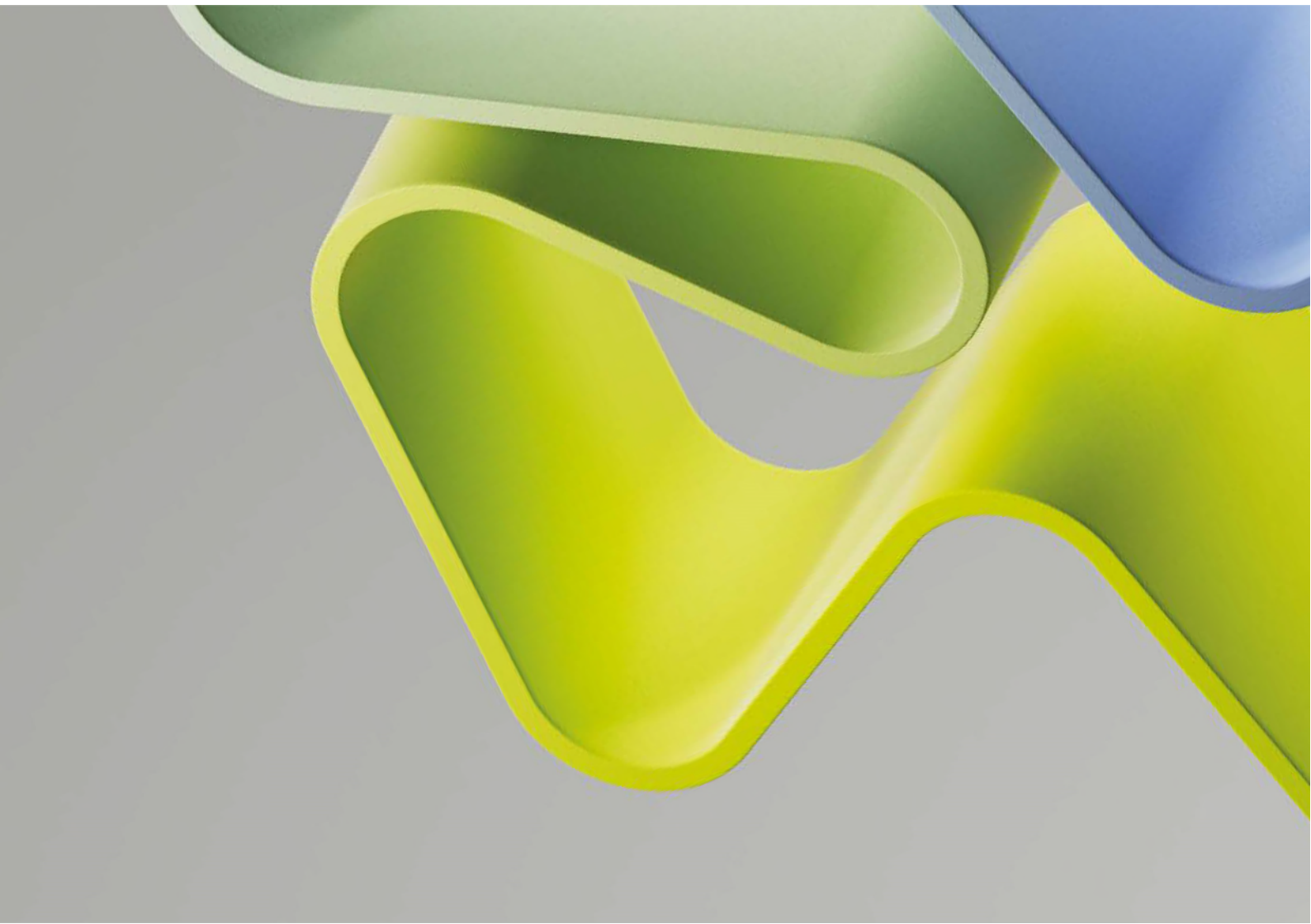
The Research Council of Norway

Project Results 2017–2023

Research Cooperation Norway-India



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Preface

Dear reader,

The backdrop to the results presented in this report spans back, in truth, more than a decade.
The strong tradition for Norwegian-Indian research collaboration has been steadily built across many years of consistent work by many talented and dedicated researchers who have shared a vision of closer collaboration between our countries, in the pursuit of solving some of the most wicked problems in our world. To solve these problems and achieve the United Nations' Sustainable Development Goals, we must work interdisciplinary, transdisciplinary, and internationally.
Over the years, Indian and Norwegian research communities have been paving the way for knowledge-based, sustainable development. Areas such as combating mother and infant mortality, saving the ocean, making our buildings and engines more energy efficient, digital innovation, and boosting the circularity of our economy.
India is becoming a powerhouse for science and technology and is a preferred choice for many Norwegian institutions looking for partnerships.
The thematic areas covered under the Indo-Norwegian research cooperation have been quite broad, spanning from social sciences and natural sciences and technology. Many of the areas are directly related to the Sustainable development goals, such as research on the climate, polar sciences, geohazards, energy, bioeconomy, and antimicrobial resistance. And it has produced impressive results.
To take an example, in 2005, Norway and India engaged in a partnership on vaccine research, which turned out to be instrumental in the development of a new and more affordable Rota vaccine. It is an example of how joint efforts and competences can be used to achieve a solution to critical global challenges.
The Norwegian and Indian governments have been firm supporters of this vision of joint research and have a long history of financing joint research collaboration between our countries. In the two decades spanning 2003-2023, the Norwegian government has dedicated nearly 1,2 billion NOK, about 9 billion rupees, to 204 projects which have had Indian partner organizations. India matches this with its own funding. The collaboration with Indian partners is characterized by reciprocity, drawing on each country’s strengths and sharing financial obligations.
Since 2010, the Norwegian Ministry of Foreign Affairs has been allocating dedicated funding to the Research Council to further the cooperation with India, in line with the then newly launched national India-strategy, which was published in 2009.
Under the current strategy, Norway-India 2030, we have seen that the investments in and results of our joint research projects are multiplying. This strategy recognizes research cooperation as a key tool in priority areas such as oceans, energy, climate, environment, digital public goods, democracy, and a rules-based world order. Due to these efforts, we saw a significant increase in the number of collaborative research projects between Indian and Norwegian institutions from 44 in 2013 to 71 in 2022.

The results presented in this report are evidence of that and are focusing on the projects financed specifically by the Norwegian MFA's dedicated funds.
In effectuating the projects presented in this report, the Research Council of Norway has enjoyed a very good partnership with our main partner Department of Science and Technology. Over the years, the cooperation has been extended with Memorandums of Understanding with Ministry of Earth Sciences and Indian Council for Medical Research. In addition, the RCN has a good partnership with the Indian Council for Social Science research. This has been important to cover relevant thematic areas under the Program of Cooperation.
All projects have been chosen for their high scientific quality and show complementary competence. Numerous joint workshops have aided in mapping potential areas of cooperation. Strong institutional relationships have been developed, facilitating sustainability in the cooperation. The number of co-publications between Norwegian and Indian researchers has shown a significant increase in the past few years, from 242 in 2017 to 698 in 2022.
This report outlines the main results and gives a glimpse of a selected number of projects. Project funding for Indo-Norwegian cooperation can take many forms. The Research Councils open arenas encourage international cooperation and will in most instances also finance international partners. In addition, several joint calls based on reciprocal funding with Indian government have been issued over the years. Participation in multilateral platforms is also an important arena, connecting the India cooperation with a wider international network. In this sense the EU framework program and EU partnerships are of particular interest. It is therefore encouraging to see Indias increasing interest in engaging with the EU also within science and technology.
India and Norway have a strong foundation for future research cooperation. Our job is to get the necessary agreements in place. To open doors. To clear bureaucratic obstacles, so that information and cooperation between our research institutions can be as smooth as possible. But our job is also to celebrate all the great research that has come out of this dedication to join research between our countries to this day. That is what this report is about.

We hope you enjoy the read!

All the best,

Mari Sundli Tveit, Chief Executive, The Research Council of Norway

Introduction

The Norwegian Initiative for Research Cooperation with India (INDNOR)

- **In the period 2010-2023, more than 20 calls have been issued to strengthen Indo-Norwegian research cooperation, resulting in over 100 projects being funded. The calls have covered broadly among cooperation topics, with a mix of unilateral calls, bilateral calls with Indian funding partners, and multilateral Indo-European calls.**
- **After the initial phase of establishing and consolidating the initiative as well as the relationship with partners in India, the activity level has been high the past few years before the pandemic and is again gaining momentum. The INDNOR initiative now has in place a good framework for research cooperation with India that future collaboration can build upon.**
- **This report highlights the research cooperation between Norway and India channeled through the Research Council of Norway (RCN) in the period 2017-2023. In this period close to 70 projects have been active and financed through funding from The Norwegian Ministry of Foreign Affairs (MFA) and additional funding from other budget lines at RCN.**

Background and bilateral framework

India's rapidly growing economy and systematic investment in knowledge production makes it an interesting market for Norwegian knowledge-based industry and an attractive scientific partner in many research fields. Leading documents for Indo-Norwegian research cooperation are The Norwegian Government's "Panorama 2021 – 2027 – Norway's strategy for bilateral cooperation on higher education and research with key partner countries outside the EU), "Panorama II, and The Norwegian Government's strategy for cooperation between Norway and India, "Norway – India 2030". The latter highlights research cooperation as one of three focus areas for achieving the objectives sat out in the strategy.

An "Agreement between the Government of the Republic of India and the Government of Norway on Cooperation in the Fields of Science and Technology" was signed 14. Nov 2006. Under this Agreement a "Programme of Cooperation" defining areas of research cooperation was signed 14. May 2009. This «Programme of Cooperation" is revised in the bi-annual meeting of the Joint Working Group (JWG) on Science and Technology.

The INDNOR funding initiative collaborates and joins financial and administrative resources with other thematic research funding initiatives at the RCN in national calls. Joint calls are being arranged with Department of Science and Technology in India, in addition to directly with other Indian funding partners such as the Ministry of Earth Sciences and Indian Council for medical research, and European platforms. Joint and multilateral calls have the added value of generating funding from Indian and EU partners, making the potential impact of the projects larger.

Financial and decision-making framework

The INDNOR funding initiative is financed by MFA with 174 357 000 million NOK total in the period of 2017-23. The Portfolio Board for Global development and international relations has from January 1st. 2022 been given the responsibility for the initiative and will make decisions om allocations of funding.

Objectives

The INDNOR funding initiative has been established to promote collaboration on research and research funding between India and Norway. The INDNOR initiative did originally focus on the following five thematic priority areas: **international political issues, climate, the environment, clean energy and social development.** The initiative is aiming at including a wider range of thematic areas and scientific fields.

The funding initiative is also used as a tool to follow up on the bilateral agreement on Science and Technology. The Programme of Cooperation has set the following thematic priorities for the cooperation for 2016-2019 and is set to be renewed and updated with a new period of collaboration.

- **Climate research** including **ocean** and arctic/**polar** research
- **Clean energy**
- **Geotechnology** and **geohazards**
- **Marine** research – **bioprospecting** and polar research
- **Nano-**science/-technology
- **Vaccines** – human and fish/ animal, including vaccination programmes and biotechnology of new vaccine development
- **Information and Communication Technologies**
- **Glaciology**
- **Medical research** (Cancer, diabetes, infectious diseases etc)
- **Bioeconomy**
- **Industrial R & D relevant/ complementary to both countries**

The Norwegian Government's strategy for cooperation between Norway and India, "Norway – India 2030", highlights research cooperation as one of three focus areas for achieving the objectives set out in the strategy. Important thematic areas for research outlined in the strategy are **international relations, the ocean, energy, climate and environment and global health.** These thematic issues will be hallmarks of the cooperation going forward.

A position as Science and Technology Counsellor is established at Innovation Norway’s office in New Delhi. The position is co-financed by Innovation Norway, Ministry of Education and Research, the Norwegian Directorate for Higher Education and Skills and the Research Council of Norway. This position allows for further exploring of synergies between Innovation Norway and The Norwegian Embassy’s activities and mandates in India. Closer alignment with the embassy’s priorities and MFA’s strategy for research and thus coordinating the research effort will give greater impact to the prioritized areas. Close cooperation with Innovation Norway will facilitate an increased level and quality in the industrial research and Innovation cooperation with India.

Allocations and calls for proposals 2017-2023

The funding from MFA 2017-2023 has partly been allocated to financing of ongoing projects active from 2017 and onwards. In addition, new calls have been issued within the areas of antimicrobial resistance (one bilateral, one national), ICT (bilateral), bioeconomy (bilateral), energy (bilateral), social sciences and humanities (multilateral), nanotechnology (bilateral) and international politics (national). The INDNOR funding initiative has also contributed with funding for three INTPART (International partnerships for excellent education, research and innovation) calls. Other funding initiatives at RCN have also supported projects with Indian partners through their regular calls, doubling the dedicated funding from MFA.

In the period 2017-2022 the number of projects funded over the RCN portfolio has risen from 49 in 2017 to 71 in 2022. (**Figure 1**)

Figure 1: Projects in Cooperation with India (Active)

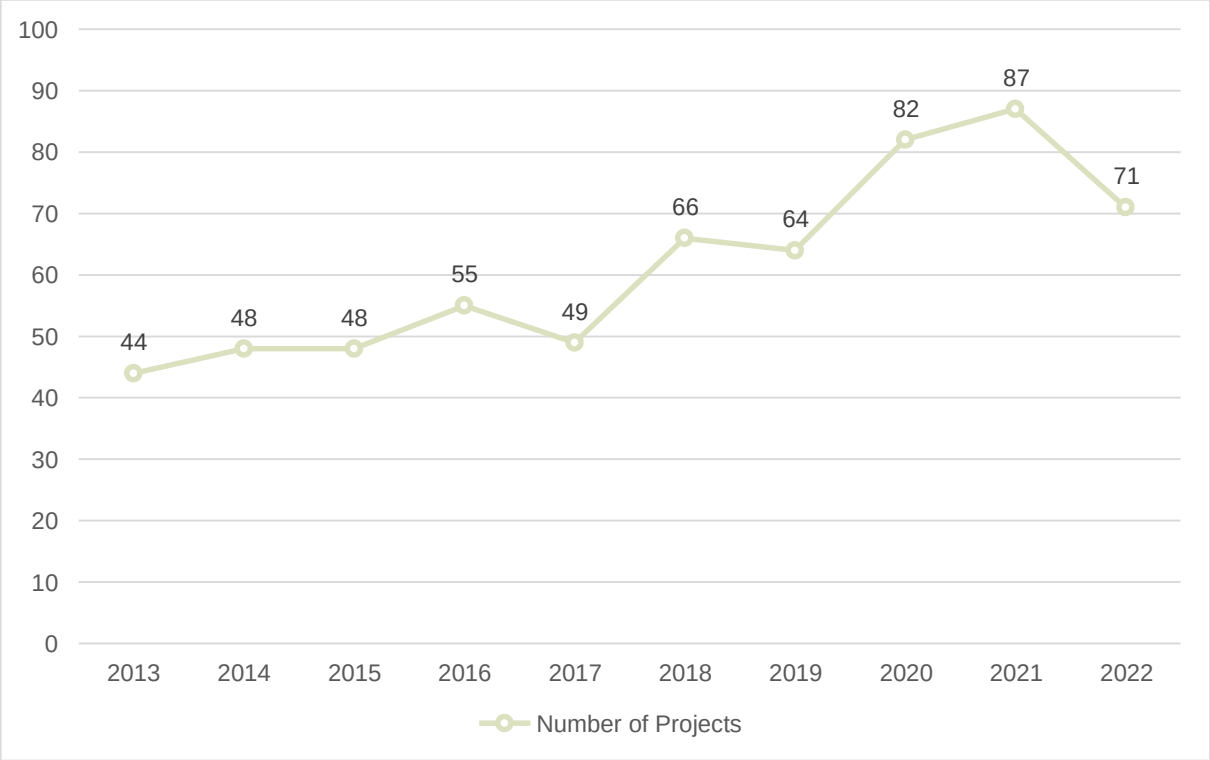
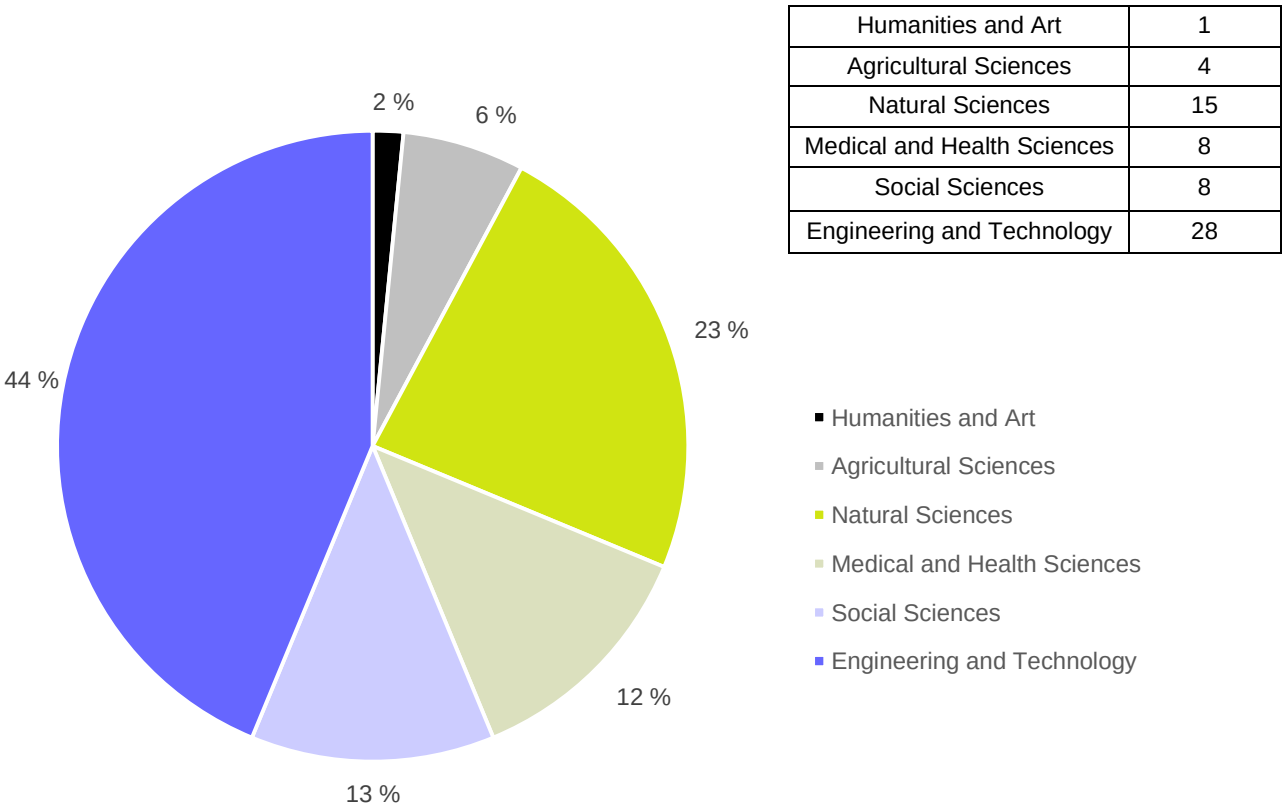


Figure 1: Source: RCN Portfolio (10.08.23) *The diagram is solely based on the RCN Portfolio and does not include potential cooperation projects from e.g., Horizon2020 or Horizon Europe*

Technology (ICT, nano, energy, bioeconomy) is the strongest area (44 % of the projects). Mathematics and natural sciences (climate and environment, polar sciences) and health (global health, AMR) are well represented with 22 % and 12 % of the projects. Social sciences are making up 13 % of the projects. (**Figure 2**).

Figure 2: MFA-Financed Projects – Distributed on Subject Areas



Humanities and Art	1
Agricultural Sciences	4
Natural Sciences	15
Medical and Health Sciences	8
Social Sciences	8
Engineering and Technology	28

Figure 2: Source: RCN Portfolio (10.08.23) *The diagram displays the distribution of research projects funded by the Ministry of Foreign Affairs in the period 2017-2022.*

Norwegian research institutions are represented in a broad scale within the portfolio. Norwegian University of Science and Technology (NTNU) (10), University of Oslo (UiO) (10) and SINTEF (9) are leading in terms of number of projects. In total, 26 Norwegian entities are represented in the portfolio (**Table 1**).

Table 1: Norwegian Research Institutions

Research Organization	Number of Projects
The Oslo School of Architecture and Design	1
CICERO – Center for Climate Research	2
Norwegian Defense Research Establishment (FFI)	1
Helse Bergen (Haukeland University Hospital)	1
Innland Norway University of Applied Sciences	2
Western Norway University of Applied Sciences (HVL)	1
Institute for Energy Technology	1
Norwegian Institute of Bioeconomy Research (NIBIO)	1
NOFIMA AS	1
NORCE – Norwegian Research Center AS	1
Norway Geological Service (NGU)	1
Norwegian University for Life Sciences (NMBU)	2
Norwegian University of Science and Technology	10
Research Institute for Water and The Environment (NIVA)	1
Norwegian Polar Institute	2
Oslo University Hospital	1
Oslo Metropolitan University	1
SINTEF AS	5
SINTEF Energy AS	3
SINTEF Ocean AS	1
NORSAR	1
University of Agder	4
University of Bergen	4
University of Oslo	10
University of Stavanger	1
University of Tromsø – The Artic University of Norway	5

Scope of the report

This report focuses on active projects funded by MFA in the period 2017-2023. In the appendix there is a list over all projects with link to the Project Databank for further reading. 15 projects are presented in more detail on the following pages. We hope this makes for interesting reading.

The programme has established a Facebook group "Research Cooperation With India".

In addition to this report the Norwegian Research Council and the Norwegian Ministry of Foreign Affairs has developed a short 4-minute video to highlight some of the main developments that have occurred within in the research cooperation between India and Norway. See the Video here.

Born in the Twilight of Antibiotics

Implications of antibiotic use to the preterm infant
respiratory microbiome and resistome development

“Covid killed 2 million people in the first year of the pandemic. Antibiotic resistance killed 5 mill.in the same period.” Professor Fernanda C. Petersen

The overuse, misuse and even use of antibiotics is causing a global increase in drug-resistant infections, which is a serious threat to human health. It is crucial to understand how microbes develop resistance to antibiotics to discontinue this development. Premature infants are a particularly vulnerable group. Antibiotic resistance causes tens of thousands of infant deaths every year.

Improved evidence-based guidance for antibiotic is needed

There is an urgent need to improve the understanding of how antibiotics affect premature infants' respiratory microbiomes (bacteria, viruses and fungi that live in the respiratory tract) and resistomes (resistance genes that the microbiomes carry). This knowledge and understanding should be used to prevent colonization by resistant bacteria and to develop better guidelines for the use of antibiotics to treat vulnerable infants.

60% of Indian infants carry high-risk antibiotic-resistant bacteria

Approximately 700 samples were collected from premature babies in India and Norway to examine the microbiome in the respiratory tract and gut. Sample analysis is still going on due to delays caused by COVID-19. Of the samples collected, ~50–70% of the babies received antibiotics in the first days of life.

For the Norwegian part of the study, we are finding an increased number and diversity of resistance genes immediately after ending the antibiotic treatment. These are short-lived and are not observed at 8 to 9 months of age. The response to antibiotics is individual, and not all resistance genes are dangerous. However, some are considered high risk as they are found in drug resistant pathogens where antibiotics are no longer effective. High-risk antibiotic-resistant genes were found in both antibiotic treated and non-treated infants.

The Indian research team with a newborn preterm infant at the Kalawati Saran’s children hospital in New Delhi. Photo: Sushma Nangia

Preliminary results indicate high carriage of antibiotic resistant bacteria in the respiratory tract of Indian babies. 60% of the Indian infants were found to carry drug resistant pathogens, including bacteria resistant to last resort antibiotics.

Could breast milk make antibiotic-resistant bacteria sensitive to antibiotics?

HAMLET is a substance found in human breast milk that can make resistant bacteria sensitive to antibiotics and kill certain types of bacteria, including those that cause pneumonia. The studies investigated its properties and found that HAMLET, in contrast to antibiotics, does not have negative impacts on immune responses protective against respiratory infections. The findings highlight the potential of HAMLET as a future strategy to fight drug resistant infections.

Optimized methods as a result of the collaboration between India and Norway

Both analytical and methodological tools were developed as part of the project. The analytical tool "Resisto Explorer" created by the group has been utilized by more than 3000 users around the world. It is designed to make data exploration easier, without requiring specialized technical knowledge. It is available for free, and a course was also developed to help researchers use it effectively.

The research team focused on studying the respiratory microbiome, which posed a challenge due to low *bacterial* DNA and high *human* DNA in samples. The group developed a method allowing for successful extraction of sufficient microbial DNA from the respiratory samples. Such methodological tools will hopefully contribute to further studies exploring the extent that drug resistant bacteria colonize the human respiratory tract.

Lessons and challenges

In large part the group created a good climate for collaboration despite a few challenges due to COVID and the time difference. One unexpected issue was that only 10% of the samples from the research in India could be shared with Norway. Researchers and institutions in India are required to comply with various regulations and guidelines related to research and data sharing. Increased possibilities for sample sharing would have strengthened knowledge production and transfer.

Key takeaways

- The overuse, misuse and even use of antibiotics is one of the main health challenges of the world – some even compare it to climate change.
- So far, of the samples collected, 50-70 % of the babies received antibiotics in the first days of life. This increased the number of resistance genes found in their respiratory microbiomes. More importantly, babies never treated with antibiotics were also carriers of antibiotic resistance genes, highlighting the importance of preventing antibiotic resistance in our communities and hospitals.
- India's vast samples and frequent resistant bacteria emergence make the research collaboration with Norway crucial.

Sources

1. Interview with Professor Fernanda C. Petersen
2. Project description

FACTS
Awarded: NOK 8.5 mill.
Project Manager: Professor Fernanda C. Petersen
Contributing programs: BEDREHELSE-Bedre helse og livskvalitet
Research collaborators: LHMC & KSCH hospitals in New Delhi and the OUS in Norway, and ongoing collaborations between OUS, UoO and NIPH
Project period: 2018–2023
Project aims:
1. Create tools to study resistomes.
2. Study how antibiotics affect the microbiomes and resistomes of infants in countries with different challenges related to antibiotic resistance, with special focus on the respiratory tract.
3. Study how early-life exposure to antibiotics affects the ability to fight off infections.
Scientific impact: Defining factors that contribute to infant carriage of antibiotic resistance genes and resistant bacteria are a crucial step in optimizing strategies – to reduce the escalated challenge posed by infections that no longer respond to antibiotics.

3D Printing of Prostheses and Reconstructive Implants

Alloy development for additive manufacturing
of prostheses and reconstructive implants

“We can immediately apply the results of this research, which is immensely inspiring and beneficial.” Mona W. Minde

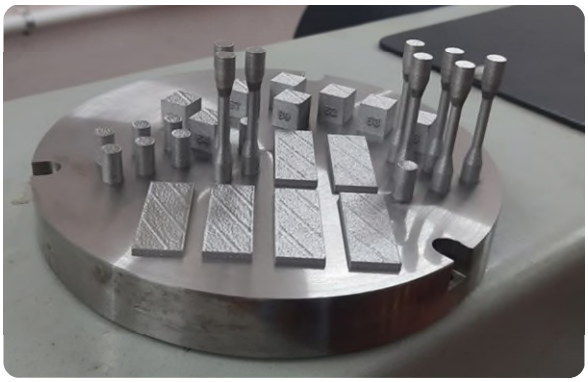
Medical implants and prostheses – one print at a time

Serious accidents or illnesses can result in injuries to the jaw and oral cavity. This may require surgery and a need for implants or prostheses. The project aims to create medical implants and prostheses using 3D-printing-technology. This approach offers three significant benefits: Firstly, it minimizes the use of raw materials and reduces costs and energy consumption. Secondly, it enables the production of customized parts more efficiently. Finally, it addresses the issue of limited cobalt supply by reducing its usage while maintaining the implants' mechanical strength.

This project's impact extends beyond the medical industry, as the 3D printing technology reduces costs by producing parts on demand, avoiding overproduction and excess storage.

Finding the secret sauce

To achieve 3D printing of customized prostheses and reconstructive implants, the team had to determine the correct printing parameters and identify the most suitable powder composition for the alloy. There are two research fellows, one located in India and the other in Norway, each working on their own alloy composition for the implants. The solution was to reduce the amount of cobalt by replacing it with iron. The material had to meet certain requirements, including the ability to withstand the harsh environment in the mouth and the body.



Printed test cubes of the studies alloy.
Photo: Dena Khazeni

The power of complementary expertise

The project is still on-going and so far, the collaboration has been successful. The Indian side has valuable expertise and printing equipment as well as the know-how and expertise required to find the right print settings. Their methods of analysis have been very useful as the Norwegian team does not have this expertise. Meanwhile, the Norwegian team has extensive knowledge and expertise in studying the microstructure of materials at a very small scale (nanometer and atomic level) – which is crucial for understanding the material's functionality and behaviour. One of the notable aspects of this project is the engagement of researchers from different fields. The interdisciplinary collaboration has proven to be highly beneficial, facilitating the exchange of ideas and fostering innovation.

Collaborating through a pandemic

The pandemic caused some challenges. India was hit harder than Norway, causing several delays. The appointment of a research fellow was delayed, and laboratory work took longer than expected. However, the Research Council offered much-needed support, providing flexibility in terms of time

and funding. A workshop in India was put on hold and is now planned for March 2023. The team will finally be able to meet face-to-face and present the results so far.

Key takeaways

- 3D printing with an optimized alloy composition reduces material and energy usage, produces customized parts more efficiently, and reduces the usage of cobalt while maintaining mechanical strength of the implants.
- The research results are immediately applicable, enabling print-on-demand which allows for easy supply of customized parts with rapid delivery.
- The project is a great example of how complementary expertise powers a successful collaboration.

Sources

1. Interview with Mona W. Minde
2. Project description

Facts
Awarded: NOK 5.1 mill.
Project Manager: Head of department of IMBM Mona W. Minde
Contributing partners: NANO2021-Nanoteknologi og nye materiale
Research collaborators: The University of Stavanger, The Nordic Institute of Dental Materials, The Indian Institute of Technology Madras (in Chennai) and Advanced Research Centre for Powder Metallurgy and New Materials
Project period: 2020–2024
Project aim: To investigate the replacement of traditionally produced implants and medical prostheses with parts produced by 3D printing
Scientific impact: The project will increase the fundamental knowledge about materials used in 3D printing which is beneficial for several areas where 3D printing is used. 3D printing processes enable, among others, print-on-demand. This may reduce the need for production of unused spare parts, reducing costs, material use, energy and space.

Indian Security Policy – a Balancing Act

China in Indian strategic thinking

“The project's impact may lead to better informed political decisions as well as up-to-date knowledge for business communities operating in the region.” Lars Tore Flåten

India's geographic location, size, population, and resources have ensured a leading position in South Asia. This position is presently being challenged by China. While economic collaboration is increasing, the countries have a history of conflict and disagreement. The main conflict pertains to border disagreements between the two countries as well as the overall influence in the South Asian region.

India and its neighbours

In recent years, India has prioritised their so-called "neighbourhood first"-strategy, seeking to improve their standing with their South Asian neighbours. To a large extent, this strategy is a response to China's growing influence in India's neighbourhood. There are two main aspects to consider when looking at India and its neighbours:

1. How Indian approaches to Pakistan and the Kashmir conflict are influenced by the China-Pakistan axis.
2. How India approaches its neighbours in the north and east: Nepal, Bangladesh and Myanmar – in the Bay of Bengal area.

Indian partnerships: USA and Japan

Another aspect to consider is how India seeks to balance the expansion of China by entering strategic partnerships with countries outside the South Asian region. The most notable partnerships are with Japan and the USA. The main challenge India faces in creating sustainable partnerships is their need to balance security needs with economic considerations. China is India's main trading partner, and India does not seem ready to enter alliances that may antagonise China. India also shares a disputed land border with China, which also explains why India does not want to antagonise.

Research challenges

The main challenge in this project was the visitation restriction imposed on Lars Tore Flåten. Flåten was not allowed entry into India which made fieldwork impossible to complete.

Research impact

Insights developed during the project have been conveyed to the general public through interviews and articles in the media. It has also been conveyed to business communities (3 events) and policy briefings (2 events) with the Norwegian Ministry of Foreign Affairs. The project's impact may thus lead to better informed political decisions as well as up-to-date knowledge for business communities operating in the region. In addition, Flåten published two peer-reviewed articles (India Review and Oxford University Press). Both articles were concerned with the growth and influence of the Hindu nationalist Bharatiya Janata Party in India.

Key takeaways

- The Kashmir conflict is still causing trouble for the India-Chinese relationship.
- The main challenge India faces in creating sustainable partnerships is their need to balance its security needs with economic considerations.
- India does not seem ready to enter alliances that may antagonise China, but this may change if India perceives that the threat from China is growing.
- The research is important to both business communities and the MFA so that they can make better informed decisions.
- The ideological underpinnings of India's Hindu nationalist government may have implications for Indian foreign policy. This is already visible in a more aggressive approach to the Kashmir issue. In addition, the BJP's approach to religious minorities may have consequences both domestically and with regards to India's relations with other countries.

Sources

1. Interview with Lars Tore Flåten
2. China in Indian Strategic thinking
3. Regjeringen.no

Facts
Awarded: 2,9 mill.
Project Manager: Lars Tore Flåten
Contributing programs: INDEMB-Indo-Norwegian research and de
Research collaborators: UoH-sektor/Andre høyskoler/Forsvarets Høgskole Fhs/ Inst. For Forsvarsstudier
Project aim: The project studies Indian security policy in the light of geopolitical changes in South Asia, with particular emphasis on the rise of China.
Scientific impact: The project's impact may thus lead to better informed political decisions as well as up-to-date knowledge for business communities operating in the region.

India's Strategy for Climate Change Mitigation and Adaptation

India’s climate change and energy policy strategy in a globalizing world: Changing global structures and international cooperation.

“India's agricultural industry receives subsidized electricity, so there is no incentive to practice energy efficiency.” *Solveig Aamodt, Senior Researcher*

The aim of the project was to explore whether India has the domestic capacity and international strategy for designing well-functioning policies to reduce greenhouse gas emissions – while adapting effectively to the impacts of climate change. During the research period, the implementation of the Paris Agreement brought a new global perspective to the project. It shifted the focus towards finding ways to prevent the increase of greenhouse gas emissions despite continuing growth.

Creating climate policies without creating opponents

At the domestic level, climate and energy policies cannot be adopted and implemented without critical levels of support from key interest groups, voters, and industries. Because of this, the relationship between these groups and veto players in political institutions was studied.

Another important aspect was to analyse if climate change mitigation and adaptation can be addressed without creating opponents. It is essential for climate change prevention to create policies that will not ignite a mobilization against proposed reforms and thus prevent climate positive actions.

At the international level, the development of the “BASIC cooperation” (a coalition between Brazil, South Africa, India and China) has positively affected India's interest and strategy in international climate policy. The cooperation allows India to present a unified front with other developing countries, which gives them more influence in the negotiation process. It has also provided India with access to funding and technology transfer opportunities for climate change mitigation and adaptation.

Challenges at home

Coordinating climate politics in India has several challenges: the country's vast regional diversity, the need to balance developmental priorities with climate commitments, limited resources, and changing international climate politics. It requires balancing multiple perspectives and priorities while also addressing India's unique ecological, social, and economic contexts.

At the start of the project period, 400 million Indians did not yet have access to power supply. A major challenge for the Indian policy makers is providing power supply access to the entire Indian population without it negatively impacting the climate.

Higher consumption, lower emissions?

Projections show that continued economic growth will lead to rising energy consumption. Introduction of new technology suggests that energy consumption and emission growth has been, and will continue, to be reduced. Technical innovation is essential; however, mitigation of climate change is dependent upon innovation on an institutional and political level as well as in the private sector.

Indian agriculture is an example of a sector where policy change *and* technical innovation are needed. The agricultural sector receives subsidized electricity, so there is no incentive to practice energy efficiency. As the economy grows agricultural emissions will increase, and if measures are

not taken, emissions will be very high. Coal is India's main energy source and will continue to be for some time.

Cooperation – lessons and challenges

The research partners organized several meetings and seminars with public and private Norwegian participants. As Norway is a small country and India is very large, most of the learning was done on the Norwegian side. Norway needs to understand India and the rapid development there, and this project contributed to that. The project also initiated new cooperation and new research projects with Indian partners.

On the practical side, working with researchers in another country was somewhat challenging as you cannot meet very often. This project was completed prior to the pandemic, so Zoom was not as widespread and available as it is now. Video meetings therefore proved to be a technical challenge, as well as the time difference.

Key takeaways

- There is a need for both policy change *and* innovation.
- If measures are not taken, emissions will become extremely high as India's economy continues to grow.
- Policies need to be created in such a way that it does not create opponents.

Sources

1. Interview with Solveig Aamodt
2. Project description

Facts
Awarded: NOK 4.5 mill.
Project Manager: Research Professor Guri Bang/Senior Researcher Solveig Aamodt
Contributing programs: NORGLOBAL-Norge –Global partner
Research collaborators: Instituttsektor / Miljøinstitutter / CICERO senter for klimaforskning, Pondicherry University, Indian Institute of Technology Bombay, Jadavpur University Kolkata, Potsdam Institute for Climate Impact Research
Project period: 2013–2018
Project aim: To explore drivers and barriers to India's climate policy development– both domestic and international.
Scientific impact: The study produced information that was shared with several entities in Norway that collaborate with Indian companies or authorities, including DNV, Norway's delegation to the UNFCCC, the Norwegian Embassy in New Delhi, and Statkraft.

India’s Footprint in Africa

India’s footprint in Africa: South-South cooperation and the politics of gifts and reciprocity

“India is widely considered to be the word’s pharmacy and an attractive destination for affordable healthcare.” Professor Dan Banik

The new scramble for Africa

Major economies in the Global South such as India, China, and Brazil, are now increasingly engaging with African countries. In addition to natural resources such as lithium, oil, and minerals, this growing interest is driven by security interests, political support in the UN, and support in other multilateral arenas. This research project investigates development assistance that India offers to African countries and what these countries believe India expects in return. The study is based on findings in Senegal, Malawi, and Mozambique.

What can India gain, and what can it offer?

The African continent is now India’s third largest export destination and New Delhi is the fifth largest investor on the continent. The INDAF project focuses on India's competitive advantages within health expertise, ICT (Information, communication, and technology) and education. A key aim is to better understand the motives for India’s activities under the South-South Cooperation (SSC) umbrella and how these shape the perceptions of India’s growing soft power and influence on the continent.

Health-related opportunities

The project identified three broad sets of health-related opportunities and benefits that may shape the future of India-Africa relations:

1. **India as the “pharmacy of the world” and producer of 60% of global vaccines**
   One example is how India’s expertise in affordable healthcare became important during the pandemic. New Delhi’s capacity and willingness to produce and share COVID-19 vaccines further boosted the country’s diplomatic heft and recognition as a global power. Although the vaccine delivery halted during the second wave of COVID-19 in May 2021, denting India’s reputation in Africa, it was expected that India would bounce back as soon as vaccine deliveries resumed.
2. **Increased capacity and collaboration and “medical tourism”**
   We are witnessing increased collaboration between leading Indian healthcare providers and African partners. Some Indian businesses have opened, or plan to open, specialty hospitals across Africa. With its state-of-the-art medical facilities, which offer services at competitive costs, India has also emerged as an attractive destination for “medical tourism”.
3. **Medical diplomacy**
   It is likely that Africa’s reliance on a cheap supply of essential medicines is likely to increase soon, which in turn will increase the influence of the Indian pharmaceutical sector. African countries have enjoyed considerable success in containing pandemics such as Ebola. This is a learning opportunity for New Delhi as numerous additional lessons on disease control from African countries can also be scaled up to further strengthen India’s health sector.

Health and education through ICT: The Pan Africa E-network (PAEN) project

PAEN was initiated by former Indian President A. P. J. Abdul Kalam to offer distance education to 35 African countries using satellite technology. While it was successful in offering tele-education, it faced challenges when it came to offering tele-health consultations due to issues related to project design, language difficulties, and lack of ownership at African hospitals. Despite these challenges, PAEN demonstrated the potential of digital technology to bridge the education gap and improve access to quality education in remote and underserved areas of the continent. PAEN is an illustrative example of India's use of soft power to advance its economic and strategic interests in Africa while also promoting South-South Cooperation.

So, what does Africa want from India?

African policymakers are particularly interested in academic scholarships, investments in infrastructure, and medical equipment. In addition to imparting technical advice and knowledge, African countries want Indian businesses to build manufacturing capacity and undertake long-term investments. However, African policymakers must also show greater ownership of projects initiated by India, especially when the initial funding from New Delhi comes to an end.

Key takeaways in this project

- Medical diplomacy and medical tourism are a major focus for India through the construction of hospitals, and the provision of affordable vaccines and medication.
- The PAEN-project is an example of India using soft power to advance its economic and strategic interests in Africa while also promoting South-South Cooperation.
- Numerous lessons on disease control from African countries can be scaled up to improve India's health sector.

Sources

- Interview with Dan Banik
- Project description

Facts

Awarded: NOK 5.9 mill.
Project Manager: Professor/Research Director Dan Banik
Contributing programs: UTENRIKS-Internasjonale forhold - utenriks- og sikkerhetspolitikk og norske interesser
Research collaborators: UoH-sektor / Universiteter / UNIVERSITETET I OSLO / Senter for utvikling og miljø (SUM), University of Mumbai, University of Malawi
Project period: 2020–2024
Project aim: The study aims to better understand perceptions and influence of India's soft power in three similar (yet different) country contexts of Senegal, Malawi, and Mozambique.

Landslide Hazard Assessment

Landslide hazard assessment in NE India along the Gangtok-Tsomgo / Changu Lake and Gangtok / Chungtang-Lachen corridors

“The rock avalanche jumped over a 300-meter-high cliff causing an air blast that entirely flattened 1.4 square kilometres of mountain forest.”

Senior researcher Reginald Hermanns

The steep Himalayas with high levels of precipitation are prone to multiple landslides among others large rock slope failures. Due to its rugged topography and maritime climate, Norway is also susceptible to such types of landslides. The rock slope failures in the Himalayas and Norway have some similarities, such as similar rock types, and rock damage – and sadly, they have caused significant loss of life throughout history. However, there are also differences in climate and the Himalayas experience more frequent and stronger earthquakes.

The aim of the research cooperation between India and Norway was to learn from each other, and to develop methods to evaluate unstable slopes enabling better and safer planning of the use of land.

Norway is leading in the field of satellite technology

Norway is one of the leading countries in the use of satellite technology. The main product of the cooperation is a map that indicates the potential for landslides that is based partly on data gathered from satellites. This map is further built on an inventory of landslides, and the inventory includes large rock slope failures and rock slope instabilities – as well as a map that shows how strong earthquake effects will be.

This project used techniques to map landslide risk that are commonly used in Norway but not yet used by Indian partners for the Indian Himalaya in the same way. The project helped share knowledge of these techniques with the Indian partners.

Indo-Norwegian Team mapping landslide in Sikkim. Photo: Rajinder Kumar Bhasin (NGI)

Frequent occurrences of landslides in Himalaya provides insight

Several of the rock slope failures the project studied in the Himalayas were recent, dating back to 2016. This provided the project group fresh material to research. In Norway the last rock slope failure of large volume took place in 1950.

Challenges: Border region, altitude, climate, language barriers and Covid

The project faced several challenges. Firstly, restrictions along the country border meant that remote data collection using satellite techniques was necessary as researchers were not allowed near critical infrastructure. Secondly, altitude made research difficult in India as some mountains were too high for helicopters or being reached by foot. The climatic conditions in India also posed a challenge as

vegetation growth made it harder to study rock slope failures compared to Norway, where similar deposits can be traced back 10,000 years. Additionally, linguistic diversity in these remote places of India caused unexpected delays, with even basic information taking hours to obtain. Finally, Covid prevented travel and left Indian partners unable to participate at certain points, requiring the team to rely on remote analysis.

Great need to do further research

Because of ongoing climate change there is a great need to do further research so that we will be able to better plan safe land use in the future.

In Norway, rock slope failures are rare, but they cause more deaths than any other natural disaster. To learn more about these events, a project proposal was submitted for funding. The project would involve India and Norway with partners from Canada, France, Germany and the USA. However, the funding was not approved because the project was considered too complicated with six partner countries.

Key takeaways

- Rock slope failures in the Himalayas are more frequent which has enabled us to learn about this type of landslide from recent, well preserved and documented events.
- Rock slope failures in the Himalayas cause destructive air blasts beyond the immediate impact, not seen in Norway. A method was developed to measure this secondary effect.
- Research in the Indian Himalayas gives a larger dataset, but has its challenges due to topography, culture, and restrictions in the border regions.
- Because of climate change and a potential increase of related rock slope failures, there is a great need to do further research in areas where it is possible to collect data from recent events.

Sources

3. Interview with Senior researcher Reginald Hermanns
4. Project description

Facts
Awarded: NOK 5.2 mill.
Project Manager: Senior researcher Reginald Hermanns
Contributing programs: Globalbærekraft - Forskning for global bærekraft Research collaborators: Norges Geologiske Undersøkelse (NGU), Norges Geotekniske Institutt (NGI), Wadia Institute of Himalayan Geology (WIHG), Indian Institute of Technology Kharagpur (IITKgp)
Project aim: To develop a multi-approach procedure to assess unstable slopes, that will facilitate effective land-use planning taking into account the primary and secondary consequences of landslides.
Project period: 2016–2022
Scientific impact: Increased understanding of rock avalanche processes. Testing a European remote sensing technique in a new location. Landslide susceptibility mapping. Measures to reduce risk.

Displacement, Placemaking and Wellbeing in the City

“The project provides important knowledge for policy makers at all levels of urban governance, as well as in development agencies and NGO/CSOs.”
Professor Peter Hemmersam

The world today is experiencing a high degree of migration, both forced and voluntary. This has consequences both for those who move and for the cities that receive them. This project investigates how migrants and refugees become part of cities, in ways that sustainably contribute to economic development, cultural advancement and wellbeing. The project has compared local communities in four countries: India, Finland, Norway and the United Kingdom.

Establish good lives in new cities
The project’s aim was to understand the mechanisms of what is important for establishing good lives in new cities for migrants and refugees. It also aimed to understand how people succeed or fail to make urban spaces into places of belonging, participation and wellbeing in conditions of scarcity and increasing urban inequality.

Increased international cross-disciplinary cooperation
The project has contributed to increased international cross-disciplinary cooperation between professionals and researchers in architecture and planning, as well as migration researchers with a social science background. This is both innovative and unique.

The project provides important knowledge for policy makers at all levels of urban governance, as well as in development agencies and NGO/CSOs. It provides a better understanding of what roles they can play to support greater equity, reduced inequalities and wellbeing in cities.

Researchers and students associated with the project have gained a greater understanding of the connection between design disciplines and social science when developing and designing urban spaces. The connection is also important when working with living conditions for migrant groups and refugees. It has also led to increased focus on migration as a theme in architecture education and research. Additionally, it has increased the understanding and interest in architecture and design within the migration research communities associated with the project. The project has particularly contributed to increased competence for younger academics associated with the project.

Through exhibitions, presentations, and media contributions, the project has contributed to increasing general interest and knowledge concerning the role of cities and urban spaces in everyday life for different people and migrant groups.

Collaboration between Norway and India
The project team experienced open and efficient communication and collaboration between the countries. During the collaboration it became clear that India has a more humanitarian perspective on how migrants and refugees become part of cities than in Norway. In Western parts of the world, the focus is on the legal and economic questions surrounding immigration.

A good framework for city life is the key to success

The outcome of this project has clearly shown that the city and the use of urban space are of great importance for migrants and refugees to have good lives. This concerns the planning of cities but also the legal and economic frameworks that govern their access to urban space. For example, how can we in Norway make the city's nature accessible to those who haven't lived in nature before, and facilitate the first skiing trip?

Key takeaways

- In India, research has pointed to the need for playgrounds for children and toilets/showers for women, and researchers are now working with an NGO, WaterAid, to build a prototype for mobile sanitary stations.
- In Norway, student work has contributed to knowledge for a development and conservation plan for a settlement in Stovner
- In England, researchers and students have collaborated with Southwark Borough Council and a voluntary organization aimed at helping underage refugees.

Sources

5. Interview with Professor Peter Hemmersam
6. Project description
7. Policy briefs

Facts
Awarded: NOK 3,2 mill.
Project Manager: Professor Peter Hemmersam
Contributing partners: GLOBAL BÆREKRAFT-Forskning for global bærekraft
Research collaborators: India, UK and Finland
Project aim: To investigate how migrants and refugees become part of cities, in ways that contribute to economic development, cultural improvement and wellbeing.
Scientific impact: The project has contributed to the knowledge base for decision-makers at all levels (including the voluntary sector) when it comes to the city as an arena for migration and integration

Ice Melting in Antarctica

MADICE: Mass balance, dynamics, and climate of the central Dronning Maud Land Coast, East Antarctica

“The collaboration was an opportunity for both nations to combine complementary strengths both in science and logistics.”

Senior researcher Kenichi Matsuoka

This project collaborates with India's National Centre for Polar and Ocean Research (NCPOR) in Goa and relies on logistics support from India's Maitri Station. The project’s aim was to investigate floating ice shelves and adjacent grounded ice in central Dronning Maud Land (DML).

Warmer water and rising sea levels impacts ice melting

The ocean's temperature is high enough to cause ice to melt from the base which faces the ocean. With further research, the aim is to investigate the extent of ice melting and its environmental impact through further studies. We can see that the ocean is becoming increasingly warmer and that the ocean is rising. This will cause more extreme weather, and parts of coastal areas to be under water.

Is East Antarctica more stable than West Antarctica?

East Antarctica has been believed to be more stable than the rapidly changing West Antarctica. However, recent studies have questioned this conventional belief. DML’s coast in East Antarctica has a chain of small ice shelves that have distinct environmental settings. This suggests that individual regions have different responses to the ongoing climate change.

Seasonal variations at calving front

Results from this project shows that this region has been relatively stable in the past millennium. Ice cores from the two sites at different elevations show distinct characteristics, and the project group was able to reconstruct both paleoclimate and local surface melting history. This reconstruction shows that the melt rate varies seasonally near the calving front but is low and more uniform at a landward site.

Drilling deeper for more answers

The research project successfully measured basal melting, surface snow accumulation, and other factors, resulting in new knowledge and understanding. However, as often happens with extensive research, the new findings sparked several new questions in need of exploration. There is an ongoing effort to attain further funding so they can conduct research that reaches back 20,000 years. This will allow for a more comprehensive understanding of how the region has evolved. It will also enable the reconstruction of climate records from the past several millennia.

Successful collaboration between India’s and Norway's Antarctic programs

Norway’s Troll Station is situated far away from the research site. The support from India's Maitri Station was therefore essential in bringing the research gear to the site. The collaboration was an opportunity for both nations to combine complementary strengths both in science and logistics. Beyond published and ongoing publications, this project generated a strong foundation for future collaborations between India and Norway in Antarctica. It also developed glaciology capacity in India through Ph.D. and postdoc training, as well as through the summer school program.

Complications due to COVID-19 and bad weather

Due to bad weather conditions they were not able to investigate “Verbljud” and “Kamelryggen” ice rises in the second field season. A fourth field season was therefore planned to complete this work, as well as to provide maintenance service to the continuous radar sites on the ice shelf. As Covid hit, the fieldwork had to be postponed for one year, to the 2021–22 season.

Key takeaways

- has generated a strong foundation for future India-Norway collaborations in Antarctica. The melt rate varies seasonally near the calving front but is low and more uniform at a landward site.
- Collaboration with India gives the unique opportunity for Norway to study central DML.
- Research shows that the melt rate varies seasonally near the calving front but is low and more uniform at a landward site.
- The project

Dictionary

Paleoclimate/paleoclimatology: Paleoclimate records are used to determine the past states of Earth's global atmosphere and more local environment such as sea ice.
Ice calving: The breaking of ice chunks from the edge of a glacier.

Sources

1. Interview with Senior researcher Kenichi Matsuoka
2. Project description

Facts
Awarded: NOK 6.0 mill.
Project Manager: Senior researcher Kenichi Matsuoka
Contributing programs: POLARPROG-The Polar Research programme
Organization: Institute sector / Other research institutes / Norwegian Polar Institute
Project aim: To investigate floating ice shelves and adjacent grounded ice in central DML from India's Maitri Station using complementary strengths from India and Norway.
Scientific impact: The scientific impact of the research project shows that coastal DML, East Antarctica has been relatively stable in the past millennium and that the melt rate under an ice shelf varies seasonally near the calving front but is low and more uniform at a landward site.

How Does Climate Change Impact Global Rainfall Distribution?

Counteracting effect of future Antarctic sea-ice loss
on projected increases of summer Monsoon rainfall

“The students involved in the research project will be the future collaborators. This is how we ensure effective research in the years to come.” Researcher Thomas Toniazzo

The impact of future Antarctic sea-ice loss on global atmospheric circulation

South-Asian society and economy depends on Indian Summer Monsoon's rainfall which can be erratic, with dry "break" phases that cause droughts and excessive rain that harms agriculture. Climate change will alter the rainfall amount and frequency, but it is unclear how it will affect different regions. The aim of this project was to document changes in rainfall distribution globally and the potential hydrological impact. More specifically, the impact of future Antarctic sea-ice loss on global atmospheric circulation was investigated.

Further research is needed as warmer climate melts more ice

There has been a 10 percent drop in Antarctic sea-ice in 2016, compared with the average since 1979. Record low Antarctic sea-ice cover has recurred most years since 2016, and a clear long-term decreasing trend is now detectable. The research results suggest that drop could be due to increased air temperatures near the sea ice edge, strong winds and a shift in the Southern Annular Mode. It has also demonstrated the importance of future sea-ice changes on the global circulation. The inter-hemispheric effects of Antarctic sea-ice loss uncovered by this project are now recognised and researched by the international research community.

“This project highlights the importance of continuity. Throughout this research project, we shared as much knowledge as possible and created new channels to exchange ideas and continue working on the impacts of environmental change. The information exchange and knowledge sharing were as important as the actual results of the research.”

The ambition of the research project was that it would contribute to further research concerning the impact on infrastructure and agriculture in the affected areas. Food production is highly sensitive to both dry and wet rainfall extremes, so continuing research on this topic is both essential and relevant. Funding from the Indian government will be needed for such research to continue.

Collaboration and training ensure future research

The researchers placed a strong emphasis on collaborative research and training between the Norwegian and Indian partners. For this to be possible, a strong research framework was developed to support the collaboration. The collaboration led to a C-ICE Research School that took place in New Delhi in August 2019. The school was led entirely by the research project and has received great feedback from both students and researchers. Researchers shared as much information with the students as possible, which is important for future research. The students involved will be the future collaborators and they are how effective research is ensured in the years to come.

Funding barriers and time limitations

A focus for future research is to lower the funding barrier to allow for more continuous research. This is also an important factor in India's ability to retain its research talent and ensure effective research going forward, enabling the local talent to carry out projects on their own.

Another complication was the time limitation. The complications caused by delays and cuts in funding from the Indian side caused the parts of the project to finish before the researchers could work on the results. Covid also caused challenges as physical meetings were not possible due to travel restrictions.

Key takeaways

- This research demonstrates the importance of future sea-ice changes on the global circulation.
- The educational side of the project is equally important to the scientific side.
- A strong research framework combined with collaboration is necessary to carry out research projects at this level.
- Retaining talent is key to perform research in the future, and this can be achieved by lowering the funding barrier in India.
- In this type of work, physical meetings are essential and intellectually productive.

Dictionary

Hydrology: The study of the distribution and movement of water both on and below the Earth's surface. (nationalgeographic.org)

The Hadley circulation: Also known as Hadley cells, the Hadley circulation is low-latitude overturning circulations that have air rising at the equator and air sinking at roughly 30° latitude. (harvard.edu)

Boreal summer: A phenomenon that active convective regions migrate northward in the Indian Ocean and the western pacific within a period of 30-90 days. (copernicus.eu)

Southern annular mode: is a climate pattern that describes how the southern hemisphere atmospheric circulation varies in space and time

Sources

1. Interview with Researcher Thomas Toniazzo
2. Project description

Facts

Awarded: NOK 5.7 mill.
Project Manager: Researcher Thomas Toniazzo
Contributing program: POLARPROG-Polarforskningsprogram
Research collaborators: Institute sector / Environmental institutes / NORCE NORWEGIAN RESEARCH CENTRE AS / NORCE Klima
Research period: 2016–2020
Project aim: To investigate the impact of future Antarctic sea-ice loss on global atmospheric circulation through collaborative research between Norway and India.

Coastal Transformations and Fisher Wellbeing

Coastal transformations and fisher wellbeing –
synthesized perspectives from India and Europe

“The reflections from the project support advancing sustainable use of ocean resources and climate resilience. This is particularly important in India, where the blue economy is developing at a slower pace than the other countries in the study.” Project manager Maarten Bavinck

Wellbeing of fishing communities in coastal areas

The fisher populations in coastal regions of India have been put under increasing pressure due to a combination of natural and socio-economic factors. In the past decades, modernization of fisheries has attempted to secure economic progress, but also caused unfortunate side-effects such as damages to marine ecosystems, inequality and social conflicts. As a result, the fisher populations are resorting to various strategies to handle their new circumstances. This research investigates how the physical, ecological and social character of coastal areas in India and selected European countries have been impacted by government policies regarding coastal development.

Liberation of economy causing increase in pollution

Fishing communities have historically been the main coastal inhabitants, and their wellbeing is the focus of the research project. In India there was a shift in 1990 as the government decided to liberate the economy, and the country has since seen an increase in pollution caused by industrialization. Especially the development of the petrol chemical industry has affected the fisher populations as it has caused enormous amounts of pollution to the ocean.

A finding was that a common strategy for the impacted communities in India was migration. In some cases, the fisher populations moved to cities close by, fostering urbanization, and in other cases they moved to other countries. However, in most cases this was a circular migration as a large part of the population eventually would come back to where they originated from.

For many fisher families, the ambition of the parents is to help their children leave the fishing industry and pursue other professions. This is heavily dependent on the parents’ ability to invest in education for their children. In some cases, this is realized, but many also end up returning to fishing as they failed to find other jobs. This is a different pattern than what is seen in Norway for instance, where many have successfully left the industry.

No successful policies in sight, but better insight will spark engagement

Industrialisation and transformation of fisheries are likely to continue in the years to come, and there are no new successful policies in sight to this day. Environmental challenges such as overfishing and pollution from industry will remain a topic of interest for researchers and politicians. As results from this research project are shared, they will encourage better understanding and political engagement. This is particularly important in India, where the blue economy is developing at a slower pace than the other countries in the study.

Expansion of study as a result of collaboration

The collaboration between Norway and India contributed to another study on trawl fisheries. It was carried out by a PhD-student and was expanded by senior researchers in Norway after reviewing the

Norwegian and Indian project. This has led to the creation of mapping materials on coastal change in Northern Norway.

The project is expected to produce a range of outputs, including journal publications, articles, blogs, interactive coastal web mapping, and a mobile exhibition. The mobile exhibition will be set up in four fieldwork locations and contribute to arranging collaborative dialogues with a range of stakeholders. Furthermore, research and policy briefs will be shared with global and national policymakers.

Fishery industry took a hit during COVID-19

Covid had a large impact on the research as India was substantially affected by the pandemic. This caused difficulties for the field work, and the fishery industry took a hit as fishers were not allowed to go to sea in many cases. Despite the challenges, the researchers managed to complete the project in a responsible manner.

Key takeaways

- Industrialisation and transformation of fisheries are likely to continue in the years to come.
- There are no new successful policies in sight, but the research has managed to generate a series of comparative results which has encourage political engagement.
- Advancing sustainable use of ocean resources and climate resilience will be important in the coming years.

Sources

1. Interview with Maarten Bavinck
2. Project description

Facts

Awarded: NOK 3.6 mill.
Project Manager: Maarten Bavinck
Contributing programs: GLOBALBÆREKRAFT-Research for global sustainability
Research collaborators: UoH sector / Universities / University of Tromsø - The Arctic University of Norway / Faculty of life sciences, fishery and economy
Project aim: Comparing coastal transformations in India with three European countries including Norway
Scientific impact: Increased critical understandings of the impact of movement of the fisher

Creating More Efficient Fuel Cells

India ERA-NET: Muti-functional Nanocomposite Materials for Low-temperature Ceramic Fuel Cells

“To make fuel cells more efficient, the researchers have been studying a new type of nanocomposite electrolyte.” Project manager Truls Eivind Norby

In this project, researchers from University in Oslo (UiO), along with their collaborators from India, Turkey, Portugal, and Finland, have been working on improving fuel cells. Fuel cells are devices that convert fuels such as hydrogen into electricity without producing harmful emissions. To make fuel cells more efficient, the researchers have been studying a new type of nanocomposite electrolyte.

Could new nanocomposite materials operate at lower temperatures?
It has earlier been suggested that nanocomposites of a ceramic and a molten salt could be promising electrolytes. They have good mechanical stability and high conductivity operating at lower temperatures (300-600°C) than solid-state electrolyte materials such as yttria-stabilized-zirconia (YSZ) that require high operating temperatures (600-800°C). The focus has been on the assessment of possible protonic conduction in these nanocomposite electrolytes.

Efficient energy conversion technology for sustainable energy
The theory going into this research project was that the new nanocomposite would provide faster pathways for protonic charge carriers at a lower temperature. This theory proved to be inconsistent with the results of the research. The research provided a new understanding concerning proton conduction and different ions’ roles in this.

In the later stages of the project UiO studied and established a new model of adsorption of water and protonic transport on surfaces of oxides. This provides a basis for understanding composites made from similar porous oxides. Ceramic fuel cells with ceramic and molten salt composites for intermediate and low temperatures have great potential for efficient and sustainable energy conversion, but for now, the concept needs more research.

Collaboration is key
The international partners have made, and tested laboratory-scale fuel cells based on the materials developed in the project. UiO has had student and researcher exchanges with all international partners in the project. Truls Eivind Norby described this project as, “a network project creating a community that could further research nanocomposites for fuel cells”. The research contributed to a better understanding and the sharing of knowledge between the partners.

Key takeaways

- New understanding of nanocomposites for fuel cells.
- It was challenging to make electrolytes with enhanced stability and conductivity operating at lower temperatures.
- It was a successful network project creating partnerships and the sharing of knowledge.

Dictionary

Charge carriers: Particles or holes that freely move within a material and carry an electric charge. (“Charge Carrier - Energy Education,” n.d.)

Proton conduction: In a fuel cell, protons are transported through a proton-conducting material to generate electrical energy.

Nanocomposite: A nanocomposite is a manmade material designed for enhanced performance in any number of unique applications: structural, functional or cosmetic.

Electrolyte: An electrolyte is a medium containing ions that is electrically conducting through the movement of those ions, but not conducting electrons.

Oxides: An oxide is a chemical compound containing at least one oxygen atom and one other element

Low-temperature ceramic fuel cell (LTCFC): A low-temperature ceramic fuel cell (LTCFC) is a type of fuel cell that converts the chemical energy of a fuel (such as hydrogen) directly into electrical energy using an electrochemical process.

Power Density: Power density is the amount of power (time rate of energy transfer) per unit volume.

Sources

1. Interview with Truls Eivind Norby
2. Project description
3. Satori, D.R. (2023, 11. Mars). What is a Nanocomposite? All the Science. Website address.
4. Charge carrier - Energy Education. (n.d.). Retrieved from: Website address.

Facts

Awarded: 1,1 mill
Project Manager: Truls Eivind Norby
Contributing programs: ENERGIX-Stort program energi
Research collaborators: Portugal, Finland, Turkey, India
Project aim: To unravel the charge carriers and transport mechanisms in the composites.
Scientific impact: So far, results indicate that lithium, carbonate, and oxide ions play significant roles, while the protonic conduction is of varying significance and mainly due to hydroxide ions. In the later stages of the project UiO has studied and reached a new understanding of adsorption of water and protonic transport on surfaces of oxides, which gives a fundament for understanding composites made from similar porous oxides.

Silicon Crystals for Efficient Solar Cells

Czochralski growth of low-oxygen silicon single crystals for high-efficiency solar cell applications

"What India is doing now to build new solar industry, is one of the most important actions being taken worldwide to reduce emissions."

Senior Scientist Eivind Johannes Øvrelid

Enhancing solar cell efficiency by reducing oxygen levels in crystals

The project aims to develop an advanced modelling framework that will be used to reduce oxygen levels for crystals grown with the Czochralski method. The new model will be an important tool for the future development of the Czochralski process for further optimization and upscaling.

This project aims to significantly reduce the oxygen level in the crystal to make better quality solar cells, with increased efficiency, and lower production cost. As a result of cost reduction and higher quality, solar cells will become more accessible. This advancement could represent a significant step towards reducing emissions and providing clean energy to more areas.

Open source framework for future development

In the project a new modelling framework was developed, where results from a 2D model are used as input to an open source (OpenFoam) 3D model. The model will be useful for more advanced modelling of the Czochralski process and other solidification processes. The use of open source software allows for more efficient sharing and co-development for academic and industrial research.

Collaboration – lessons and challenges

The collaboration had a significant impact because each team member brought their own unique expertise. The Indian team focused on research and scientific aspects, and the Norwegian team primarily aimed to gain insights from industrial production and utilisation of solar cells. As a result of this project, a large network has been established, allowing researchers to collaborate and conduct more work together in the future.

During the project, the team encountered some challenges due to delayed deliveries when sending tests, samples and results to India. The delays resulted in a shortened time frame to analyse the results. In projects like these, success often hinges on everything proceeding according to schedule, as this is necessary to conduct research and obtain the desired outcomes.

Key takeaways

- The project aims to reduce oxygen levels in solar cell crystals. By lowering oxygen levels, solar cells can be made with increased efficiency and lower production cost. This will make them more accessible and potentially reduce emissions.
- A new modelling framework was developed, where results from a 2D model were used as input to an open source 3D model. The use of open source software allows for more efficient sharing and co-development for academic and industrial research.
- During the project a large network was created enabling researchers to efficiently collaborate and conduct more work together in the future.

Dictionary

Solidification processes: Solidification is a process in which atoms are converted into an ordered solid state from a liquid disordered state.

Czochralski growth: A method used to grow large, single crystals of materials such as silicon.

Sources

1. Interview with Eivind Johannes Øvrelid
2. Project description

Facts
Awarded: NOK 2.5 mill.
Project Manager: Senior Scientist Eivind Johannes Øvrelid
Contributing programs: ENERGIX-Stort program energi
Project period: 2019–2022
Research collaborators:
Project aim: The primary objective of the project (SUCCESS) was creating a cost-effective method/tool for controlling the heat and mass transport in Czochralski silicon growth with the aim of significantly reducing the oxygen level in the crystal. This will enhance the longevity of the solar cells, increase their efficiency, and lower the production costs at the same time.
Scientific impact: The development of a new modelling framework, where results from a 2D model developed by SINTEF were used as input to an open source (OpenFoam) 3D model developed by IIT in India. The model will be useful for more advanced modelling of the Czochralski process and other solidification processes. The use of open source software allows for more efficient sharing and co development for academic and industrial research.

Saving Lives with Smarter Detection of Pollution

Nanoparticle-2D hybrid structures for smart environmental sensing

“We showed that combining nanoparticles with 2D heterostructure sensors gave significantly higher sensitivity and selectivity. This innovation could potentially save many lives.” Senior Scientist Branson Belle

Poor air quality has contributed to over 4.2 million deaths globally and is a significant contributor to a poor quality of life experienced by many people around the world. Because of this there is a need to develop ultra-sensitive and selective gas sensors for accurate detection of hazardous environmental gasses.

The aim of this research project was to develop highly sensitive environmental gas sensors (NOx, CO) through the innovative use of “two-dimensional (2D) material devices” decorated with functional nanoparticles. The idea was that the nanoparticles would make the 2D material devices even more selective, detecting the smallest amount of targeted gas species.

2D materials offers new possibilities

2D materials are a new class of materials that are extremely thin. They can detect extremely low concentrations of gasses. This type of material offers new possibilities to develop ultra-sensitive sensors. Their gas sensing selectivity and sensitivity can be further tailored by decorating their surfaces with nanoparticles specific to a particular gas.

There were several objectives that this research project was able to meet:

1. This research project was able to develop sensors capable of detecting NOx and CO down to single digit PPB (parts per billion) levels.
2. They were able to fabricate size-selected nanoparticles of various materials, i.e., palladium.
3. They fabricated 2D-based heterostructure devices.
4. They fabricated hybrid nanoparticle decorated 2D heterostructure devices.

Further research needed to make sensors “smart”

Going into this project, the researchers wanted to develop smart sensor systems. To create this, you need two things: good sensors, and the connectivity that makes them smart. The scope was too large for the funding provided, so in the initial project they focused on creating good sensors – namely combining 2D materials with nanoparticles.

As Senior Scientist Branson Belle explained, “We showed that combining nanoparticles with 2D heterostructure sensors gave significantly higher sensitivity and selectivity than using the individual components by themselves.”

To improve the quality of gas detection, further research is needed. Going forward the results of this project are being used as the basis for larger EU projects. The aim is to build on these results and develop scalable approaches to hybrid 2D heterostructure sensors.

Lessons and challenges

In addition to the scientific research an important part of this project was cultural exchange. This was a great success, and the collaboration has continued beyond the project with four additional papers in the pipeline. A factor contributing to the successful collaboration was that the expertise in India and Norway was complementary – Norway had expertise in creating 2D material sensors, and India had expertise in creating nanoparticles. Both sides had competence in detecting gas sensors making the collaboration useful and effective.

Covid was a major challenge for this project as it prevented travel and physical meetings as well as joint experiments.

Key takeaways

- Deaths due to air pollution can be reduced using Nanoparticle-2D hybrid structures.
- The technology is ready for scale-up which could help save many lives.
- Hypothesis was proven: To develop highly sensitive environmental gas sensors (NOx, CO) through the innovative use of two-dimensional (2D) material devices laced with functional nanoparticles.
- They were able to demonstrate single digit PPB.
- They were able to demonstrate the sensing mechanism: How they detect a gas (charge transfer) in an operando study.

Dictionary

2D material – A new class of materials that is extremely thin.
Heterostructure – 2D materials stacked together like pancakes.
PPB – Parts per billion.
Operando study – surface analysis of the sensor material in an active sensor whilst in the presence of gas.

Sources

1. Interview with Senior scientist Branson Belle
2. Project description

Facts
Awarded: NOK 10.1 mill.
Project Manager: Senior scientist Branson Belle
Contributing programs: IKTPLUSS-IKT og digital innovasjon
Research collaborators: Instituttsektor / Teknisk-industrielle institutter / SINTEF AS / SINTEF DIGITAL / Smart Sensor Systems
Project aim: To develop highly sensitive environmental gas sensors (NOx, CO) through the innovative use of two-dimensional (2D) material devices laced with functional nanoparticles.
Scientific impact: They were able to demonstrate single digit PPB and demonstrate the sensing mechanism: How they detect a gas (charge transfer) in an operando study.

Curing Cancer: Is There a Better Treatment in the Future?

Inno-Indigo: Nanoplatform-based drug delivery system: combinational therapy against breast and colorectal cancer

“With the LNC targeting the tumour and delivering drugs that effectively kill cancer stems and cells, it will revolutionize cancer treatment.”

Professor Kirsten Sandvig

One of the major causes of failure in conventional chemotherapies is the poor entry of anti-cancer drugs into tumours. Another major challenge in chemotherapy is loss of therapeutic effectiveness through acquired drug resistance. This project aimed to find a better way to deliver anti-cancer medicine and the team wanted to test a “lipid nano capsule (LNC) drug delivery system”. Lipids are fatty compounds that perform a variety of functions in our body and were chosen because of our bodies’ ability to break them down.

Better treatment for cancer patients

The focus of this project was to find out if LNCs could be used to more efficiently deliver anti-cancer medicine to attack the tumour. If this was confirmed as an option, cancer patients would be able to receive better treatment with less side effects.

In the larger scope, the aim is to create a new LNC-based drug delivery system that will solve the following problems:

1. A significant portion of the drug molecules end up in normal organs, rather than accumulating at tumour sites. This causes severe side effects and limits the dosage of the therapeutic regimen.
2. There is a loss of therapeutic effectiveness over the course of treatment because of acquired drug resistance. This phenomenon, called multidrug resistance, is found in up to 50–70% of breast cancer patients undergoing chemotherapy.

Efficiently killing cancer cells

The LNCs can load a broad range of drug molecules. With the LNC targeting the tumour and delivering drugs that effectively kill cancer stems and cells, it will revolutionize cancer treatment. The research has provided promising results. It forms a good basis for further research and development before potentially becoming a finished product.

Building expertise together

The research groups in the project have built interdisciplinary expertise in preclinical documentation of biodegradable lipid nanocapsules (LNCs). The project has also been a solid learning platform for two young researchers from the Giri group in Hyderabad who visited the Sandvig-lab for two months. Knowledge transfer went both ways and the Sandvig group had the opportunity to learn about production of LNC particles from the Giri group.

Research challenges

After this project, the researchers applied for a new project to continue the Indian/Norwegian collaboration. This time the Indian group did not receive application approval as they had to send documentation in paper form through the postal services. The documentation did not arrive in time, which led to the application being declined.

Key takeaways

- The aim was to find a more efficient method of delivering anti-cancer medicine and create a better treatment with less side effects.
- New knowledge and insights were shared between the Sandvig and Giri group.
- Promising results that form a good basis for further development

Dictionary

LNC: Lipid Nanocapsule. Lipids are fatty compounds that perform a variety for functions in our body and our bodies can break down the compound.
Therapeutic regimen: A treatment plan that specifies the dosage, the schedule, and the duration of treatment.

Sources

1. Interview with Kirsten Sandvig, Tore Skotland, Tore Geir Iversen
2. Project description

Facts
Awarded: 3.3 mill
Project Manager: Professor Kirsten Sandvig
Contributing programs: BEHANDLING-God og treffsikker diagnostikk, behandling og rehabilitering (TREATMENT-Good and accurate diagnostics, treatment and rehabilitation)
Research collaborators: India and Belgium
Project aim: Using the lipid nanocapsule (LNC) drug delivery system that has recently been developed for the treatment of breast and colon cancer.
Scientific impact: Promising results from the project form a good basis for further development of this type of drug delivery system for targeted delivery of anti-cancer medicine.

Can Proton Therapy Lead to a More Accurate Cancer Treatment?

Nanodos: Synthesis of Nano-Phosphors and Spin-Trapping Nano-Crystals as Energy-Independent Dosimeters for Radiotherapy Beams

“Proton therapy is already safe and effective. We want to contribute towards making it even better.”

Radiotherapy is, second to surgery, the dominant form of cancer treatment world-wide. Traditional radiotherapy is based on technology utilizing X-rays, whereas proton radiotherapy is a more advanced approach and an alternative to the traditional method.

The NANODOS project focuses on proton radiotherapy as cancer treatment, and how to gain more knowledge from radiation dose measurements. Compared to traditional radiotherapy, proton radiotherapy potentially reduces side effects and radiation injury. More specifically by damaging less healthy tissue in the radiation process.

The research on proton therapy is ongoing and will be introduced as a cancer treatment in Norway in 2024. Globally, this therapy method is implemented and used at about 130 treatment facilities.

Assessing the effect of radiation dosage on different materials

Through this research project, the Norwegian and Indian research communities aligned their expertise in order to assess the radiation dosage (a practice referred to as dosimetry) used in order to accurately measure and predict how the protons interact when moving through different materials. The researchers manufactured and used various crystalline materials together with “thermoluminescence (TL)” as a detection principle to measure radiation dosages. The TL signal from irradiated samples was explored to search for even better predictors of proton energy deposition in tissue.

Best-practice sharing leading to a more accurate cancer treatment

The project aims to assess the radiation dosage in proton radiotherapy in order to predict how protons interact with different materials. The objective is a more accurate cancer treatment, with less side effects and radiation injury.

The most important aspect of the project is the exchange of information and expertise, as well as the collective sharing of best practice, knowledge and insights across fields of research and borders. The aim was to increase knowledge in this specific field, gain experience within new research methods and collaborate with international partners. In the long run, the project could contribute to a more accurate and efficient cancer treatment.

Further research needed as a result of this project

The project is ongoing with testing, simulations and calculations. It is difficult to assess the short-term scientific and clinical effect of the study, but it is anticipated that further research could increase the impact. This may be achieved by investigating new materials and methods of analyses.

Proton therapy has already been introduced as a cancer treatment in several countries. USA, Japan and Germany are at the forefront of utilizing this technology. Still, more research is needed to gain full insight into the effects of this treatment.

A successful Indian-Norwegian collaboration

The alignment between the two Research Councils in Norway and India was essential in creating a successful project. Combining expertise from both countries has allowed an efficient and useful exchange of knowledge. The overall knowledge concerning radiotherapy of cancer is extensive in Norway. Combining this knowledge with the unique technical and technological expertise from India created a successful collaboration.

Norway has one of the highest survival rates for cancer treatments in the world, but this is not the case in many other countries. Through bilateral collaborations like this, the research communities have an opportunity to exchange knowledge, thus supporting the development of cancer treatment in countries where research has not progressed as far.

Dictionary

Photon radiotherapy: A radiation therapy method that delivers x-rays or gamma rays at the surface of the body, going into the tumour and through the body.
Proton radiotherapy: A radiation therapy method that delivers a beam of protons that basically stops at the tumour, so it's less likely to damage nearby healthy tissues.
Nanophosphors: Nanoparticles of crystalline materials doped with optically active ions (activators)
Nanocrystal: A crystalline particle with at least one dimension measuring less than 1000 nanometres (nm)
Thermoluminescence: The process where a material emits light while it is being heated; it is a process that e.g., follows the absorption of energy from irradiation of the material.
Dosimetry: The science by which radiation dose is determined by measurement and/or calculation

Sources

1. Interview with Eirik Malinen
2. Project description

Facts

Awarded: NOK 5 mill.
Project Manager: Eirik Malinen, professor at University of Oslo
Contributing programs: The Research Council of Norway and The Indian Ministry of Science and Technology
Project aim: To assess the radiation dosage in order to predict effects of proton radiotherapy when protons interact with different materials, with the objective of an even more accurate cancer treatment.
Scientific impact: Overall, the research can elevate the knowledge we have on cancer therapy by gaining more insight and knowledge on proton radiotherapy as a more accurate and effective treatment of cancer. Increased accuracy in the radiation process reduces the risk of damaging healthy tissue, leading to reduced side effects and radiation injury.

Appendix

Project no.	Project title	Contributing activity	Project owner	Project leader	Project Bank
244831	China in Indian Strategic thinking	INDEMB	FORSVARETS HØGSKOLE FHS	Lars Tore Flåten	More information about the project
246784	Operation of the Smart Grid with Wide Area Information	ENERGIX	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Kjetil Uhlen	More information about the project
246809	Photoelectrochemical Splitting of Water with N-doped Graphene-Hematite Composites for Hydrogen Production	ENERGIX	SINTEF AS	Kaushik Jayasayee	More information about the project
246810	Hydrodynamic Loads on Offshore Wind Turbine Substructures due to Nonlinear Irregular Breaking, High Steep and Extreme Waves	ENERGIX	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Øivind Asgeir Arntsen	More information about the project
246821	EcoLodge - Efficient production of Butyl-Butyrate from Lignocellulose derived Sugars	ENERGIX	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Heinz A. Preisig	More information about the project
248774	Landslide hazard assessment in NE India along the Gangtok-Tsomgo / Changu Lake and Gangtok / Chungthang-Lachen corridors	GLOBALBÆREKRAFT	NORGES GEOLOGISKE UNDERSØKELSE	Reginald Hermanns	More information about the project
248776	Ocean - sea-ice - atmosphere teleconnections between the Southern Ocean and North Atlantic during the Holocene	POLARPROG	NORSK POLARINSTITUTT	Arto Miettinen	More information about the project
248780	Mass balance, dynamics, and climate of the central Dronning Maud Land coast, East Antarctica	POLARPROG	NORSK POLARINSTITUTT	Kenichi Matsuoka	More information about the project
248786	Delineation of the target fault-zone for Koyna scientific deep drilling by accurate location of microearthquakes	INDNOR	STIFTELSEN NORSAR	Daniela Kühn	More information about the project
248793	Pliocene Arctic Climate Teleconnections	POLARPROG	UNIVERSITETET I TROMSØ - NORGES ARKTISKE UNIVERSITET	Jochen Knies	More information about the project
248803	Counteracting effect of future Antarctic sea-ice loss on projected increases of summer Monsoon rainfall	POLARPROG	NORCE NORWEGIAN RESEARCH CENTRE AS	Thomas Toniazzo	More information about the project
248815	Intraplate Seismicity in India and Norway: Distribution, properties and causes (IPSIN)	GLOBALBÆREKRAFT	UNIVERSITETET I BERGEN	Lars Ottemöller	More information about the project
248834	Quantifying Impacts of South Asian Aerosols on Regional and Arctic Climate	POLARPROG	CICERO SENTER FOR KLIMAFORSKNING	Marianne Tronstad Lund	More information about the project
261091	INNO Indigo, Multilayer Nano-Capsules and targeted DNA vaccines for Immunotherapy of Cancer	BEHANDLING	UNIVERSITETET I OSLO	Bjarne Bogen	More information about the project

261093	Inno-Indigo: Nanoplatform-based drug delivery system: combinational therapy against breast and colorectal cancer	BEHANDLING	OSLO UNIVERSITETSSYKEHUS HF	Kirsten Sandvig	More information about the project
261094	Inno-Indigo: Initiative for development of biomarkers in immune neuropathies	BEHANDLING	HELSE BERGEN HF	Christian A. Vedeler	More information about the project
273319	Drug targeting for improved treatment of multi drug resistant tuberculosis.	BEDREHELSE	UNIVERSITETET I OSLO	Gareth Griffiths	More information about the project
273332	Inhibition of clinically relevant carbapenemases (ICARBA)	BEDREHELSE	UNIVERSITETET I TROMSØ - NORGES ARKTISKE UNIVERSITET	Hanna-Kirsti Schroder Leiros	More information about the project
273588	Structure-based target exploration for the discovery of new leads for antibiotics	BEDREHELSE	UNIVERSITETET I BERGEN	Ruth Brenk	More information about the project
273609	AMR-Diag: A Novel Diagnostic Tool for Sequence Based Prediction of Antimicrobial Resistance	BEDREHELSE	HØGSKOLEN I INNLANDET	Rafi Ahmad	More information about the project
273646	Antimicrobial peptides (bacteriocins) as alternative to conventional antibiotics	BEDREHELSE	NORGES MILJØ- OG BIOVITENSKAPELIGE UNIVERSITET (NMBU)	Sigrid Gåseidnes	More information about the project
273833	Born in the twilight of antibiotics: Implications of antibiotic use to the preterm infant respiratory microbiome and resistome development	BEDREHELSE	UNIVERSITETET I OSLO	Fernanda C. Petersen	More information about the project
280617	Cyber-Physical Security in Energy Infrastructure of Smart Cities (CPSEC)	IKTPLUSS	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Sokratis Katsikas	More information about the project
280731	Mathematical Aspects of Information Transmission: Effective Error Correcting Codes	IKTPLUSS	UNIVERSITETET I TROMSØ - NORGES ARKTISKE UNIVERSITET	Trygve Johnsen	More information about the project
280788	Nanoparticle-2D hybrid structures for smart environmental sensing	IKTPLUSS	SINTEF AS	Branson Belle	More information about the project
280797	Resilient and Optimal Micro-Energy-grid	IKTPLUSS	SINTEF AS	Giancarlo Marafioti	More information about the project
280835	LOW-ALTITUDE UAV COMMUNICATION AND TRACKING (LUCAT)	IKTPLUSS	UNIVERSITETET I AGDER	Linga Reddy Cenkeramaddi	More information about the project
283485	Production of JP-8 Range Fuels and Chemicals from Pyrolysis bio-oil using Nanostructured Catalyst	ENERGIX	SINTEF AS	Roman Tschentscher	More information about the project
283541	IU: CRISPR/Cas9 editing to test and control genes implicated in influencing Aeromonas disease resistance in carp and salmon	BIOTEK2021	NOFIMA AS	Nicholas Robinson	More information about the project
283566	Biotechnology applied for controlling diseases in aquaculture in Norway and India	HAVBRUK2	NORGES MILJØ- OG BIOVITENSKAPELIGE UNIVERSITET (NMBU)	Øystein Evensen	More information about the project

283570	Greenhouse gas emissions from biogas digestate applications to rice production systems	BIONÆR	NIBIO - NORSK INSTITUTT FOR BIOØKONOMI	Bente Føreid	More information about the project
285139	Czochralski growth of low-oxygen silicon single crystals for high-efficiency solar cell applications	ENERGIX	SINTEF AS	Eivind Johannes Øvrelid	More information about the project
285165	Design and development of modular multilevel converters for large scale grid connected Photovoltaic and Battery Energy storage systems	ENERGIX	SINTEF ENERGI AS	Raymundo Enrique Torres-Olguin	More information about the project
285180	Grid Interconnection protocols for largely dispersed minigrids/microgrids for electrification of rural India	ENERGIX	SINTEF ENERGI AS	Merkebu Zenebe Degefa	More information about the project
285545	Integrated Renewable Resources and Storage: Operation and Management	ENERGIX	UNIVERSITETET I AGDER	Van Khang Huynh	More information about the project
297855	Coastal transformations and fisher wellbeing - synthesized perspectives from India and Europe	GLOBALBÆREKRAFT	UNIVERSITETET I TROMSØ - NORGES ARKTISKE UNIVERSITET	Maarten Bavinck	More information about the project
298358	Challenging Inequalities: An indo-European perspective	GLOBALBÆREKRAFT	UNIVERSITETET I OSLO	Karl Ove Moene	More information about the project
299037	Displacement, placemaking and wellbeing in the city	GLOBALBÆREKRAFT	ARKITEKTUR- OG DESIGNHØGSKOLEN I OSLO	Peter Hemmersam	More information about the project
299085	OPTIMIZATION OF STEM CELL-LADEN SMART BIOMATERIALS FOR 3D BIOPRINTING OF HUMAN CORNEA	NANO2021	UNIVERSITETET I OSLO	Goran Petrovski	More information about the project
299098	Alloy development for additive manufacturing of prostheses and reconstructive implants	NANO2021	UNIVERSITETET I STAVANGER	Mona Wetrhus Minde	More information about the project
299181	NANODOS - SYNTHESIS OF NANO-PHOSPHORS AND SPIN-TRAPPING NANO-CRYSTALS AS ENERGY-INDEPENDENT DOSIMETERS FOR RADIOTHERAPY BEAMS	NANO2021	UNIVERSITETET I OSLO	Eirik Malinen	More information about the project
299261	Synthesis and Characterization of New emerging Nanomaterials and tools for evaluating impacts on human health and Environmental Risks	NANO2021	NORSK INSTITUTT FOR VANNFORSKNING	Ailbhe Macken	More information about the project
299279	High Efficiency Micro-electromagnetic Energy Harvesting System for Self-powered Smart Environment--EMPOWER	NANO2021	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Cuong Phu Le	More information about the project

299315	High-throughput Synthesis of Non-spherical Plasmonic Nanoparticles (NPs) for Applications in Endotoxin Sensing (Nano-Syn-Sens)	NANO2021	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Sulalit Bandyopadhyay	More information about the project
299363	Nano-selective, bio-mimetic membranes for integrated biotechnological production of biofuels from lignocellulosic biomass	NANO2021	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Heinz A. Preisig	More information about the project
302597	Indias Footprint in Africa: South-South Cooperation and the Politics of Gifts and Reciprocity	UTENRIKS	UNIVERSITETET I OSLO	Dan Banik	More information about the project
303173	India's ambitions and possibilities of becoming a global green leader (INDGREEN)	UTENRIKS	CICERO SENTER FOR KLIMAFORSKNING	Solveig Aamodt	More information about the project
336420	OH-AMR-Diag: Novel technological solutions for rapid detection and screening of AMR from a One-Health perspective	BEDREHELSE	HØGSKOLEN I INNLANDET	Rafi Ahmad	More information about the project
249875	Designing Information Systems for Strengthening Patient Based Care in Resource Constrained Settings	INTPART	UNIVERSITETET I OSLO	Sundeep Sahay	More information about the project
261709	International Partnership for Research and Education in energy efficient resource utilization in Food value chains between Norway and India	INTPART	SINTEF OCEAN AS	Kristina N. Widell	More information about the project
274808	Work Inclusion in North and South: Comparative Urban Contexts	INTPART	OSLOMET - STORBYUNIVERSITETET	Erika Gubrium	More information about the project
274976	LawTransform: Effects of Rights & Law	INTPART	UNIVERSITETET I BERGEN	Siri Gloppen	More information about the project
275014	India - Norway partnership for research and education in materials for energy and environment	INTPART	UNIVERSITETET I OSLO	Helmer Fjellvåg	More information about the project
275156	Intelligent Circular Manufacturing research and educational collaboration with India and Japan	INTPART	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Kristian Martinsen	More information about the project
287918	Indo-Norwegian collaboration in Autonomous Cyber-Physical Systems	INTPART	UNIVERSITETET I AGDER	Linga Reddy Cenkeramaddi	More information about the project
309582	Indo-Norwegian Collaboration in Intelligent Offshore Mechatronics Systems (INMOST)	INTPART	UNIVERSITETET I AGDER	Jing Zhou	More information about the project
309592	Reversing antimicrobial resistance (AMR)	INTPART	UNIVERSITETET I OSLO	Tone Tønjum	More information about the project
309827	Complex of online and onsite lectures on materials for hydrogen generation by solar water splitting	INTPART	INSTITUTT FOR ENERGITEKNIKK	Smagul Karazhanov	More information about the project

309857	International Network for Image-based Diagnosis	INTPART	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Faouzi Alaya Cheikh	More information about the project
309994	Educational Program for Sustainable Heating and Cooling Solutions for India	INTPART	SINTEF ENERGI AS	Ingrid Camilla Claussen	More information about the project
322275	Circular Manufacturing research and educational collaboration with India and Japan	INTPART	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Carla Susana A Assuad	More information about the project
322325	Collaboration in MicroBial Fuel Cell Research and Innovation Driven Graduate Education	INTPART	UNIVERSITETET I TROMSØ - NORGES ARKTISKE UNIVERSITET	Rajnish Kaur Calay	More information about the project
322644	Autocratization Dynamics: Innovations in Research-Embedded Learning	INTPART	UNIVERSITETET I BERGEN	Lise Rakner	More information about the project
337301	Collaborative Research Based Education for Optimized Performance of Wind Farms	INTPART	HØGSKULEN PÅ VESTLANDET	Maneesh Singh	More information about the project

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