



Crossing borders to contribute to the Sustainable Development Goals

Lessons from ten years of the Wageningen University
Interdisciplinary Research & Education Fund (INREF)

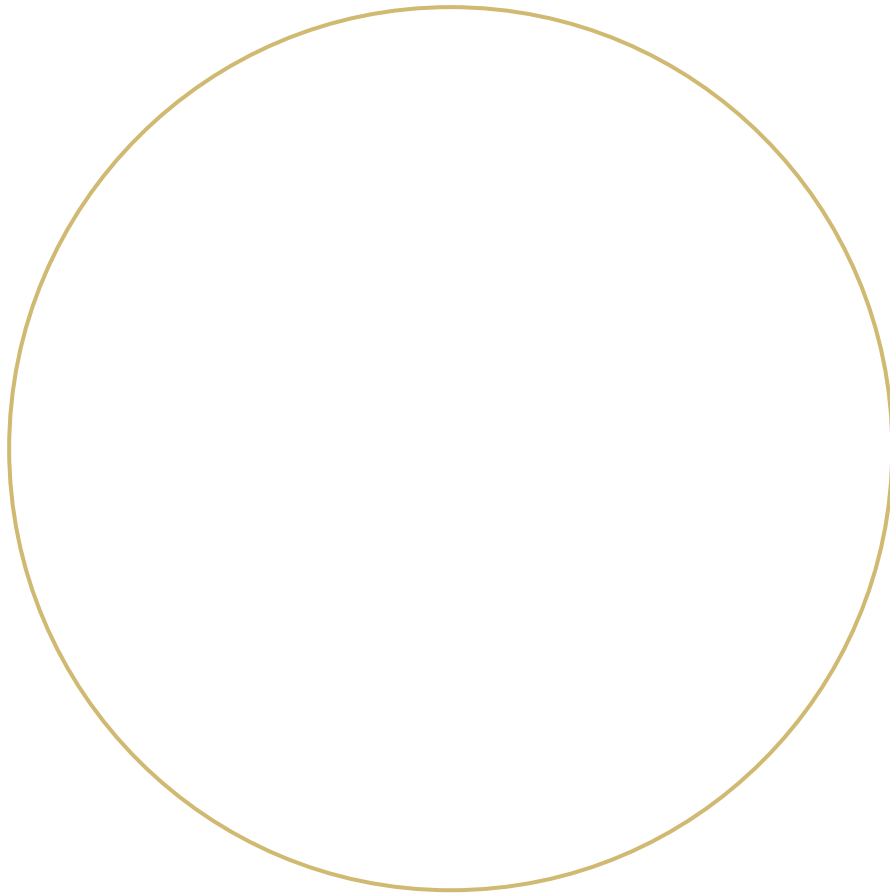


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◀ Cover photo: the Resilient Reef programme in Indonesia was preceded by a 10-day consortium-building boat expedition for researchers and local stakeholders. It functioned as a floating interdisciplinary workshop.





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Foreword

To tackle the world's most pressing social and environmental problems, in 2015 the United Nations adopted the Sustainable Development Goals: 17 goals for peace and prosperity for people and the planet. Wageningen University is strongly committed to contributing to these goals through its sustainable operations and premises, but most of all through its research and education programmes. And we have built up a strong track record over many years.

The Interdisciplinary Research and Education Fund (INREF), established in 2000 by the Executive Board, is one of our major contributions to the SDGs. This ambitious fund addresses development-related challenges around the world and embraces a systems approach. INREF's guiding principle is that complex problems cannot be solved by a single scientific discipline alone. They require an interdisciplinary research and education approach, combining and integrating perspectives and methodologies from multiple disciplines. Moreover, research and education carried out in large INREF programmes are transdisciplinary, executed in close collaboration with governmental and non-governmental stakeholders, and in direct partnership with research and education partners in low-income countries and emerging economies. To make an impact, research and education needs to be connected to and rooted in the real world.

This publication chronicles the 17 major research and education programmes implemented over the past ten years, illustrating how these programmes have made a difference in tackling complex challenges in the global South. This publication also shows how performing research and education in an interdisciplinary and transdisciplinary way is essential for coming up with effective solutions and impact. It sheds light on how INREF has contributed to international research collaborations, capacity building and partnerships and how it has developed and promoted an integrated perspective.

Twenty years of INREF research and education has created fertile ground for experimentation, innovation and learning on interdisciplinary and transdisciplinary research. The concluding chapter presents the researchers' learnings on how to perform such groundbreaking forms of research, focusing on the opportunities and challenges encountered. In June 2022, academics and practitioners from around the world will meet to discuss these lessons and recommendations, with an eye to designing new front-running interdisciplinary programmes and possibly a new phase of INREF-like programmes, at Wageningen University & Research and other partner institutions.

Professor Arthur Mol
Rector Magnificus of Wageningen University

Introduction

How can we make sure there will still be tuna in our seas in the future? How should we tackle Panama disease, which threatens the banana as we know it? And how can palm oil producers in Indonesia and Thailand make a living in a sustainable way? These are just some examples of subjects investigated in the Interdisciplinary Research and Education Fund (INREF) of Wageningen University. All are linked to the major global issues concerning health, energy, food and water, captured by the UN in the Sustainable Development Goals (SDGs).

One common characteristic of these challenges is that they are complex and multifaceted in nature, involving many different stakeholders and evolving over a longer period of time. Complex and wicked problems like these cannot be tackled from a single scientific perspective, or even by science alone. They need the combined expertise and perspectives of different scientists and stakeholders, brought together in an integrated systems approach. Yet science is still predominantly organized in a mono-disciplinary way. Scientists are expected to excel in one particular field and publish in journals that are largely monodisciplinary.

Over 20 years ago Wageningen University established the Interdisciplinary Research and Education Fund (INREF) to stimulate interdisciplinary research, in the firm belief that this is needed to contribute to development-related challenges. Between 2000 and 2010, twelve research and education programmes were executed (phases I and II). In the past eleven years, another 17 research and education programmes have been started (phases III and

IV) and they are the subject of this booklet. Each programme is described in a separate chapter. Most of the programmes in phase III have been finalized, many of the programmes in phase IV are still ongoing. The programmes take place in low-income countries and some emerging economies.

Apart from research programmes, INREF also finances seed money projects. Each year a maximum of ten projects are awarded €25,000 to enable the preparation of research proposals. This can result in a proposal for INREF funding, but can also lead to proposals submitted to other research funders such as the Dutch Research Council (NWO) or the EU. In addition to the programmes and seed money, INREF invests in the co-financing of programmes (e.g. with NWO-WOTRO in the SDG programme, three projects) and invests in spreading the word with events, a newsletter, videos and this publication.

One of the guiding ideas behind INREF is that complex problems cannot be solved from within a single scientific

INREF at a glance



Each programme has trained 3-15 PhD students.
Number of PhD students:

- 53 in phase I
- 65 in phase II
- 69 in phase III
- 76 in phase IV

Research in INREF programmes has been done in 28 countries in Africa, Asia and Latin America.

INREF has had a budget of 10-12 million euros for each research phase (five years).

Hundreds of PhD theses, peer-reviewed articles and other publications have been published. For a full overview please visit www.wur.eu/inref.



▲ A farmer field school on potato disease management in Ethiopia.

discipline. They require an interdisciplinary approach, combining perspectives from multiple disciplines in research and education. In INREF, scientists from different fields, both social and technical, come together to define research questions and share insights and methods. The core activity of the INREF programme is formed by interdisciplinary, multi-annual, graduate school-overarching PhD research projects on complex development-related issues. PhD students often work as a group on a common problem and are supervised by at least two scientists from different fields. This approach brings many new insights and solutions that it is hoped will make lasting changes in the countries themselves. These insights are described in this book. The interdisciplinary approach also brings challenges, as scientists from different fields need to learn to understand each other's language, tools and methods, and how to interpret each other's results. Over the years many

lessons have been learnt on how best to do this kind of research. These lessons are reflected upon in a synthesis chapter at the end of this booklet.

Another guiding idea behind INREF is that scientists who aim to make an impact cannot work in splendid isolation. Research and education in INREF are done in a transdisciplinary way: in close collaboration with stakeholders and integrating scientific knowledge with experience-based or indigenous knowledge. The extent to which researchers engage with stakeholders and the degree to which stakeholders have a say in the research and education programmes differ among the programmes. But all start from the assumption that to make an impact, research needs to be rooted in the real world. The aim is to achieve results that really make a difference for the intended end users, for example policymakers, NGOs, farmers or companies. An important contributory factor is

that INREF research is done in partnership with research partners in low-income countries and emerging economies. The PhD research projects are implemented by early-career scientists from low and middle-income countries. They come to Wageningen to prepare a proposal, then go back to their employer in their own country and conduct field research, after which they return to Wageningen to analyse their findings and write their thesis, in cooperation with Wageningen colleagues. PhD students are expected to contribute part of the funding for the research from their home institution. This so-called sandwich structure ensures that research is relevant to the partner-institutions.

INREF's interdisciplinary and transdisciplinary approach enhances the co-creation of research results, thus ensuring they can be applied by those who need them. In other ways too, INREF aims to make a lasting impact, for example through training, methodologies or tools that last after the programme ends. Moreover, INREF's integrated approach not only impacts directly in the research area, but also indirectly, by influencing science and policy debates. INREF also brings about new collaborations and partnerships. In many cases, INREF programmes have led to spin-offs through new scientific programmes funded by other donors, or through development or government-funded programmes or policies.

Mono-, multi-, inter- and transdisciplinary

INREF does not adhere to strict definitions, but the following gives an indication of how these concepts are understood and used.

Monodisciplinary: researchers from one scientific discipline work together; science is assumed to deliver solutions *for* society.

Multidisciplinary: researchers from different scientific backgrounds work on the same topic and share their results, but base their work on their own research questions, methods and concepts; science is assumed to deliver solutions *for* society.

Interdisciplinary: 'between the disciplines' – researchers from different scientific disciplines work on an integrated research question that is created together, and work with methods and concepts from two or more different scientific fields, or create new ones; science is assumed to deliver solutions *for* society.

Transdisciplinary: researchers work in an interdisciplinary way, but also involve the knowledge of non-academic actors such as farmers, policymakers or other stakeholders. The degree to which non-scientific actors' perspectives and needs are leading varies. Science with: knowledge is co-created *with* society.

Above all, INREF makes a lasting change through capacity building in developing countries and emerging economies. After graduation, many of the PhD graduates return to their institute, are often promoted and establish themselves in influential positions. Through them, the seeds of interdisciplinary research are sown further among peers and younger generations. The INREF alumni form a unique network of policymakers and researchers that extends beyond national borders – and which is made up of people dedicated to crossing disciplinary borders in order to tackle complex problems. ■





Research programmes

INREF phase III

The programme contributes to these SDGs



Containing Panama disease in banana

Panama disease, which affects banana plants, is caused by a suite of fungi and threatens banana production worldwide. Interdisciplinary research alerted the sector to the problem and spurred multi-million investments for further research.

Panama disease is a killer. Caused by a various strains of *Fusarium* fungi, it poses a major threat to global banana production. These soil-borne fungi infect the roots, and then colonize and occlude the vascular system of the plant, causing its leaves to wilt, and eventually the plant's death. In the first half of the 20th century, banana production in South America was heavily damaged by Panama disease. From the 1950s, producers switched to another cultivar, the current Cavendish, which was resistant to the fungi that caused the epidemic. But in the 1990s a new strain of the *Fusarium* fungus appeared and began to spread from Southeast Asia, causing great economic losses for millions of smallholder producers and multinational traders alike.

One solution would be to find or create new cultivars that are resistant to the disease, in the same way that the introduction of the Cavendish provided a solution in the last century, tells Gert Kema, Professor of Phytopathology,



▲ Gert Kema visiting a banana plantation in the Philippines.

'The INREF programme greatly contributed to raising awareness in the sector'

the science dealing with plant diseases. 'We are indeed working towards understanding this Fusarium-banana pathosystem and that should eventually lead to new resistant cultivars. For sure, that would make a change to the sector, but it would not be the ultimate solution.' This is because overall sustainability does not revolve around Panama disease alone. Not one, but a variety of new cultivars would be needed, and would then have to be introduced to farmers. Questions remain, however, like how to organize producers to deal with the many sustainability issues in the sector, such as pesticide use. These questions cannot be solved by a single technical solution, Kema says. 'We need interdisciplinary research, looking at the problem from a technical *and* social perspective.'

Different worlds

An interdisciplinary INREF research programme was set up in which plant pathologists, soil scientists and social scientists worked together. One aspect of the programme was to combine monodisciplinary research on plant resistance with integrative research on the issue of disease control. Kema: 'Real interdisciplinary research means bridging the gap between technical and social scientists, who are usually in different worlds. With the help of an INREF seed money project, we were able to invest time in really getting to know each other. Gradually,



Title Panama Disease in Banana: multi-level solutions for a global problem

Duration 2012-2017

Number of PhDs 7

Wageningen University chair groups involved

Environmental Sciences: Soil Geography and Landscape (SGL), Plant Sciences: Laboratory of Phytopathology (PHP), Social Sciences: Knowledge, Technology and Innovation (KTI), Rural Sociology (RSO)

Wageningen Research Biointeractions & Plant Health

Partners Corporación Bananera Nacional (Costa Rica); Cleardetections (Netherlands); National Agricultural Research Organization (NARO Uganda); Tagum Development Company (Philippines); Nader & Ebrahim S/O Hassan (Philippines); University of The Philippines; Unifruitti (Philippines) Asociación De Bananeros De Colombia; Bayer Crop Science (Germany); Agrofair Netherlands; Musaradix (Netherlands); Agroamerica (Guatemala); Corporación para Investigaciones Biológicas (Colombia); Universidad Nacional de Colombia; Centro de Investigaciones Biotecnológicas del Ecuador (CIBE, Ecuador); International Plant Genetic Resources Institute (IPGRI); Escuela de Agricultura de la Región Tropical Húmeda (Costa Rica); Empresa Brasileira de Pesquisa Agropecuária, (EMBRAPA Cassava & Fruits, Brazil)

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we managed to comprehend each other's take on the problem, and this resulted in the INREF Panama disease programme.' During this period Kema also engaged with many partners from the banana industry, who almost doubled the budget for the INREF research programme, thus making money available to cover the high costs of laboratories and banana production.

Insight in many aspects

Seven PhD students did research in the programme. One of them characterized hundreds of different banana accessions, searching for resistant cultivars. The gene that makes bananas resistant has now been mapped, providing knowledge needed to breed new resistant varieties. Another PhD student studied the epidemiology of the disease which at times has evolved into a pandemic: how the disease spreads, and how it can be controlled. The results revealed that while many banana growers do

disinfect their shoes and equipment, too many do not use the disinfectant properly, so dissemination of the disease is not stemmed. Soil scientists found that soil fertility affects the spread and severity of the disease. And social scientists found that the contracts under which many smallholders produce bananas for larger fruit companies, are often not helpful in containing the disease. There is a culture of blaming the producers for the disease, which means smallholders prefer to keep silent when their plants are infected, which is disastrous for the spread of the disease. On the other hand, they also found that large companies are increasingly supporting smallholders to combat the disease.

Awareness

'The INREF programme greatly contributed to raising awareness in the sector about the magnitude of the Panama disease crisis,' Kema says. Research results



▲ Group discussion with farmers in Java, Indonesia.



▲ Cross section of infected banana plant.



▲ Visit to Yunnan, China.

'Interdisciplinary research requires mutual humbling'

showed how the disease affects plants, and how it can easily spread due to the interconnectedness of global value chains. In response, large multinational banana companies are now contributing several millions to Wageningen research aimed at finding technical solutions to contain the disease. 'INREF has put Wageningen University on the map as a leading world expert in this field. But we still need to convince many more people that a real solution needs interdisciplinary research.'

Humbling

Interdisciplinary research requires mutual humbling Kema says. None of the experts or experiences can be missed or

is dispensable. 'We discovered wonderful things with our biology, but to achieve sustainability in the sector, much more is needed.'

Kema comments that the experimental plant sciences are not particularly prominent in INREF. 'Our programme was the exception, and it was on the applied side, with substantial focus on technical experiments. Yet, it has been incredibly successful and has put WUR on the map of international banana research and development.' The spin-off has been enormous in terms of funding, scientific achievements, and recognition. Kema's recommendation would be to stimulate interdisciplinary programmes across



▲ Leaves start yellowing and the plant dies. Cause: Panama disease.



▲ Disinfecting a car in a plantation.





▲ Thousands of hectares of plantations have been wiped out by Panama disease.

the different WUR departments – animal, plant, social and environmental sciences – but at the same time not shy away from involving the more monodisciplinary teams in these. ‘We should stimulate them to engage with colleagues outside their own domains. Underscoring the need for interdisciplinary and transdisciplinary work to target the big agricultural problems of the world is still required at WUR. Too many of us think that their solution is the best.’ ■

‘Too many of us think that their solution is the best’

◀ Sampling banana plants in a small backyard banana production site in Indonesia.

‘The need for diversification was made clear’

‘A new variant of Panama disease emerged in Asia as long ago as the late 1990s. But we stayed asleep and for years, the large banana companies underinvested in research. It is crucial that banana research is now on the agenda, and this is partly thanks to INREF.’ These are the words of Luud Clercx, project manager at AgroFair, a fair trade and organic banana importer which co-financed the INREF programme.

In the 1990s, development organization Solidaridad tried to persuade large banana companies such as Chiquita and Dole to become more sustainable and introduce a fair-trade certified banana. When that failed, Solidaridad decided in 1997 to set up its own sustainable importer: AgroFair. The introduction of fair-trade certified bananas was a success and their market share grew rapidly.

Through the INREF programme, a close collaboration arose between Clercx and Gert Kema. After the outbreak of Panama disease in Mozambique in 2013, they co-founded the Panama disease Task Force in the World Banana Forum, a consultative body in which large companies, NGOs, certification organizations, government representatives and supermarkets work together on the future of banana production. ‘The presentations we made in this forum have helped to raise awareness in the sector of the importance of Panama disease and research on it,’ Clercx says.

It is very important that researchers now screen varieties and investigate disinfecting shoes and cars of people in plantations, for example. ‘But it is especially encouraging that the research shows the need for diversification. We must move towards a different kind of banana cultivation worldwide, one in which several varieties are used, with higher levels of biodiversity and healthy soils in the plantations. We have to get rid of monoculture and the use of clones.’

The programme contributes to these SDGs



Developing a nuanced perspective on sustainable palm oil

The debate on palm-oil sustainability tends to be polarized and as a result opportunities for solutions are often missed. The integral and interdisciplinary approach used in the INREF programme SUSPENSE has helped to move the debate beyond diametrically opposed positions, and made Wageningen a sought-after partner in international research and policy advice on palm oil. But to work this way requires all-rounders.

Production and trade of palm oil – an important ingredient in many food products, cosmetics and biofuel – is a complex global business, worth billions. The commodity is produced by many different types of smallholders, privately owned plantations, and state-owned enterprises. Indonesia is the world's biggest palm-oil producer, and home to some 2.7 million smallholders.

'The palm-oil sustainability discussion in the public arena and among policymakers ignores the complexity of the issues. It is much too black and white,' says Otto Hospes, manager of the INREF programme SUSPENSE. Advocates of palm oil present it as the ideal commodity, while opponents denounce the ongoing human rights violations

and deforestation in the sector. The reality is complex, and the sustainability of the sector would be better described in many different shades of grey. The debate is also too Eurocentric, says Hospes. Parties in Europe often lay the problem at the door of producers in Indonesia or Thailand, without looking at the bigger picture and the role of Western companies and governments. A comparison is lacking with other vegetable oil crops cultivated in Europe, such as sunflower or rapeseed oil. 'This Eurocentric view does not always show respect for partners in Indonesia and Thailand, such as the governments.' This impedes dialogue with them and, as a result, the approach to sustainability in Asia often diverges from the ideas prevalent in Europe.

'The discussion on palm oil is much too black and white'

Integral approach

'A more integrated approach leads to more nuance,' says Hospes. With its interdisciplinary and transdisciplinary research methods, the SUSPENSE programme laid the foundation for an integral, systems approach. The research done by the eight PhD students yielded scientific insights that add nuance to the discussion and enable solutions that contribute simultaneously to several sustainable development goals (SDGs).

An example of this is research on the intercropping of palm oil with other crops, which increases both biodiversity and farmers' income. Other research showed that good agronomy combined with policy and legislation



▲ Visit to a palm oil mill.



Title Towards environmentally sustainable and equitable palm oil: promoting sustainable pathways by exploring connections between flows, networks and systems at multiple levels (SUSPENSE)

Duration 2012-2017

Number of PhDs 8

Wageningen University chair groups involved

Environmental Sciences: Environmental Systems Analysis (ESA), Plant Sciences: Plant Production Systems (PPS), Social Sciences: Public Administration and Policy (PAP), Environmental Policy (ENP), Development Economics (DEC)

Wageningen Research Wageningen Centre for Development Innovation (WC DI)

Partners Bogor Agricultural University (IPB), Walailak University

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'Many of our alumni are now in influential positions'



that supports farmers can help to close the yield gap. And another study revealed that although the Indonesian government has a strict policy against deforestation it struggles to implement this and stay abreast of the real situation – thus contradicting the European perception of what is happening there. One PhD student showed that it is feasible to develop the Thai palm oil sector in an environmentally friendly way, and mapped out a pathway to do so.

Hospes explains that the interdisciplinary part of the approach involved building a framework using concepts – such as flows and systems – that are familiar to agronomists, researchers in public administration and policy researchers, economists and ecologists. The PhD students used this common language and were supervised by professors with different disciplinary backgrounds.



▲ Prices of fresh fruit bunches at factory gate in Thailand vary depending on oil extraction rates. Better quality pays off.

► Dutch PhD student Lotte Woittiez brought supervisors and fertilizer company reps to farmers' fields in Sintang, Indonesia, to discuss fertilizer use.





▲ Some of the research team on a visit to a palm-oil mill in Thailand.

Leading position

The research was also made transdisciplinary. For the agronomists, this meant doing research together with farmers. For the public administration researchers, it meant having contact with and getting input from policymakers in government, NGOs and companies. Hospes: 'Key questions are who will participate, when will they participate, and how much say will they have in the research?' The practical impact of the research done in the SUSPENSE programme is seen mainly in the work that the PhD researchers went on to do after they graduated. 'Many of our alumni are now in influential positions, in government, NGOs or international organizations. They

lead large programmes or advise governments at the highest level.'

Internationally, initiatives and programmes to make palm oil more sustainable are on the rise. 'The nuanced and integrated approach that we developed in this INREF programme is much appreciated.' Numerous new research projects, high-level policy debates and policy advice have resulted from the programme, says Hospes. 'Wageningen University has become a world leader in international policy discussions on palm oil.' Respect for partners in the South, rather than a Eurocentric vision, plays a role in this, he continues. 'It's great that, for example, a high-

ranking official from the Indonesian Coordinating Ministry for Economic Affairs is now doing doctoral research at Wageningen University.'

Demanding work

Interdisciplinary and transdisciplinary research is crucial to the success of this programme, says Hospes, but it is also very demanding and challenging. 'In many cases, it is asking too much of individual PhD students that they excel in their own discipline while using methods and knowledge from other disciplines, plus expecting them to have good contact and cooperation with non-academic partners.' The sandwich model of financing, whereby PhD students have to bring in part of their funding from elsewhere, makes it difficult to recruit suitable candidates for this kind of research, says Hospes.

Another idea of Hospes is to not require all PhD students to publish all their research in peer-reviewed journals. 'Some PhD students aspire to a future in science, but most of them want to use the insights they have gained in the 'outside world' and go on to work for the government, NGOs or business, with great success. The question is whether you should ask them to publish in triple-A journals.' ■

'It helped a lot to explore this issue from different perspectives'

Managing the dialogue on sustainable palm oil



Eusebius Pantja Pramudya has a background in banking and finance, and obtained his PhD in the SUSPENSE programme. He studied the governance strategies adopted by Indonesian state actors for sustainable palm oil and how they interact or come into conflict with global actors such as the Roundtable for Sustainable Palm Oil (RSPO). He now works as an independent researcher and consultant, and is able to exert influence, for example by advising the Indonesian government on how to manage the country's largest fund for sustainable palm oil, which is financed from export taxes levied on the commodity.

'I try to contribute to the dialogue between Indonesian government agents and international actors, which is not really addressed in the existing sustainable palm oil initiatives,' Pramudya says. On the one hand, the Indonesian state struggles with the demand for sustainable palm oil, he says. The government has limited financial resources, and law enforcement against encroaching palm oil plantations is hard in such a big country. 'This situation is also influenced by the widespread belief that there should not be state involvement in market mechanisms.' On the other hand, the continuously changing demands and standards called for by the international companies and NGOs who orchestrate the debate on palm oil sustainability are not helpful either, Pramudya says. 'The government needs time to implement sustainability improvements step by step.'

To facilitate the dialogue, it's important to realize that both parties use different jargon, Pramudya says. For example, for Indonesian state officials, 'sustainable development' means in the first place managing poverty. But for external international actors, it means addressing deforestation. Pramudya says he learned about managing divergent views from the interdisciplinary approach of INREF. 'Professors had an open mind. It helped a lot to explore this issue from different perspectives. And I had the space to bring in my perspective as a scholar from the Southern hemisphere.'

The programme contributes to these SDGs



'Sustainable soil management should attribute more value to local knowledge'

Along the riverbanks of the Amazon and its tributaries lies a mysterious type of land. Its black soil or terra preta is highly fertile and, contrary to what was long assumed, this fertility is human-induced. The *Terra Preta do Indio* programme examined the origin of these soils and how they might inspire sustainable agriculture practices and climate change mitigation through carbon sequestration.

Terra Preta de Índio, Portuguese for 'Indian black earth' or Amazonian Dark Earth, has fascinated soil scientists for decades. With its deep black colour, it is distinctly different from the rust-coloured earth that is found in the areas around it. The ecologically poor soil of the Amazonian was long thought to be unsuitable for agriculture, but *terra preta*, which is found in many locations along the riverbanks of the Amazon and its tributaries, proved to be highly fertile.

Terra preta is believed to have originated between 3000 and 500 years ago. For a long time, little was known

about its origins, but gradually consensus has moved toward the conviction that the fertility of the soil was at least influenced by humans and possibly even man-made. This opened new possibilities: recreating such 'black soil' could make more land suitable for agriculture, and at the same time store carbon in the ground and contribute to solving the climate problem.

Sustainable alternatives for agricultural practices

Thom Kuyper, Professor of Soil Biology at Wageningen University and leader of the Terra Preta programme, became intrigued by the promising qualities of this soil

'Biochar is not a panacea for enhanced carbon sequestration'

and helped set up a large interdisciplinary programme around the Terra Preta do Indio, together with universities and partners in Brazil, Bolivia and Colombia. The programme aimed to draw inspiration from the process of creation of the *terra preta*, to come up with sustainable alternatives for agricultural practices. This was and still is urgent, since Lowland Amazonia is threatened by high rates of environmental degradation, caused by large-scale deforestation in the wake of agricultural expansion for both rangelands and soybean production.

The programme resulted in some 25 published papers, and plenty scientific achievements: increased knowledge of soil in these soils, increased understanding of how farmers use and possibly create such fertile soils, increased knowledge of tropical tree diversity and



▲ Researchers making a soil profile.



▲ Unloading and bagging biochar.



Title Terra Preta - Recovering the past, regaining the future of Amazonian dark earths

Duration 2008-2016

Number of PhDs 8

Wageningen University chair groups involved

Environmental Sciences Soil Biology (SBL), Soil Chemistry and Chemical Soil Quality (SOC), Forest Ecology and Forest Management (FEM), Forest and Nature, Conservation Policy (FNP), Plant Sciences: Centre for Crop Systems Analysis (CSA), Social Sciences: Sociology of Development and Change Group (SDC), Knowledge, Technology and Innovation Group (KTI), Law and Governance (LAW), Development Economics (DEC)

Partners Brazil: Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA); EMBRAPA, Amazônia Ocidental; EMBRAPA, Solos; Instituto Nacional de Pesquisas da Amazônia; Museu Paraense Emílio Goeldi; Universidade de São Paulo, Bolivia: Instituto Boliviano de Investigación Forestal, Colombia: Universidad Nacional de Colombia

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'We could work with soil in a much more constructive way than we do now'

successional processes in human-modified landscapes and of the mechanisms that allow tropical soils like *terra preta* to store high amounts of soil organic carbon, to name but a few.

Work with soil

Kuyper: 'The Terra Preta programme contributed to the popularization of the idea that sustainable soil management should attribute more value to local knowledge. Nowadays, that is a widespread idea, but it certainly was not back then.' The fact that the fertile soils turned out to be anthropogenic is, according to Kuyper, a major inspiration for (re-)creating soils for sustainable futures: 'The programme led to the insight that the diversity in tropical forests, notably in the Amazon, is not due to the fact that the Amerindians did not impact soils, but rather that they actively created them. It feeds into the important idea that humans could work with soil in a much more constructive way than we do now.' The programme involved different universities and research partners in the three countries, 8 PhD students and 15 other researchers. One of those partners was the Brazil National Institute for Amazonian Research (INPA). Biologist Charles R. Clement was one of the researchers from INPA who collaborated with the Terra Preta programme. 'The indigenous and local communities that collaborated, living themselves in these lands, also learned a little more about the *terra preta*,' he says about the impact of the programme. 'And one of the outgrowths of research on *terra preta* is biochar.'

Biochar is not a panacea

Biochar, a charcoal-like substance that results from anoxic combustion of organic material, is what gives the *terra preta* its distinct black colour. It allows the soil to retain nutrients and its presence in the *terra preta* is explained by the alleged burning of forest patches when indigenous people living in the Amazon wanted to start using a piece of land for agriculture.

The concept of biochar originates from Amazonia, but gradually became disconnected from the discourse of indigenous culture and Terra Preta and gained international traction as part of the ecological modernization discourse, suggesting that simply adding biochar to soils would enhance both carbon sequestration and fertility of the soil at the same time, concluded Kuyper and the Terra Preta team. The programme helped to gain a better understanding of exactly how biochar in soils works. Many other components are found in *terra preta*: fish bones, organic waste and potsherds. The researchers found that in interaction with each other the different components made a rich, living soil: a delicate, balanced process. 'It is now appreciated that the simple application of biochar is not a panacea for enhanced carbon sequestration,' explains Kuyper.

'It opened up my scientific view'

Interdisciplinarity was at the heart of the Terra Preta programme. The programme brought together a diverse mix of researchers, from soil ecologists, soil scientists





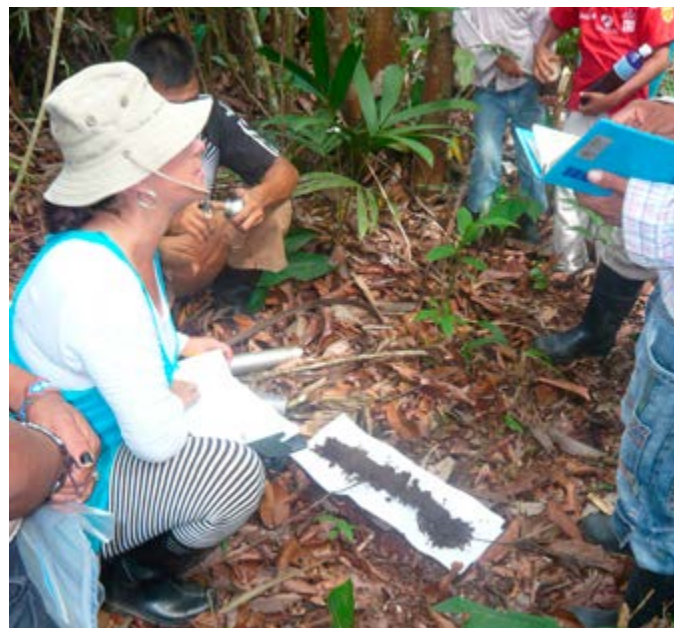
◀ Researchers in a cassava field in Brazil.

and forest ecologists to agronomists and anthropologists. An example of an interdisciplinary question that the programme addressed was: why do some farmers in Amazonia not use the fertile soils sustainably? 'This is something that could only be understood by working together with agricultural technologists and social scientists, to understand the practices of local farmers. We found that since these soils are so fertile, they also cause more weeds to grow. When labour is a limiting factor people will use more pesticides, causing agricultural activities on these grounds to be less sustainable than they could be.'

Former PhD student of the Terra Preta programme, Clara Patricia Peña Venegas, worked with indigenous communities in the Colombian Amazon and looked into the use of soil quality. 'In my research on the human-soil-manioc interaction, one of the most remarkable findings was that local farmers do not select the most fertile soils to grow their main crop, manioc. Manioc does not require fertile soils, which means their food security is not dependent on the fertility of the soil. This is opposite to the Western understanding that successful agriculture is only possible on fertile soils. Indigenous people of the Amazon domesticated a crop that grows well regardless of the soil quality and even stimulates the growth of beneficial fungi that help the crop to acquire nutrients from the soil.' Manioc, she adds, is now one of the target crops being used to promote sustainable use of Amazonian resources. Peña Venegas, a microbiologist, worked with different scientific methods: experiments, statistics, lab analyses, interviews and discourse analysis. 'This experience enriched myself as researcher and opened up my scientific view.'

Interdisciplinarity tackles the biggest problems

Kuyper has one important recommendation for future interdisciplinary projects and education: 'Work on the educational programmes that universities offer. Current programmes, also at WUR, still mostly reproduce the discipline that they originate from, instead of focusing on applying a certain way of thinking. We work in an academic world where monodisciplinarity usually leads to publication in high-impact journals. But I think following one disciplinary path also means switching off a lot of different viewpoints and trading off academic high impact against societal high impact. Multidisciplinary and interdisciplinary working is essential to be able to tackle the biggest problems in the world.' ■



▲ Taking soil samples.

The programme contributes to these SDGs



Nature conservation in Africa is not just about elephants – it's about people too

While transnational nature reserves in southern Africa have created more room for wildlife to roam the African savannahs, they have often ignored the people who live in and around the parks. Research revealed how this led to conflicts, and pointed to ways in which these conflicts could be resolved. 'We gave the residents a voice and brought people back into nature conservation.'

It seemed like a great idea: remove the fences between the adjoining conservation areas in South Africa, Zimbabwe and Mozambique, and you have one large reserve. This way a much larger habitat was created for elephants and other wildlife, but the people living in and around the nature reserves came second. South Africa has a history of forced removals of people from conservation areas and those living on the edges of national parks are still not well protected against wildlife, nor do they receive compensation for damage to their livestock from predators. In Mozambique and Zimbabwe, farmers living in or around the park have lost access to natural



▲ Donkey killed by a lion.

'For interdisciplinary research to work well, it takes two to tango. You need good students, but you also need supervisors who are willing to compromise'

resources, or have been forced to move out due to increasing numbers of elephants destroying their crops and lions killing their livestock and threatening their livelihoods. Farmers who have moved elsewhere come into conflict with the people already living there.

'It was a mistake that people were only taken into account after the fences were removed to create the Great Limpopo Transfrontier Conservation Area,' concludes sociologist Jens Andersson, Southern Africa coordinator of the INREF programme Competing Claims on Natural Resources. The nine PhD students in this research programme mapped out – together with residents, farmers, policymakers and park rangers – the conflicting claims on land and water in the area. The aims were to guide these stakeholders in dealing with conflicting, multiple uses of natural resources, to develop more equitable management options that reduce rural poverty and conflict, and to achieve more sustainable use of natural resources and wildlife management.

The nine PhD students each looked at different aspects. One engaged with farmers who had to resettle due to the encroaching wildlife in the newly declared nature conservation area in Mozambique where they lived. She assisted these people in adjusting their farming practices to a more sedentary form of agriculture on the small lands that they were allocated. She used her scientific outputs



Title Competing Claims on Natural Resources

Duration 2006–2011

Number of PhDs 9

Wageningen University chair groups involved

Animal Sciences: Animal Production Systems (APS), Environmental Sciences: Resource Ecology Group (REG), Forest Ecology and Forest Management (FEM), Soil Inventory and Land Evaluation (SIL), Plant Sciences: Plant Production Systems (PPS), Social Sciences: Rural Development Sociology (RDS), Communication and Innovation Studies (CIS), Development Economics (DEC), Environmental Economics and Natural Resources Group (ENR)

Partners Nine universities and research institutes in South Africa, Zimbabwe, Mozambique and the Netherlands

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▲ Fence that has been mended.



▲ Porous park boundary, South Eastern Lowveld, Zimbabwe.

to help negotiate better compensation for those who had to move.

Other research focused on more intensive agricultural practices that can support livelihoods on the edge of conservation areas while sparing land for nature. Policymakers promoted conservation agriculture, a form of farming based on minimal tillage and crop residue retention. But research revealed that this did not improve the yields and livelihoods of these smallholder farmers. Conservation agriculture requires artificial fertilizer and high productivity levels to generate enough crop residues, and this was not achievable here. Andersson: 'Our research debunked assumptions and advised against the promotion of conservation agriculture as a way of improving smallholder farmers' food security and livelihoods.'

Research in this INREF programme also revealed that farmers in South Africa living near the nature park where foot-and-mouth disease was endemic among wildlife – and

whose cattle were at risk of infection – were prohibited by law from moving their cattle. This was to protect the export position of the large-scale meat farmers but it seriously hampered smallholders' livelihood options, as they are dependent on local market sales and sharing oxen for ploughing the fields.

Bigger picture

'Although the PhD students all studied different aspects of life on the edge of conservation areas, they interacted with each other and thus contributed to a broader, interdisciplinary perspective on human-wildlife relations and nature conservation,' says Andersson. The resulting publication – *Transfrontier Conservation Areas: People living on the edge* – captures that interdisciplinary perspective. Agronomists, ecologists, animal scientists, economists and sociologists exchanged ideas and worked together, and all met up twice a year in a fieldwork location. In addition, each PhD student had one supervisor from the social sciences and one from ecological or technical sciences. 'For interdisciplinary research to work

well, it takes two to tango,' says agronomist Maja Slingerland. 'You need good students, but you also need supervisors who are willing to compromise on disciplinary depth and who recognize that the power of this kind of research lies in its interdisciplinarity.'

All PhD students started their research with a scoping study, in which they engaged with farmers, nature park rangers, NGOs and local research partners to identify the competing claims and collect research ideas. 'This was a great idea, and we recommend doing this for future inter and transdisciplinary work,' continues Slingerland. 'It creates engagement and motivation, and ensures that the research focuses on real and relevant topics. The PhD students gain a sense of ownership and can operate as a cohort towards a group of stakeholders in their research location.' The researches within the programme were guided by two frameworks that were developed specifically for this research. One was on the interaction between local, national and international factors – highlighting the limited influence that local people have on higher levels of policy and decision making. The other framework was based on a research cycle that starts with describing and explaining resource use dynamics and competing claims, followed by exploring and designing alternatives.

'Negotiation was central to this research programme,' says Andersson. Competing claims on natural resources arise mostly between stakeholders with unequal endowments. 'With our research we managed to give a voice to weaker parties, the poor smallholder farmers living in or on the edge of conservation areas. The stakes are high,' he adds. Wildlife tourism brings in big money for private conservancies and national governments. 'Some parties

'Some parties were not so happy with the way our researchers revealed the impact of the nature parks on local communities'

were not so happy with the way our researchers revealed the impact of the nature parks on local communities. Some researchers even received threats.' Trying to involve all stakeholders in the research process was a way to create space for this research and for acceptance of the results.

In the end the research programme did make a difference, Andersson and Slingerland conclude. Slingerland: 'Many NGOs involved in nature management no longer look only at nature and wildlife, but now focus more on supporting livelihoods, for example through agricultural programmes. We have really set something in motion.'

In addition to that, the programme's impact was in creating and establishing new concepts, Slingerland says. 'The term "competing claims" was coined by this programme and has since been adopted by many others.' It is now used widely in scientific literature and has inspired many new large research programmes. 'By moving beyond an ecological view – drawing attention to actors with competing interests, and making the point that we should consider the effects of these on the livelihoods of poor people – we have put humans back into nature conservation efforts.' ■

The programme contributes to these SDGs



Collaborating for quality fruit and vegetables



Better quality of fruit and vegetables can only be achieved by all value chain actors jointly seeking technical, organizational *and* institutional solutions together. The CoQA programme aimed to understand the success factors in the supply chains for pineapple, citrus and potato in three African countries.



▲ Researchers looking at a calendar made to promote pineapple from Benin.

Quality is becoming increasingly important in the production, processing and marketing of food products in African supply chains. 'Low quality causes loss of sales opportunities and efficiency throughout the supply chain. Smallholder farmers benefit from producing better quality produce, as it strengthens their market access and competitiveness,' says Jos Bijman, leader of the CoQA programme. 'But quality issues prevail throughout the value chain. A pineapple producer can have a beautiful field of pineapples, but the quality may deteriorate during transport and storage. Quality issues can therefore not be ascribed to only farmers or traders, retailers or transporters.'

What is the best way to achieve quality improvement in smallholder fruit and vegetables value chains? The CoQA

*'Quality issues prevail throughout the value chain,
and cannot be ascribed to one actor only'*

programme searched for answers in a study of the pineapple, citrus and potato supply chains in three African countries: Benin, Ethiopia and South Africa. The aim of the programme was to understand the success of certain quality co-innovations in the value chains.

Integrated solutions, multiple perspectives

Integrated quality solutions are needed to ensure that chain actors comply with increasingly stringent food safety and quality standards. But it's not only technical solutions, such as improved crop varieties, storage, processing or packaging techniques, that are needed. Different organizational arrangements, process innovations and an enabling institutional environment are equally important, as these can strengthen coordination among actors, encourage investments and ensure greater control over product quality and safety.

This is why scientists in the CoQA programme studied the different value chains from multiple perspectives and used a wide variety of research methodologies. Bijman: 'The agronomist tested new varieties and technical inputs and the food technologist tested new fruit juices in the laboratory. The social scientist did qualitative research, which involved surveys and interviews with all actors, to understand the bottlenecks and the potential for improvements. Another researcher performed a marketing study that focused on consumer quality perception and willingness to pay.'



Title Co-Innovation for Quality in African Food Chains (CoQA)

Duration 2008-2014

Number of PhDs 6

Wageningen University chair groups involved

Agrotechnology and Food Sciences: Product Design and Quality Management (PDQ), Food Quality and Design (FQD), Plant Sciences: Centre for Crop Systems Analysis (CSA), Social Sciences: Business Economics (BEC), Business Management and Organisation (BMO), Marketing and Consumer Behaviour (MCB), Development Economics (DEC), Operations Research and Logistics (ORL)

Partners Hawassa University, Ethiopia; Université d'Abomey-Calavi, Benin; University of Fort Hare, South Africa

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'Researchers tend to look at issues primarily from their own disciplinary and cultural background'

Different interests

The CoQA programme revealed that quality preferences and requirements are not strongly aligned between different actors within the value chain. 'The link between them is weak,' explains Professor Joseph Hounhouigan from the University of Abomey-Calavi, Benin. 'They don't know what the others need or what their problems are.'

The various actors – especially those in the more upstream parts of the food value chain – have different interests, adds Bijman. 'Producers in Ethiopia, for example, were very focused on yield, whereas quantity does not necessarily imply good quality. And when the Ethiopian government wanted to introduce new varieties,

traders were not that interested because their clients complained about the taste or the texture.'

'These issues were mostly due to lack of communication and coordination between the different actors,' says Bijman. 'It didn't occur to the trader to ask the supplier to use a different variety or other storage facilities, for example. Each focused on their own quality interests and each wanted to solve their own problem.'

Co-innovation approach

The programme studied why certain innovations were more successful than others, adds Bijman. 'We encountered a fairly successful pineapple processor, whose success could be attributed to a few factors: the person's entrepreneurial qualities and the clear agreements that had been made with the farmer. These small-scale actions were also helpful, as they provided room to experiment in a setting where the market is only partly ready to receive new products.'

The CoQA programme has shown the importance of coordination not only between value chain actors, but also between those actors and other public and private organizations. Exchange can be informal, says Bijman. 'For example, through visits and a lot of talking. Exchanging more information, say on quality requirements, doesn't necessarily imply an immediate joint investment. Communication between potential collaboration partners is also needed to find common







▲ Dutch and African project partners visit McCain's potato processing plant in Lelystad, the Netherlands.

ground and joint interests. For joint innovation to be successful, each partner needs to see the individual benefit of collaborating and coordinating with other value chain actors. By exchanging information, but also by jointly experimenting, potential partners learn about what motivates and what constrains the others.'

This kind of coordination is facilitated by an institutional environment of trust, backed up by stable rules and norms. Bijman: 'The extension officers in Benin also played a supportive role, bringing the different actors together to make agreements.'

Role of government

Engaging policymakers is very important, says Bijman. 'Local policymakers often only think from a policy perspective. They generally don't make much effort to understand the positions, goals, drives and limitations of entrepreneurs.' In Benin, for example, the government

is less involved in the pineapple market, says Hounhouigan. 'The farmers are not centrally organized, unlike the cotton farmers, who belong to a national cotton federation. Government involvement in pineapple is weak.'

But both Bijman and Hounhouigan see changes as a result of the programme. Bijman: 'I believe the government in Benin has gained a more nuanced perspective and a better understanding of what drives the actors and what limits them, such as certain regulations or laws that delay trade due to administrative requirements.' According to Bijman, this has led to improvements in the decision-making on research priorities, for instance at state research centres, but also on supporting farmer organizations in their efforts to improve storage and transport facilities. Hounhouigan explains that the government in Benin created a federation, involving pineapple farmers, producers,

'Different actors don't know what the others need or what their problems are'

traders and processors. 'This increased collaboration and led to closer and improved relations, which has eventually contributed to improved productivity and better storage and conservation practices.' Researchers, companies, farmer organizations and governmental agencies – in research, innovation, extension and education – have come to realize the importance of integrated solutions as a result of the programme.

Building capacities

Besides being a research programme, CoQA also was a capacity building programme, not only for the nine PhD candidates, but also for MSc students in Wageningen and in the partner countries. Annual international workshops and field visits were organized, to determine objectives, share challenges and discuss research outcomes. Attendance was compulsory for PhD students and their supervisors, and policymakers, farmers and processors were present as well.

'Researchers tend to look at issues primarily from their own disciplinary and cultural background,' says Bijman. 'This programme contributed greatly to interdisciplinary discussions among researchers from different backgrounds and countries. They learned about other perspectives and appreciated that these could support solutions to the same problem.'

The programme was of an interdisciplinary nature, because improvements in technology had to be accompanied by changes in organizations and institutions. But, adds Bijman, an approach like this requires time and budget. Most PhD projects took longer than four years and budgets were generally not sufficient. Bijman believes future projects should be less complex, allot larger budgets per PhD student, and provide more training on multidisciplinary and transdisciplinary research.

Give and take

Bijman appreciates the willingness and enthusiasm of all actors to contribute to the study. 'This was wonderful. As a researcher you ask quite a lot of people, especially their precious time, without giving much in return. This has always been the case and considered normal. But we should also reflect more on what we can give back, especially to producers and the communities.' ■



The programme contributes to these SDGs



Sustainable tuna fishing and empowering local fishermen in the Western Pacific

The Western Pacific is home to the largest stock of tuna in the world. Since tuna is one of the most valuable fish species, the area attracts many fishing vessels, putting it at risk of overfishing. The BESTTuna programme explored how to improve the ecological management of this stock, while ensuring that surrounding island states benefit from sustainable tuna fishing in their waters.

'The sustainable management of tuna is a long-standing and well-known challenge in the Pacific,' says Simon Bush, Professor of Environmental Policy and coordinator of the BESTTuna programme. 'However, we had not yet seen research conducted that covered social and environmental issues together, so we decided to develop a broad interdisciplinary programme.' The programme came about after Lida Pet Soede, former representative of the Global Marine programme of WWF, brought potential partners together in Wageningen. She organized a Tuna Think Tank, in which INREF researchers, representatives of WWF, INREF and policymakers brainstormed about these



'This research idea did not stem from science; it came from both NGO and business practice'

issues. One of the outcomes was the BESTTuna programme. Pet Soede: 'We were active in some countries in the western Pacific region in improving tuna fishing and coral reef protection. We wanted to stimulate a regional approach. BESTTuna helped answer research questions that arose from that wish.'

It was, therefore, a transdisciplinary programme from the start. Eventually, more than 100 researchers – MSc students, PhD students and postdocs – were involved. In addition to WWF Indonesia, there were collaborations with other NGOs, companies and governments. Simon Bush: 'This research idea did not stem from science; it came from both NGO and business practice.'

Certification and traceability

BESTTuna covered issues of stock allocation between Pacific Island States and distant-water fishing nations. Additionally, it focused on MSC certification of fisheries, fishing methods used and traceability of the fish caught.

The programme started at a time when sustainability was becoming increasingly important in the tuna value chains. This was a market-based development: consumers were increasingly demanding sustainable fish. This led to an increase in initiatives to improve sustainability in tuna fisheries, all of which made their own sustainability claims, and which in turn led to an emerging risk of coordination failure between claims of fishers and those of buyers. Moreover, if claims turned out to be false or inadequate,



Title BESTTuna

Duration 2011-2019

Number of PhDs 9

Wageningen University chair groups involved

Animal Sciences: Aquaculture and Fisheries (AFI), Environmental Sciences: Aquatic Ecology and Water Quality Management (AEW), Social Sciences: Business Economics (BEC), Environmental Economics and Natural Resources (ENR), Environmental Policy Group (ENP)

Partners

Adessium, Bogor University, Indonesia (IPB), University of the Philippines in the Visayas (UPV), University of the Philippines in Mindanao (UPM), University of the South Pacific, WWF Indonesia, Australian National Centre for Ocean Resources and Security (ANCORS), University of Technology Sydney (UTS)

Website

fundamentalchange.wur.nl/proven-power/best-tuna/

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'The system that we helped develop is now being implemented in other countries'

this would have potential repercussions for the credibility of all claims to sustainability, even for large labels such as that of the Marine Stewardship Council (MSC).

Empower fishermen with data

BESTTuna addressed these issues by making an inventory of active fishery improvement projects in the region, as well as helping local fisheries to meet data requirements. Bush: 'Before, local fishermen could often not prove that they met certification criteria.' These fisheries had their own tracking system that often did not match the requirements for certification. 'There was virtually no enumeration of their activities. Through BESTTuna, we

were able to empower fishermen by letting them take control over their own data.' In order to do so, the programme helped to set up systems to enable the often-illiterate fishermen to keep track of their activities and thus to prove to potential certification organizations that their fish was caught in accordance with sustainability and fair-trade demands. 'It put them in a better bargaining position, and they are now MSC and Fair Trade certified.' This success story served as an example. 'The system that we helped develop is now being implemented in other countries.'

To get these systems working, an interdisciplinary approach was important. 'If we had just looked at the biological side, we would have come up with beautiful but ineffective systems,' says Bush. Also focusing on the social dimensions allowed the researchers to understand how tuna value chains are organized and how information is passed along them, which is vital for understanding and developing effective market-based approaches.

Systems approach

Another focus point of the programme was traceability of tuna stocks. Underestimation of the fish landed has been a worldwide problem for tuna. A BESTTuna research team used a mix of methods, ranging from literature research, expert interviews, and data analyses to field surveys, to get to the real number. They discovered that in Indonesian waters around Northern Sulawesi, the catch was up to 38 percent higher than what was reported.





'If we had just looked at the biological side, we would have come up with beautiful but ineffective systems'

'Interdisciplinarity for this programme didn't necessarily mean that everyone would work on multiple disciplines,' Bush continues. 'It meant taking a systems approach for everyone involved; MSc students that went to Indonesia to do their thesis in the social sciences had to learn how our data systems worked. We were always asking ourselves: if a certain intervention were implemented, what would it do to the economics, the biology of the fisheries, as well as wider social issues such as equity? You have to have an understanding the other field, even if you're not using it yourself.'

Limits of certification

Due to its high economic value and impending scarcity, the tuna stakes are high. Bush and his team experienced this first-hand during the programme: 'We published quite some articles with conclusions that were inconvenient for both companies and NGOs, even those that were partners in the programme.'

Pet Soede, who represented WWF at the time of BESTTuna, underlines that the research outcomes were not always positive for WWF as a partner either, but values this as an important outcome of the research. She cites the outcomes on the MSC certification as an example. These were of particular interest to WWF as a co-founder of the MSC. 'The research illuminated the limits of what certification can do, and clarified that

certification is not the answer to all the problems in this field. We learned from that as an organization.'

High stakes

An outcome that gained a lot of attention was their research into the certification of Dolphin Safe Tuna, an example of how the high stakes became tangible during the research. 'A PhD student of mine and I were taken to an integrity inquiry by lawyers of the company that started this label, because our findings were critical of the Dolphin Safe Tuna label. We assessed their way of working and basically concluded that the label was less credible than other labels such as MSC. That meant that their label





was less effective than they claimed. Of course, they were not happy with that, so we were challenged and had to account for every result, and every method that we used. That really drove home the value of organizing our data well,' Bush laughs.

Pet Soede says the programme was very valuable for WWF in terms of research output. 'It generated a lot of information we could use in policy advice for example. But it also created a lot of buzz around the topic, which is something you cannot do as an individual organization.' Bush, too, acknowledges the power of doing such a large research programme: 'Because of the high stakes, our publications received a lot of attention. Many people in the industry saw our papers, which is why we could make such an impact.'

Constant dialogue

Bush concludes: 'We certainly contributed to the development of sustainable seafood markets. On top of that, a lot of students who were involved in BESTTuna now have jobs in the sustainable seafood sector and are spreading that knowledge. I can't go to an industry conference now without bumping into a whole group of Wageningen alumni.'

Bush has some recommendations for future projects: 'Be very active in enabling constant dialogue between supervisors and students. Students from different disciplines in BESTTuna were having constant discussions, which was very valuable to the programme.' ■

The programme contributes to these SDGs



Searching for synergies on the frontier between forest and farming

Deforestation is a major problem in many areas in Brazil and Mexico, often driven by expanding agriculture. The FOREFRONT research programme investigated whether synergies can be found on the frontier between forest and agricultural land, using the advantages nature can offer. 'We found that strategies are more sustainable when people are intrinsically motivated to protect nature.'

Coffee is a selective crop when it comes to temperature. Due to climate change, the area in Brazil where farmers can grow coffee is shifting as temperatures in lower-lying areas rise too high. In Zona da Mata for example, 60% of the land where coffee is grown now will no longer be suitable in 2050. However, in the future, it will become possible to grow coffee at higher elevations, which could lead to deforestation.

These predictions were made by Lucas Gomes, who carried out a model-based scenario study for his PhD research. He also investigated, together with coffee farmers, whether the climate vulnerability of coffee could be reduced by growing coffee in different ways. For example, instead of planting coffee in sunlight, the

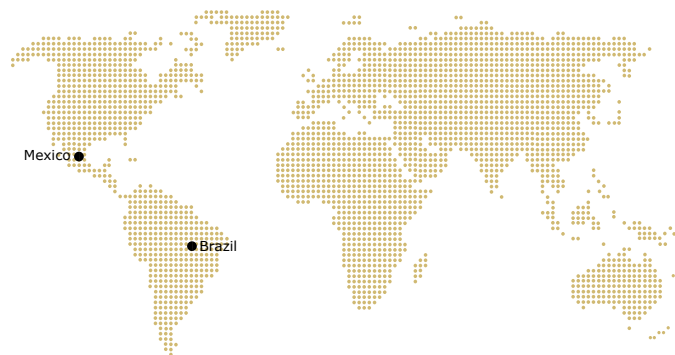


▲ Products from the frontier between forest and agricultural land.

farmers could intercrop it with taller trees – agro-forestry – and so derive benefit from the shade provided. A combination of trees and coffee can increase the area that will be suitable for growing coffee, thereby cushioning considerably the consequences of climate change. As in forested terrain, the soil in agro-forestry systems is better protected and retains more moisture, and the trees mitigate extreme temperatures. Moreover, biodiversity is greater in an agro-forestry system. Farmers benefit too because they produce other products in addition to coffee. Moreover, if they grow the coffee in accordance with organic agriculture regulations, they can sell it at a premium price.

This is one of the many examples of research done in the FOREFRONT programme, an interdisciplinary comparative research programme in Brazil and Mexico that aimed to design and negotiate strategies for land use that reconcile biodiversity maintenance, the benefits that humans derive from nature, and the needs of local actors who depend on natural ecosystems. The programme trained 11 PhD students and involved several postdocs, under the guidance of a few dozen scientists from Wageningen University, the Federal University of Viçosa in Brazil and two institutions in Mexico, and brought together insights

'Find out how farmers in the frontier area can engage with and contribute to nature'



Title FOREFRONT. Nature's benefits in agro-forest frontiers: linking actor strategies, functional biodiversity and ecosystem services

Duration 2015-2021

Number of PhDs 11

Wageningen University chair groups involved

Environmental Sciences: Soil Biology (SBL), Forest Ecology and Forest Management (FEM), Forest and Nature Conservation Policy (FNP), Plant Sciences: Farming Systems Ecology (FSE), Social Sciences: Sociology of Development and Change (SDC)

Partners

Federal University of Viçosa (UFV) (Brazil); Instituto de Investigaciones en Ecosistemas y Sustentabilidad (IIES) (Mexico); El Colegio de la Frontera Sur (ECOSUR) (Mexico); Tropenbos International

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▲ The frontier between agricultural land and forest.

from soil scientists, forest ecologists, farming system ecologists, anthropologists and sociologists. A key aspect was that the researchers cooperated with farmers and other inhabitants of the frontier areas.

Synergies

In general, the research showed that synergies can be achieved by making better use of ecosystem services, says Thom Kuyper, FOREFRONT programme leader. 'Ecosystem services are the benefits that humans derive from nature,' Kuyper explains. For example, the use of wood or fruits from the forest, but also improved availability of water in a forested area compared to a

deforested area. Apart from direct benefits for the local inhabitants, ecosystems also provide services that benefit humankind as a whole, such as carbon storage or biodiversity maintenance. 'We have observed that strategies are more sustainable when people are intrinsically motivated to maintain forest.' Payment for ecosystem services – for example paying a farmer for not cutting a piece of woodland – seems to be less sustainable.

The scientists in the programme concluded that the concept of ecosystem services is not always helpful. Kuyper: 'This concept places nature in opposition to

- Discussion at final workshop of the FOREFRONT programme.

humans, and thus turns nature into something that humans can benefit from. In reality, however, humans are part of nature and influence nature. An alternative vision could be to see how farmers or other inhabitants of the frontier area can engage with and contribute to nature.'

Agroecology

Irene Cardoso, Professor of Soil Science at the Federal University of Viçosa, one of the key partners in the FOREFRONT programme, concurs with this view. 'We are part of nature. Science has traditionally separated nature from human beings. But now, people from different fields are saying that we are part of nature.' One of these fields is agroecology, in which Cardoso is an authority. Agroecology is a scientific approach that studies and uses ecological processes in agriculture. In addition, agroecology is also a practice and a social and political movement, Cardoso explains. 'The articulation of different types of knowledge is important in agroecology. In the case of rural areas, it is important to integrate scientific knowledge with popular knowledge or wisdom of the farmers.' The large part that farmers' knowledge plays in agroecology means that farmers also have a big role in doing research. Cardoso continues: 'In agroecology we work with what we call co-creation of knowledge. This integration of scientific knowledge and local or indigenous knowledge is one of the innovations of agroecology.'

Autonomy for young people

Two PhD researchers studied the agroecology movement



in Brazil. Social scientist Margriet Goris engaged with young people in Zona da Mata to understand if and how they see a future for themselves in agroecology in rural areas. She found out how, through popular education on agroecology, they build autonomy in their relationships with parents and peers, and in their relationship with nature and culture. This sense of autonomy, she concluded, is important and emancipatory, as it enables young people to find their own place in rural areas. In this sense, agroecology can increase the inclusivity of local culture with regard to different populations, generations and genders.

Interdisciplinarity needed, but difficult to realize

Different fields of science need to be integrated in a research programme like FOREFRONT, says Thom Kuyper. 'As long as scientists continue to analyse humans and nature as separate entities with a glass wall in between, we will not be able to solve issues like deforestation or climate change.' In Kuyper's view, interdisciplinary research should be more than just the exchange of ideas between scientists with different backgrounds. In truly





'We will not be able to solve issues like deforestation or climate change without interdisciplinary research'

interdisciplinary research, an individual scientist should be capable of using the methods and concepts of two or more scientific disciplines. 'That means you should be able let go of part of the conceptual framework of your own discipline as well.' Truly interdisciplinary research is hard to realize, Kuyper acknowledges. 'It is often too much to expect a PhD student to learn how to work with two instead of one set of methods and concepts, and maintain credibility in both fields. It is only the brilliant who manage this.' Irene Cardoso agrees, but adds: 'It is not always difficult, and for sure always more useful and enjoyable than monodisciplinary research.'

One of the FOREFRONT programme's main achievements has been to train and educate people in the most interdisciplinary way possible, Kuyper says. 'We had many discussions and exchanges on the insights gained. And educating a new generation of young scientists in a way that equips them to address complex issues is really the greatest impact of a programme like this.' Kuyper is proud that Wageningen University was prepared to invest in INREF. 'Few universities have such a large programme focused on interdisciplinarity, and we should definitely continue this. We now see research foundations such as NWO-WOTRO Science for Global Development following our example.' ■

The programme contributes to these SDGs



Technologies for development: the silver bullet?

Mobile technologies can offer great solutions in the fight against diseases, but nevertheless face-to-face communication remains equally important. Co-design of these technologies – involving users in the design of digital innovations – proved to be key.



▲ Research assistants explain the rules of Musa Game to banana farmers Rushenyi village, Rwanda.

Global environmental change is affecting biodiversity, health, agriculture and water systems, and endangering the existence of many societies that depend on agriculture for a living. In this context, timely, relevant and accurate information – for example on water levels, the extent of plant pests or prevalence of disease-carrying insects – is crucial. But this information is often lacking, or access is limited.

How can life-science knowledge, digital technologies and innovation be leveraged to address development challenges in crop, water, health and wildlife management? The aim of the EVOCA programme was to answer these questions by introducing mobile technologies in six different case studies, mostly related to diseases, such as potato late blight in Ethiopia, malaria in Rwanda and tick-borne diseases in Kenya.

'The use of technologies as a solution is sometimes overrated'

'Policymakers often see these issues as an individual problem,' says Cees Leeuwis, programme leader and Professor of Knowledge, Technology and Innovation at Wageningen University. 'Extension officers in Ethiopia tell farmers, for instance, that they must spray, while most farmers don't have the financial means to pay for these expensive investments. Yet those diseases require collective solutions, involving farmers, nomads, government and others,' Leeuwis stresses. 'Collaboration is required to prevent diseases from spreading and to combat them. This means reaching agreement on the rules to which all farmers should adhere: monitoring and burning diseased plants, preventing water run-off, cleaning boots and tools, etc. But generally, nobody calls for collective action, and a mandate to bring different actors together is lacking.'

Connectivity and collective action

The intention of the EVOCA programme was 'to create new forms of connectivity that can mobilize actors,' Leeuwis explains. Five farmer-led Environmental Virtual Observatories (EVOs) were launched in four African countries. These ICT-based platforms enabled users to share environmental information, to connect with others, and to coordinate actions.

In Ethiopia, the programme experimented with a WhatsApp-like app and distributed smartphones to investigate its impact on collective action. In Ghana, WhatsApp and Telegram were used to connect extension agencies with researchers so they could exchange experiences on how to fight a new pest: the fall



Title Responsible life-science innovations for a in the digital age: Environmental Virtual Observatories for Connective Action (EVOCA) in crop, water, livestock and disease management

Duration 2015-2021

Number of PhDs 11

Wageningen University chair groups involved

Environmental Sciences: Earth System Science (ESS), Laboratory of Geo-information Science and Remote Sensing (GRS), Wildlife Ecology and Conservation Group (WEC), Water Systems and Global Change (WSG), Plant Sciences: Centre for Crop Systems Analysis (CSA), Laboratory of Entomology (ENT), Social Sciences: Strategic Communication (COM), Knowledge, Technology and Innovation (KTI), Public Administration and Policy (PAP)

Partners International Institute of Tropical Agriculture (IITA); International Livestock Research Institute (ILRI); International Potato Centre (CIP); Forum for Agricultural Research in Africa (FARA); Grameen Foundation; Technical Centre for Agricultural and Rural Cooperation (CTA); Foundation for Sustainable Development (FSD); Kumasi Institute of Technology, Energy and Environment (KITE); Integrated Water & Agricultural Development Ghana LTD (IWAD); Veterinary Services Kenya; College of Medicine and Health Sciences, University of Rwanda; MDF West Africa; University for Development Studies, Tamale Ghana

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armyworm. In Rwanda, a citizen science project was set up with the aim of engaging communities in malaria mosquito surveillance and monitoring. In two other cases, games were developed to help participants gain insights into mutual dependency.

These technologies and interventions proved to be important in communicating about crop diseases and fostering collective responses, says Leeuwis. 'They can help with data collection and disease monitoring. Farmers could send pictures of the disease in their field. WhatsApp groups and other social media platforms especially offered a space where members could encourage each other to contribute, which motivated them to comply with agreements and rules.'

Face-to-face

Nonetheless, conventional, face-to-face interaction remained critically important as well. 'Technologies are only a means ... they need to be embedded in a learning environment. It takes an in-depth learning process to arrive at collective rules, and to ensure that everybody participates and accepts that sanctions will be applied to those who don't contribute. If a potato producer does not comply with the agreed-upon rules to provide disease-free seedlings, there must be a mechanism to exclude that seed material from the market,' Leeuwis explains. Research with Ethiopian potato farmers and Rwandan

**'Technologies are a means,
and need to be embedded in
a learning environment'**

banana farmers helped to understand the positive and negative effects of (digital) communication interventions on individual and collective action and performance. Leeuwis: 'We saw people providing advice, motivating others to take action and calling upon them not to be a free-rider. But we also noticed that increased insight into mutual dependence can stimulate counter-productive actions. People thinking: my neighbour's investing, so no need for me to do so as well.'

Technologies can also easily exclude people, says Leeuwis. 'Programmes that promote digital tools are often too optimistic about people's possibilities, their access and skills to make use of them. In addition, there are concerns about ownership of data and privacy issues.'

The use of technologies as a solution is sometimes overrated, adds Professor Leon Mutesa, director of the Center for Human Genetics at the College of Medicine and Health Sciences, part of the University of Rwanda, and involved in malaria research. 'Access in rural areas is also very limited. Some communities prefer offline methods, like reporting on paper instead of on a mobile phone. In one of the communities, a community team for malaria action engaged village leaders and local government. They openly discussed solutions and it worked very well.'

Co-design

Co-design of technologies proved to be key. By involving users in the design of digital innovations, farmers' confidence in their capacity to use and benefit from smartphones was enhanced, says Leeuwis. In Ghana,

- ▶ Banana farmers invited to play the Musa Game were recorded to collect audio and video data and trace game progress.





▲ A research assistant conducts a questionnaire with an extension agent on the beta version of a smartphone application for diagnosing and monitoring wilt disease and providing information on agronomic practices to banana farmers.



▲ While one research assistant facilitates the Musa Game, another takes notes and collects data in Nyabikenke, Rwanda.

co-design helped to integrate indigenous knowledge about weather and climate with information provided by advanced digital forecasting systems. In Rwanda, community members were engaged in the development of technologies to collect and report on mosquito species and the occurrence of malaria. 'It empowers communities and enhances their ownership,' says Mutesa. 'They have context-specific knowledge and skills, and thus know what works and what doesn't.'

The rules for collective disease management should also be co-designed, stresses Leeuwis: 'Agreements on how participants are going to jointly fight potato blight, with what means, and how they will monitor the disease and community members' adherence to rules.' A genuinely participative approach is not that common: 'We still see top-down interventions and innovations, often due to constraints in time or means.' At the same time, he adds, co-design does not necessarily solve power or (digital) capacity challenges. Nor can it guarantee that the resulting digital innovation is fully inclusive.

More than a PowerPoint

Each case study – except one – involved two PhD students from different disciplinary backgrounds: one from the social sciences and one from the natural sciences. All were supervised by a multidisciplinary team, which made it possible to study complex problems and to promote and study collective actions from diverse perspectives. 'They had to work as a team,' says Leeuwis. 'And this takes much more than occasional exchanges through PowerPoint presentations. To really develop an understanding of how the system works, how technological and social components interact, you have to go to the field together and do interviews jointly.'



▲ PhD student facilitates a farmer field school on potato disease management.



▲ Participant in a malaria citizen science project demonstrating his mosquito trap.

In Rwanda, the collaboration between entomological and social science disciplines was important to understand not only the technicalities of malaria mosquito surveillance and integrated vector control, but also communities' motivation for, perceptions of and barriers to participation, adds Mutesa.

According to Leeuwis, an interdisciplinary approach leads to integrated solutions and integration of knowledge. 'It also increases understanding of potential tensions and conflicts in society if you study the problem from different angles. This intensive collaboration proved to be very

'They had to work as a team, and this takes much more than occasional exchange through PowerPoint presentations'

enriching, for the students as well as the supervisors and the university in general. It works best, however, when the two PhD students have the same supervisors, who ensure coordinated and coherent work.'

Learning

Although COVID-19 halted fieldwork and workshops, and limited opportunities to engage with policymakers and other stakeholders, EVOCA yielded a lot of learning, says Leeuwis. 'Farmers in Ethiopia and Rwanda learned about crop disease transmission mechanisms and mutual interdependence. Community members in Kenya gained more knowledge about tick-borne diseases and control practices, while Rwandan community members learned how to collect mosquitoes, identify species, and develop community-level malaria control measures.' Several policy briefs have been developed to contribute to future policy dialogues. 'The synthesis study revealed that enhanced connectivity and information provision can indeed help to strengthen collective responses to pests and diseases, provided there is sufficient space and attention for deliberation and co-design.' ■



A photograph of a dairy farm with a large white circle overlaid containing text. The background shows a cow being milked by a person in a grey shirt and cap, and another person in an orange jacket in the foreground. The text inside the circle reads: Research programmes INREF phase IV.

Research programmes

INREF phase IV

The programme contributes to these SDGs



'We had to find a balance between technical innovation and social receptiveness'

In Indonesia the market for dairy, fish and animal protein is growing, but the agricultural sector struggles to expand production. Since available land is limited, the best option is to increase the efficiency and yields of existing farms. Researchers are trying to find out what high-tech and smart solutions could make that happen, while taking the local context into account.



The ongoing Smart Indonesian Agriculture (SMART-In-Ag) programme explores how smart farming techniques could be sustainably implemented in the Indonesian agricultural sector, specifically in dairy production and fisheries, to help improve productivity. Smart farming means using information and communication technologies in combination with data and sensing technologies to improve agricultural production. Examples are sensors linked to apps that help in taking decisions about animal health and feeding, or, in the case of fisheries, sensors to measure water quality or fish health.

Henk Hogeveen, Personal Professor of Animal Health Management in the Business Economics group at Wageningen University, is the coordinator of the SMART-In-Ag programme. Hogeveen has a background in animal sciences which he combines with economic theory in his research. In the programme he brings together veterinary epidemiologists, economists, social scientists and information specialists with researchers from the marine, plant and animal sciences in both the Netherlands and Indonesia.

Local data collection

The SMART-In-Ag programme combines research and implementation. Each research phase results in a practical solution, feeding into new research questions. Hogeveen: 'We started with collecting data on the local situation. Based on that data, algorithms and interventions designed for the local situation will be developed, and the final part of the programme is aimed at understanding what will happen if these interventions are implemented.' The idea is that results and insights from the programme will feed into long-term policy development in Indonesia.

'We've had to do quite some missionary work on the importance of interdisciplinarity'



Title Smart Indonesian Agriculture: Development, logistics and evaluation for animal protein production SMART-In-Ag

Duration 2019-2026

Number of PhDs 10

Wageningen University chair groups involved

Animal Sciences: Aquaculture and Fisheries (AFI), Quantitative Veterinary Epidemiology (QVE), Animal Production Systems (APS), Environmental Sciences: Laboratory of Geo-information Science and Remote Sensing (GRS), Plant Sciences: Farm Technology (FTE), Mathematical and Statistical Methods (Biometris), Social Sciences: Business Economics (BEC), Health and Society (HSO), Information Technology (INF)

Partners

Institut Pertanian Bogor (IPB) University, Indonesia (Bogor Agricultural University), Kupang State Agricultural, PT Bogor Life Science and Technology, Single Spark, eFishery, WorldFish, Dairy Pro Indonesia, Faculty of Veterinary Medicine of Utrecht University

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'SMART-In-Ag combines research and implementation'



▲ IPB University scientists check the milk samples that will go to the lab for bovine viral diarrhoea testing.

Smart farming techniques are normally used on capital intensive farms, often in western countries. Livestock farming in Indonesia is mainly small scale and extensive; farmers just have a couple of animals and lack formal knowledge on animal health or yield improvement. Hogeveen: 'When we started looking into suitable smart technologies for this area, we had to find a balance between technical innovation and social receptiveness.'

Interdisciplinarity is key

'Rather than striving for perfection on one level, we aim to consider the different aspects of local production to develop systems that are actually usable on Indonesian farms,' Hogeveen says. 'Therefore, interdisciplinarity is key.' For example, a current research project combines social and veterinary aspects and focuses on how smart techniques can help farmers to diagnose and treat their animals when health issues occur. Economists, veterinary epidemiologists and veterinary clinicians are involved, to assess both technological aptness of the smart techniques that are developed, and economic efficiency of this way of measuring animal health.

On the aquaculture side of the programme, PhD student Nurhayati Tarigan is working in West Java on developing a

- One of the PhD students of the programme takes notes in the dairy shed.





'The programme will be a success when our partners truly start to see the value of interdisciplinary working'

system called Nutritious Fish Pond. Although most aquaculture production happens in ponds, the relation between fish nutrition and pond functioning is still poorly understood. The system that will be developed should automatically balance the amount of feed fish need to grow and the amount of feed that can be given and still conserve the water quality. At the same time, the system will use waste from the pond water to produce new feed. A smartphone app will allow farmers to track fish activity and water quality, to help stabilize the production process. Hogeveen: 'This app potentially improves the effect of these fish farms on many fronts. It's better for the fish farmer's wallet, but also lowers mineral emissions and environmental pollution.'

Built to last

Smart interventions should be built to last beyond the end of the research programme in 2026. Hence, it is essential to include all perspectives on what such an intervention should entail. To this end, the programme recently held its first multi-stakeholder workshop. Hogeveen: 'We managed to get farmers unions, dairy organizations, the animal

health authority, the government, the university, milk collection centres and researchers together at one table. We asked them: what do we need to make this a working system? We will continue to keep them involved as we collect the results of our research, to ensure sustainable implementation of the systems developed.'

Eventually, some 40 researchers will be involved in the programme, of whom 10 will be PhD students, working together with numerous postdocs, supervisors and professors from different disciplines. Since every PhD student is required to adopt an interdisciplinary focus, each one has least two supervisors from different disciplines. The most challenging part, according to Hogeveen, lies with the academics. 'Not everyone is convinced of the importance of interdisciplinarity, in Indonesia and in the Netherlands. We've had to do quite some missionary work on that part.'

Hogeveen will regard the programme as a success once two goals have been achieved. 'One: when our partners truly see the value of interdisciplinary working, and start to develop their own interdisciplinary projects too. And second: when we have developed and implemented at least two working applications for the dairy and fish farmers, that are sustainably used.' ■

◀ A paravet from the dairy cooperative examines the white blood cell count of the cows' milk.

The programme contributes to these SDGs



Upgrading indigenous fermented food

Traditional fermented foods in Africa have great potential to contribute to improved food and nutrition security, as well as to economic empowerment of the women who produce the foods. Researchers are looking into the health benefits of these foods, and ways to upgrade production and entrepreneurship. What's more, better regulation contributes to the emancipation of women.



▲ Sellers of Mabisu and Chibwantu in Choma, Zambia.

In the rural areas of Zambia, Mabisu is a well-known traditional drink. It is a slightly sour, non-alcoholic beverage made from raw milk. Women produce the drink at home by putting milk in a calabash and allowing it to ferment, and they sell it at local markets. Similar traditional fermented foods are found in Zimbabwe and Benin and elsewhere in Africa.

Biologist Sijmen Schoustra became fascinated by Mabisu when he worked and lived in Zambia. Up to ten different bacterial strains are responsible for the fermentation – compare this to the two strains that make normal yoghurt. 'For me as an evolutionary biologist, the bacteria in Mabisu represent an interesting case to study how communities of organisms adapt to different circumstances.' The bacterial mix and the end product depend on how the drink is made: at what temperature,

'Traditional fermented foods deliver healthy and cheap food, and provide income to female entrepreneurs'

the duration of fermentation, the kind of milk used and whether the calabash is shaken or not.

In the Fermented Foods programme, Schoustra's scientific curiosity converges with a great opportunity to increase food and nutrition security through these traditional fermented foods. Previous research has already shown that young children who drink Mabisi are healthier than other children. Their digestive system is healthier. Laboratory experiments done in this programme have now validated this. Other microbiological research showed that Mabisi is a safe drink, even when made from milk of low quality. 'Apart from delivering healthy and cheap food to the poor, producing and trading traditional fermented foods also offers income to female entrepreneurs,' Schoustra says.

Three angles

However, Mabisi is not yet consumed in cities or sold in supermarkets, Schoustra says. To fulfil that potential and reach more consumers, the drink needs to be produced on



Title Traditional fermented foods to promote food and nutrition security in Africa

Duration 2020-2025

Number of PhDs 11

Wageningen University chair groups involved

Agrotechnology and Food Sciences: Food Microbiology (FHM), Food Quality and Design (FQD), Human Nutrition and Health (HNH), Plant Sciences: Laboratory of Genetics (GEN), Social Sciences: Business Management and Organisation (BMO)

Partners

Universities: University of Zambia, Chinhoyi University of Technology Zimbabwe, Université Abomey-Calavi Benin
Standards bureaus: Zambia Bureau of Standards (Zambia), Agence Béninoise de Sanitaire des Aliments (Benin), Government Analysts (Zimbabwe). Heifer International (Zambia), Tropical Diseases Research Centre (Zambia), Harvest plus/CIAT (Zimbabwe)
Local companies and dairy cooperatives

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a larger scale and in a more standardized way. That would allow the Zambia Bureau of Standards, the national food inspection service, to certify the product as safe. The INREF programme is aiming to do this, not only for Mabisi, but also for similar traditional foods in Zimbabwe and Benin. The programme studies the fermented foods from three angles: ecological research on the fermentation process, and on the effect of the foods on human gut microbiota; food technological research on how production can be upgraded; and socio-economic research on entrepreneurship and marketing of fermented food by women producing it.

Standardize the process

Insights from one scientific field inform research in other domains, explains Schoustra. Mabisi could be made in a plastic container using a starter culture, a bacteria mix in a bag. 'But we know from business management research that it is difficult for women to get these starters. They make Mabisi by using the same calabash time and again, so the remaining bacteria act as a biofilter on the inside of the calabash. We need to find a way to standardize that process so it fits these women's situation.' This is possible by conducting ecological research on the factors that determine the outcome of the fermentation process. The programme chose not to upgrade production by creating a large-scale dairy processing company, but by linking up with the women's existing practices, and paying attention to consumer preferences.

► Focus group discussion about Mabisi in Chibwe, Zambia.





'Impact is what inspires us, but it is very hard to measure or to control it'

Time consuming, more results

'Interdisciplinary research like this gives your work more context,' Schoustra continues. 'You learn from each other, and insights are exchanged back and forth.' Biologists, food technologists and business management researchers do their fieldwork together. All PhD students have four supervisors, from technical and social sciences, and from Wageningen and African universities. 'That means we do a lot of talking, which takes a lot of time. But in the end, this approach yields better results. The PhD students will manage to publish more and progress more quickly through their project, because they learn a lot from each other and stimulate each other.'

Top five

Development NGOs, inspection services and local businesses such as dairy cooperatives are heavily involved in the programme, Schoustra says. 'In fact, they are the ones who make the impact in the end, by putting our scientific results into practice.' These stakeholders met the programme's kick-off meeting, where they learned about the science in the programme, and got to list their top five research priorities. 'These were matched with the scientists' top five. We identified the similarities, on which we then based the actual research.' The Zambia Bureau of Standards is now planning to certify Mabisu. In other countries partners are also interested in picking up the research and giving these traditional foods a higher status. Whether this will ultimately result in better

nutrition for many African people is hard to say, in Schoustra's view. 'Impact like that is what inspires us, but it is very hard to measure or control it.'

Dilemma

The programme is also faced with a dilemma, Schoustra adds. 'Our first deliverable is PhD theses, which requires scientific articles to be published in peer-reviewed journals. This doesn't always match with doing interdisciplinary research.' Interdisciplinarity, Schoustra says, should not be judged at the level of individual PhD projects. 'A PhD thesis should achieve disciplinary excellence.' On top of that, supervisors are not valued for doing interdisciplinary research. Schoustra: 'I am on a tenure track career trajectory, but societal impact is not on the checklist of the tenure track system. If I write a chapter for a UN report, that is very nice, but it doesn't count towards my publication credits.'

Schoustra recommends creating separate funds to support the uptake of research results. 'Maybe we could focus a little less on maximizing the number of PhD theses and the initial budget, and thus save some funds for this instead.' His idea would be to follow this up about three years after the start of the research programme. 'After a few years the results start to come in, and you get an idea of how research uptake could be supported. For example, by training people at the dairy cooperatives, or at the national food inspection service.' ■

- ▶ Laboratory research on the fermented drinks Mabisi and Mukoyo.



- ▶ Home production of Munkoyo using a calabash, Mufulira, Zambia.



The programme contributes to these SDGs



Understanding human–wildlife conflicts

How can human and animal life be integrated in an increasingly populated country?
The Eco2 programme studies conflicts between humans and wildlife in Egypt.

Humans increasingly dominate the earth by using and modifying it. And likewise, humans – from fishermen to tourists – are affected by disrupted ecosystems. As such, the need to integrate rapidly changing livelihoods with the

conservation of biodiversity and ecosystems is becoming more and more acute.

How do humans and wildlife interact? How do animals respond to fishing, hunting, manufacturing and other



▲ PhD student watches birds with a telescope.



▲ Glossy ibis (*Plegadis falcinellus*) in Egypt.

*'We cannot just fence off an area.
People and animals need to live together.
Their lives need to be integrated'*

human activities? And how can livelihoods and ecosystems be integrated in this era of intensifying pressures on both human and nonhuman lives? These questions guide the Eco2 programme in Egypt, where the pressures have become extreme.

'In Egypt, most of life is restricted to the river Nile and its delta,' explains Marc Naguib, programme leader and professor at the Behavioural Ecology Group. 'As Egypt is a country with a small area populated by humans and animals, land sparing opportunities are limited.'

Degrading habitats

As a result, various conflicts arise: between humans and birds, between humans and crocodiles or other resident or migratory animals. Degrading habitats affect other habitats, which potentially leads to species decline. The Eco2 programme aims to identify the extent and nature of the human-wildlife conflict. How are natural and artificial wetlands used by birds and crocodiles, as well as by hunters, fishermen and tourists? What decisions do these people make?

An important topic being studied is hunting. Although bird hunting happens all over the Mediterranean, Egypt plays a prominent role due to its growing human population and geographic location. Millions of migratory



Title Beyond Anthropocene Pressures: Convivial conservation integrating ECOlogy and ECONomics along the Nile and its wetlands (Eco2)

Duration 2019-2025

Number of PhDs 5

Wageningen University chair groups involved

Animal Sciences: Behavioural Ecology (BHE), Environmental Sciences: Wildlife Ecology and Conservation (WEC), Laboratory of Geo-information Science and Remote Sensing (GRS), Social Sciences: Development Economics (DEC), Sociology of Development and Change (SDC)

Partners Nature Conservation Egypt, Egyptian Environmental Affairs Agency, Migratory Soaring Birds project UNDP/GEF/Birdlife, Galala University, Tour du Valet, The French National Hunting and Wildlife Agency (ONCFS), Arab Academy of Science, Technology & Marine Transport, Cairo University, Beni-Suef University

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'We cannot solve this problem ecologically unless we understand and solve the socio-economic complexities.'

birds, ranging from quails to nightingales, pass over the country every year.

Social institution

Birds have always been a source of protein for Egyptians, but hunting is also done for fun, explains PhD student Khaled Noby, who is also the head of Nature Conservation Egypt, an NGO devoted to wildlife conservation. 'Hunting is a social institution and much older than the new concept of conservation. It is deeply rooted in parts of the local culture, with a very long history, and it brings people a lot of enjoyment.'

One result of this is that many birds are caught in a wall of nets along the country's coastline. Others are captured with illegal glue traps or techniques such as bird calling devices. This can lead to further decline of bird species whose habitat is already affected due to factors like climate change. 'We want to shed more light on the practices and factors that play a role in bird trapping,' says Naguib.

At the same time, there is an urgent need to understand the relation between ecology and economy, stresses Noby. 'Most of the aggressive forms of hunting, which involve mass and indiscriminate collection of birds, take place in poor villages. Households borrow money from merchants or middlemen, and they pay this back in birds. We found ourselves in a difficult position, defending birds rather

than human lives,' he adds. 'We cannot solve this problem ecologically unless we understand and solve the socio-economic complexities.'

'We want to conduct a value chain analysis to understand who makes the profits, who make most effort,' says Noby. 'Based on these findings, we will then design and test solutions to address the problem.'

One has to be open to the human, economic and cultural sides of the problem, adds Naguib. 'You cannot just forbid hunting, you have to offer an alternative.'

There are several other examples of conflicts between humans and animals. One is that crocodiles are killed because fishermen think they eat their fish or destroy their nets. Another: windfarms on the Red Sea are an important source of energy for Egypt, but they also kill migratory birds. And sewage ponds – often toxic, but the only freshwater bodies in arid and undisturbed areas – attract birds, but hunters too.

Convivial conservation

The conflicts are being studied in three different areas: the Nile Delta, the Nile south of Cairo and Lake Nasser. Because of the delays due to Covid-19, no conclusions can be drawn yet. But, says Naguib: 'We are learning a lot, and we are establishing important connections with potential partners and authorities.' So far, local staff have





'Hunting is a social institution and much older than the new concept of conservation'

been trained in data collection, some local bird conservation communities have been trained in systematic bird counts and bird surveys have been undertaken.

To fully understand these conflicts, the programme engages scientists from different disciplines, including behavioural and animal ecologists, development economists and sociologists.

When speaking of solutions, the theories circulating in recent conservation and ecology debates do not fit Egypt, says Naguib. These theories either advocate a radical integration of conservation principles into the mainstream economy, or want to designate half the planet as protected areas. 'But Egypt is too small and too densely populated to accommodate either of these approaches.' Therefore, WUR researchers have developed the so-called convivial conservation approach, that aims to find better ways to sustainably integrate human and nonhuman life. 'We cannot just fence off an area. People and animals need to live together, their lives need to be integrated.' ■

◀ Nets used to trap birds in Egypt.



▲ Northern shovellers (*Spatula clypeata*) at a sewage pond. These human-made water sources are used by birds in arid zones.



▲ Fishermen on the river Nile in Egypt.

The programme contributes to these SDGs



Empowering local actors in tropical agro-forestry systems through serious games

Forest, water and people are at the heart of the ongoing Scenario Evaluation for Sustainable Agro-forestry Management (SESAM) programme. The goal: use serious games to explore the nexus between these elements of tropical agro-forestry systems, helping to establish serious games more firmly as a scientific method, while at the same time empowering local actors.

In areas where water, agriculture and forests meet, so do many stakeholders with different or even opposing interests. Since the policy fields of water management, agriculture and forestry are so closely intertwined, while policies tend to be based on one of the three disciplines only, this frequently results in dysfunctional policies for some of the stakeholders. The voice of local stakeholders is often lost when plans are made for landscapes and green economic development. The SESAM programme aims to develop games to help better understand different local contexts, while at the same time using these games to empower local stakeholders.



▲ Local stakeholders play a serious game in Burkina Faso.

'Serious games allow researchers to better grasp the situation and motivation of local actors'

'A big advantage of serious games is that they can be completely adjusted to the local situation and their use is not hindered by language or cultural barriers,' Erika Speelman explains. Speelman is a researcher at the Laboratory of Geo-information Science and Remote Sensing and the principal investigator of SESAM, together with Meine van Noordwijk, Emeritus Professor by special appointment at Plant Production Systems and Gert Jan Hofstede, Personal Professor of Computational Social Science.

Popularize knowledge about soil and water use

Serious games are used for educational purposes or as a scientific method, for example in scenario evaluation. Speelman: 'They allow researchers to better grasp the situation and motivation of local actors, but also give local actors a better understanding of how their actions affect their surroundings.' Gert Jan Hofstede gives an example: 'We are developing games in areas with steep mountain slopes. Some local farmers work upstream, some downstream. The idea is that these games will help farmers upstream to realize that cutting down forests for potato-growing on their land leads to erosion and floods downstream.'

The researchers hope to help popularize knowledge about soil and water use by offering a systemic view. In the SESAM-programme, 8 MSc students, 15 PhD students, 3 postdocs and 10 professors and assistant professors from various fields including sociology,



Title Scenario Evaluation for Sustainable Agro-forestry Management (SESAM)

Duration 2019-2025

Number of PhDs 15

Wageningen University chair groups involved

Environmental Sciences: Laboratory of Geo-information Science and Remote Sensing (GRS), Water Resources Management (WRM), Hydrology and Quantitative Water Management (HWM), Forest Ecology and Forest Management (FEM), Plant Sciences: Plant Production Systems (PPS), Social Sciences: Environmental Policy (ENP), Information Technology (INF)

Partners

Universitas Brawijaya, IPB University, Jomo Kenyatta University of Agriculture and Technology, Anton de Kom University of Suriname, University of the Americas, University of Montpellier, University of Koblenz-Landau, World Agroforestry Centre (ICRAF), Agricultural Research Centre for International Development (CIRAD), Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN), Tropenbos International, Indonesia and Suriname

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'Having the views of local actors was essential for the development of the case studies'



▲ Playing a serious game in Indonesia.

agro-forestry, geo-information sciences and ecophysiology are working on different subprojects. For example, PhD students Rika Ratna Sari and Lisa Tanika in Indonesia are developing a board game, complete with mini trees and crops, that illustrates how different agro-forestry decisions can influence local water levels and distribution.

Take serious games to a higher level

Speelman: 'Currently, serious games are very popular, but knowledge about them as a scientific method remains case-study based. The step to take serious games to a higher level, to use and evaluate them structurally, is still missing. Usually, a game is developed for a specific environment. In SESAM, we research the added value of that site-specificness and explore whether designing standard games that can be adjusted for different situations could work.' Also, she adds, SESAM wants to help develop methodological tools for assessing the utility of serious games. 'There are not many objective measures available yet for doing a real impact assessment.'

Hofstede wants to take this a step further: he wants to explore whether real life data from applying the games in different situations could feed into agent-based models of these games. 'Such models could have value as counterfactuals: to explore, for example, what would happen if all actors chose to behave sustainably, or, conversely, chose to go for immediate profits.'

Strong partnership

Focusing on the forest-water-people connection, SESAM needs researchers from different disciplines to work together. Moreover, says Speelman, a serious game is interdisciplinary in its essence. 'You have to consider all



▲ Playing a serious game in Burkina Faso.

relevant aspects, from social dynamics to soil type.’ All PhD students work with two different disciplines and two partners of the programme. ‘They all do case studies, and in order to understand your case and design a matching game, you need to understand all factors that play a role in that local situation,’ says Speelman.

Transdisciplinarity is just as important as interdisciplinarity for SESAM, Speelman continues. ‘Having the views, experiences and council of local actors, whether farmers or local NGOs, is essential for the development of the case studies. One of our researchers even works at our programme partner Tropenbos and is now doing a PhD in

our programme. To me, that’s an example of strong partnership.’

Tangible results

One thing Speelman and Hofstede would recommend for future programmes, is the agreement to publish one article every year, with all researchers involved. Last year, their second article was published, with no less than 27 authors, and the third is in the making. It takes some coordination, Hofstede admits. ‘But it is a great way to have something to work on together, also when you have just started, to enhance team spirit and get immediate, tangible results.’ ■

The programme contributes to these SDGs



Supporting equitable co-governance of rivers

Together with riverbank inhabitants, activists and policymakers, researchers are studying ways of developing and supporting more equitable and sustainable co-governance of rivers. New concepts are explored, such as the idea that a river has rights and can claim protection in a court of law.

In countries as widely differing as Colombia, India, the Netherlands, Zambia, South Africa, Thailand and Ecuador, rivers are under threat. Riparian communities, artisanal fishermen, local farmers and other inhabitants and users of rivers and river shores are facing the destruction of their environment. In the face of the construction of dams upstream, water transfers to large cities or discharge of untreated wastewater by industry, they see their beloved river being polluted and water resources being lost.

Together with an inspiring alliance of researchers, policymakers, activists and grassroots organizations in Europe, Africa, Asia and Latin America, the INREF programme River Commons is working on equitable and participatory co-governance of rivers and lands around rivers. 'Of course, a lot of participatory research has been



done in the past,' says programme leader Rutgerd Boelens. 'But quite often, participatory research is used in an instrumental manner, where the contributions of residents or users are merely used as research input, as a method of collecting data. We do it the other way around. Or rather, we're aiming for horizontal research partnerships: the inhabitants, farmers and fishermen determine what the research should be about and together we co-create new river knowledge. We scientists can integrate our academic knowledge with their knowledge.'

Rights for the river

In the programme, ecologists, hydrologists and water engineers, sociologists and anthropologists work on an equal footing with river users and residents who bring in vernacular and indigenous knowledge. Twelve PhD researchers will investigate nine cases of 'river commons', where local communities and their organizations co-govern the riverine environment. These cases involve inspiring ideas, as for example in Ecuador, where the river



Title River Commons

Duration 2021-2026

Number of PhDs 12

Wageningen University chair groups involved

Animal Sciences: Aquaculture and Fisheries (AFI), Environmental Sciences: Water Resources Management Group (WRM), Cultural Geography Group (GEO), Hydrology and Quantitative Water Management (HWM), Aquatic Ecology and Water Quality Management (AEW), Social Sciences: Education and Learning Sciences (ELS)

Partners Centre for Latin American Research and Documentation - University of Amsterdam (CEDLA-UvA), Het Wantij Foundation, Waterschap Rijn en IJssel, Drinkable Rivers, Deltares, World Wildlife Fund (WWF Netherlands and Zambia), United Nations Environment Programme (UNEP), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), InspirAgua (Blue Deal), Waterschap Aa en Maas, Makmende Media, UN Harmony with Nature UNESCO, Valencia Polytechnic University, Fundación Nueva Cultura del Agua, Universidad Nacional de Colombia, Fundación Alma Colombia, Society for Promoting Participative Ecosystem Management (SOPPECOM India), Centre for Social and Environmental Innovation - Ashoka Trust for Research in Ecology and the Environment (CSEI / ATREE India), CGIAR / International Water Management Institute (IWMI South East Asia), Karen Environmental and Social Action Network (KESAN Myanmar), Rhodes University South Africa, Acción Ecológica Ecuador, Universidad Central Ecuador, Syracuse University USA, University of British Columbia (UBC Canada), University of Manchester UK, Tours University France, Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV)

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'Nature does not speak for itself; it needs guardians, and those are people'

has constitutional rights that can also be enforced in court. 'We want to research, understand and support these kinds of ideas, and help them to travel,' says Boelens. By 'travelling', he means that ideas from one place can inspire others elsewhere. 'For example, the idea of making the Wadden Sea or the river Rhine in the Netherlands a legal entity comes from elsewhere in the world.' Ideas such as this do not automatically have a positive outcome, says Boelens. 'Nature does not speak for itself; it needs guardians, and those are people. They can be local inhabitants, but in India, for example, it is the nationalist government that claims to be able to speak on behalf of the river. It is the task of scientists, says Boelens, to be involved and engaged but also to remain critical.

Participatory methods

The river as a subject, to which rights can be attributed, is one of the four 'frames' through which rivers are looked at in the INREF programme. Another way is to see the river as a social movement, focusing on the interaction between humans and nature in riverine systems. This translates into researchers working together with residents, farmers and fishers in 'River Co-Governance Labs', using various participatory research methods. These may include joint measurements of water quality, but also the use of ethnographic methods such as walking, cycling or sailing

on rivers together. In addition to yielding scientific results, this approach delivers practical solutions that benefit the residents, farmers and fishers, says Boelens. A digital platform will be created where PhD researchers and communities from all countries can exchange experiences. This will enable the person who is doing research on the Rhine in the Netherlands to exchange experiences with farmers in Ecuador, for example.

Open minded

The approach in this INREF programme seeks to go a step further than most transdisciplinary research, says Boelens. 'We also want to be transformative, that is, make a positive contribution to fairer and more sustainable river governance.' That requires working transculturally as well, says Boelens. 'As a researcher, you must be open to other views. Some communities, for example, see the river as

an animated landscape, with river gods in it. You need to be open to that and understand how particular beliefs, norms, traditions or power relations shape people's river-related behaviour.'

The research has only just started and there are no results yet. There is, however, already experience with the working method, as the research proposal was also made in a participatory manner. Because of the COVID-19 pandemic, physical meetings were not possible, but a globally operating grassroots media company made four videos on location together with the partners, in which residents talk about their vision of the river. Those videos were discussed online, and this formed the basis for the proposal.

Boelens notes that there are structural obstacles to transdisciplinary research in the way scientific research is organized, and INREF is no exception. 'In the sandwich construction, PhD students have to bring a large part of the funding for their research from their own country. That is not feasible for everyone, and worse for grassroots representatives. This limits the choice of candidates.' ■



'You need to understand how beliefs, norms, traditions or power relations shape people's river-related behaviour'

► Río La Cocha, Colombia.



RESTAURANTE
Puerto Plaza
PLATOS TÍPICOS DE LA REGIÓN

The programme contributes to these SDGs



Dealing with the double-edged sword of tourism to maintain coral reefs

Coral reefs are beautiful nurseries of marine biodiversity and attract an increasing number of tourists. But, along with climate change, increasing tourism is putting pressure on the coral reefs. Together with residents, resorts and local universities, scientists from Wageningen University are studying how to balance tourism with nature conservation.

Back in January 2020, a diverse mix of people embarked on a ten-day boat trip along the beautiful coast of Raja Ampat, Indonesia, and visited the coral reefs there. It was

an explorative consortium-building expedition that involved marine biologists, sociologists, hydrologists and economists from Wageningen University, together with





▲ The research team of the INREEF programme Resilient Reefs on board an expedition ship.

scientists from universities in Indonesia. On board were also local stakeholders, including owners of tourist resorts and residents of the area.

'A floating interdisciplinary workshop, it was a creative way to get acquainted with each other's disciplines while investigating the study site,' says Lisa Becking, Associate Professor of Marine Biodiversity at the Aquaculture and Fisheries Group of Wageningen University. Becking is programme leader of INREEF: Building the Resilience of Marine Protected Areas in Tourism Destinations, which is based on the consortium that was built during this expedition.

Coral reefs are very important for maintaining marine biodiversity, for coastal protection, for food, and form the basis for many economic activities such as tourism and fisheries. They are endangered worldwide, primarily due



Title INREEF: Building the Resilience of Marine Protected Areas in Tourism Destinations

Duration 2021-2027

Number of PhDs 13

Wageningen University chair groups involved

Agrotechnology and Food Sciences: Environmental Technology (ETE), Animal Sciences: Aquaculture & Fisheries (AFI), Ecology and Water Quality Management (AEW), Environmental Sciences: Hydrology and Quantitative Water Management (HWM), Aquatic Social Sciences: Environmental Policy (ENP), Environmental Economics and Natural Resource (ENR)

Wageningen Research Wageningen Marine Research (WMR)

Partners

Institut Pertanian Bogor (IPB), Institut Teknologi Bandung (ITB), UNIPA Universitas Papua (UNIPA), University of Aruba, University of Curacao, The Indonesian National Research and Innovation Agency (BRIN), Baseftin, Raja Ampat Research and Conservation Center, The Nature Conservancy (TNC), Coral Triangle Center (CTC), Conservation International (CI), World Wildlife Fund (WWF), Dutch Caribbean Nature Alliance (DCNA), STINAPA (Bonaire), STENAPA (St Eustatius). Government parties and parties from the tourism sector

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'The sociologist joined the dive underwater to count fish, the marine biologist went along to conduct interviews'

to the effects of climate change, but also due to local stressors, such as dynamite fishing or resorts discharging untreated toilet waste into the water. 'Tourism is a double-edged sword,' says Machiel Lamers, Associate Professor at the Environmental Policy Group of Wageningen University, who co-leads the INREEF programme. 'Tourism provides income for marine protected areas through entrance fees, but too much tourism can endanger the reef and erode social cohesion.'

Above and below the surface

The INREEF programme involves 13 PhDs and only started in 2021. Its aim is to help strike a balance and see how tourism can be combined with maintaining the reef. Social and economic factors above water determine the condition of the reef as much as biological and hydrodynamic factors below the sea surface, Becking says. 'That's why we study marine protected areas as social-ecological systems.'

The research will contribute to a resilient reef in several ways, Becking explains. The programme will deliver interdisciplinary online education programmes on marine protected areas, create a governance toolbox to evaluate the ecological and socio-economic impact of management strategies, and devise policy interventions. The programme will also work on technological interventions



for wastewater pollution caused by tourism activities and raise public awareness through a citizen science app for tourists and local communities.

Safe operating space

Another result will be a dashboard that will monitor the status and resilience of marine protected areas. The dashboard can be used by policymakers, conservation NGOs or resort owners to determine the boundaries within which activities in or around the reef are sustainable, or what measures are needed to protect the reef. 'The dashboard will help to determine what the safe operating space is for marine protected areas,' Lamers says. The dashboard is based on monitoring different indicators to assess the state and resilience of the marine protected areas, Becking says. 'Simply counting the number of



▲ Tourist resort on an atoll in Indonesia.

tourists might not say so much, because some areas can handle more tourists than others, depending on the biological baseline and the other pressures on the social-ecological system. The PhD students will carry out fundamental research, which will help us to understand how different stressors are connected and how they influence each other.'

Goals set with stakeholders

The goals of the research programme were set together with the partners and the stakeholders in the programme, Becking says. 'It is their reef. We're working together on

solutions that are needed and fit their situation.' The problems that stakeholders face require an integrated and interdisciplinary approach, according to Becking. 'The resilience of marine ecosystems is inextricably linked with all societal and economic activity above the water.'

The expedition by boat was a good pressure cooker for real interdisciplinary work, Lamers tells. 'We spent ten days together, literally in the same boat.' The sociologist joined the dive underwater to count fish and coral species, the marine biologist went along to conduct interviews with the village chiefs. That way you learn to see through each

'The expedition by boat was a pressure cooker for real interdisciplinary work'

other's eyes and learn about each other's methods. This is necessary, Becking says, because you learn to understand how the different types of data can be integrated later on.

Great fun

Interdisciplinary research is great fun, comments Becking, who frequently exchanges her diving suit for conversations on land with residents and fellow researchers to find out more the connections between what happens above and under water. Lamers also likes to work with natural scientists, because they provide hard figures that the social scientist often does not have. 'That makes for a different dialogue with policymakers.' But it is also important to be realistic, says Becking. 'Supervising an interdisciplinary PhD student requires dedication and good communication between the members of the supervisory team.'

Both are enthusiastic about the sandwich construction, in which the PhD's host institute covers half of the costs. 'That's a real investment, which means they are also highly motivated and will make sure that the research is relevant to them,' says Becking. And that in turn forces the Wageningen researchers to really think along with the partners about what they want from the research and how it links to the field. 'That is very positive, because that is how the programme can make an impact.' ■



The programme contributes to these SDGs



'We identified the Missing Middle by bringing together different perspectives'

Poultry farmers in Tanzania lack good chicken feed. Interdisciplinary and transdisciplinary research revealed a disconnect between the soy value chain and the poultry value chain: the so-called Missing Middle. The result is a lack of effective soybean processing capacity. In Vietnam, a similar disconnect was discovered, but between vegetable and pork producers' food safety levels and consumers' food safety demands.



▲ Interview with shopkeeper.

Poultry products are widely regarded as a source of cheap food that can be produced locally to improve the nutritional value of people's diets. In Tanzania, however, poultry production is hampered by the absence of suitable chicken feed. Feed ingredients are often imported and therefore expensive. This problem was one of the issues that the Missing Middle interdisciplinary research programme focused on.

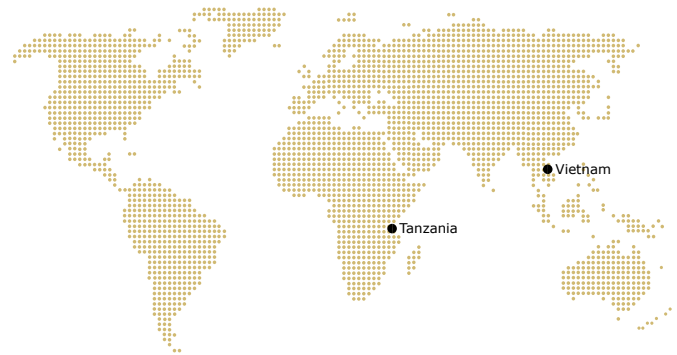
At a meeting in Iringa province, researchers discussed the problem with 50 stakeholders: not only poultry farmers, but also other farmers who could potentially benefit from

'Supply chains are intertwined, optimizing one linear supply chain doesn't work'

producing soy and maize for chicken feed; policymakers and businesses, small-scale traders and mill operators. From the discussion it emerged that current soybean processing is of insufficient quality: the simple oil pressing mills extract only part of the oil from the soybeans. Improved mills would not only increase the amount of oil extracted, which would help meet the high demand for cooking oil, but would also improve the quality of the meal destined for chicken feed.

Finding the disconnect

'We identified this as the Missing Middle,' explains Maja Slingerland, coordinator of the programme. 'The poultry, maize and soy chains are often treated as separate, while in reality they are intertwined. Optimizing one linear supply chain doesn't work, as it misses opportunities or bottlenecks related to other supply chains at the level of the producers, processors or consumers.' The Missing Middle was developed as a concept throughout the research programme, signalling a disconnect at the local level between producers and their customers across different value chains. At the national level the disconnect is between policymakers working on agricultural, livestock, economic, nutritional and health policies. Internationally, the disconnect is found between different SDG targets. The stakeholder meeting was preceded by an in-depth analysis based on interviews with farmers, millers,



Title The Missing Middle: Food system transformation pathways to link action at multiple levels to SDGs in Tanzania and Vietnam

Duration 2018-2023

Number of PhDs 2

Wageningen University chair groups involved

Agrotechnology and Food Sciences: Human Nutrition and Health (HNH), Animal Sciences: Animal Production Systems (APS), Plant Sciences: Plant Production Systems (PPS), Social Sciences: Environmental Policy (ENP)

Partners International Institute of Tropical Agriculture (IITA), Tanzania International Centre for Tropical Agriculture (CIAT), Vietnam and Vietnam National University of Agriculture (VNUA), The research programme contributed to the UN's Sustainable Development Solutions Network (SDSN) and CGIAR's A4NH programme

Co-financed by NWO-WOTRO Science for global development

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'Start off by writing a joint paper on the science underpinning the purpose of the programme'



▲ Interview with chicken farmer and sample collection.

businesses and policymakers, done by Tanzanian PhD student Wilson Charles Wilson, an animal scientist. This revealed great potential for farmers to grow soy as a cash crop, as it helps to improve soil fertility through nitrogen fixation. The practical impact of the research is that businesses and governments are now investing in improving soybean processing.

Interdisciplinary and transdisciplinary research

'We identified the missing middle by bringing together perspectives from different scientific disciplines,' Slingerland says. For example, the nutritionists pointed out the importance of micronutrients like vitamin A and zinc in chicken meat and eggs, a lesson for animal and plant scientists, who assumed it is the protein that makes these valuable additions to the diet. 'That information challenges previous assumptions: instead of trying to produce more meat and eggs, or adding soy directly to human diets, we might as well focus on fortifying flour for human consumption with micronutrients.' However, such considerations should be made carefully, she adds, taking into account not only a healthy diet but also social and economic prospects for farmers and consumers, and the environment.

'We derived these research insights thanks to the contributions from farmers, millers and businesses,' Slingerland adds. And new research questions emerged





▲ Feed sample collection for nutritional and mycotoxin assessment.

from the discussion with stakeholders. For example, a small-scale miller told the researchers that she adds micro-nutrients to maize flour for human consumption. This fortified flour could be a way to improve human nutrition, instead of producing more meat. Consumers found home processing of soy for direct consumption too labour intensive. 'Interdisciplinarity makes most sense when it's linked with the real world, in discussions with stakeholders. One learns best from other disciplines when discussing and observing concrete cases and trying to understand these.' That is why a transdisciplinary approach – doing science in cooperation with practitioners – goes hand in hand with interdisciplinary work.

Distrust around safe food

Another PhD student, Quoc Nguyen, worked in Vietnam, a very different context. After the economy was liberalized, rice, vegetable and pig production increased to meet demand for the typical Vietnamese diet. Over time, however, consumers started to question the safety of food, as hormones had been found in meat and pesticide residues in vegetables. Nguyen made a historical stakeholder analysis and found that consumers had lost trust in the government's ability to address these issues. Meat and vegetables are mostly sold at local wet markets, where effective food safety control is difficult. Some consumers therefore now avoid wet markets and buy

'One learns best from other disciplines when discussing and observing concrete cases'

directly from producers they know and trust. There is a huge disconnect between current food safety regulations and the food safety level expected by consumers. Researchers are now exploring to what extent private-sector standards combined with alternative outlets such as supermarkets might lead to improved food safety and more trust.

The Missing Middle programme trained the two PhD students, and also involved a postdoc and various researchers from both WUR and partners in Tanzania and Vietnam. The interdisciplinary nature of the Missing Middle was underpinned in different ways, Slingerland says. 'The PhD students were each directly supervised by two scientists with different disciplinary backgrounds, and two other scientists served as additional advisors. The postdoc organized exchange between disciplines on the functioning of the food system and was lead author of the first programme paper.'

Slingerland has a recommendation for other interdisciplinary programmes: 'Start off by writing a joint paper on the science underpinning the purpose of the programme. This brings together everyone involved and aligns them to the same goal. In the paper we wrote we developed the concept of the Missing Middle, which also introduced it to the academic world.' ■



▲ Field visit to a maize milling machine.

The programme contributes to these SDGs



How technologies can help the Indus basin

The Indus basin in Pakistan is a global climate change hotspot. The rapidly growing population and strong economic development are pushing demand for water and energy.

The Himalayan waters and the Indus basin are the most important sources of water for Pakistan. 'More than 200 million Pakistanis depend on the Indus, for their food, jobs, water and energy,' says agricultural engineer Jamil Muhammad Khalid, a PhD researcher for the SustaIndus programme. 'And domestic and industrial use of water – for example in the leather and sugarcane industries – is likely to increase.'

But while global warming is causing glaciers to melt, groundwater levels are decreasing due to extensive irrigation and inefficient use of water on the surrounding arid plains. Khalid: 'Within 50 years the groundwater in the basin might be depleted, which makes us very vulnerable.'

The SustaIndus programme aims to develop sustainable pathways to a future with sufficient water, food and

energy availability. The nexus between water, food and energy is high on the agenda of policymakers, so climate-



▲ Irrigation canal in a field in the Indus basin, Pakistan.

'Technologies must be combined with other practices to achieve the SDGs'

smart technologies and sustainable practices are being studied to optimize the sustainable use of these resources. Scientists from different disciplines are involved in the research, including environmental scientists, engineers, land and water management experts, and physical geographers.

Over-irrigation

Some technologies, including solar water pumps and laser land levelling – a technique to level field surfaces – had already been introduced before the programme started, says Khalid. 'But we didn't know what happens when those technologies are upscaled. That's what I'm looking at.' Khalid did field experiments and interviews with farmer communities.

'The solar pumps are intended to replace the expensive and polluting diesel pumps, which are widely used,' says programme leader Fulco Ludwig, Professor of Water and Climate Change at Wageningen University. 'But they should be used sustainably.' People normally use pumps that are dependent on electricity, but regular power cuts mean these cannot always be used. As soon as electricity is available there is a surge in use, which sometimes leads to over-irrigation. Solar water pumps avoid this problem. But over-use of all types of pumps – including solar pumps – is of huge concern, says Khalid. 'As the government wants to subsidize farmers to invest in solar pumps, we're trying to work out which regions are most vulnerable to over-pumping. It's important to understand how farmers' behaviour might change once they have free access to these technologies.'



Title Targeting a climate change hotspot: Science to support the SDGs and sustainable water management in the transboundary Indus river basin (SustaIndus)

Duration 2019-2023

Number of PhDs 3

Wageningen University chair groups involved
Environmental Sciences: Water Systems and Global Change (WSG)

Wageningen Research Wageningen Environmental Research

Partners Utrecht University, International Centre for Integrated Mountain Development (ICIMOD), Pakistan Agricultural Research Council (PARC), Leadership for Environment and Development (LEAD), Climate Adaptation Services foundation (CAS)

Co-financed by NWO-WOTRO Science for global development

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- View over Indus valley. Irrigation is needed here for agricultural production.

'It's important to understand how farmers' behaviour might change once they have free access to these technologies'

Simple and cheap devices

Khalid is also studying the laser land levelling technique, which is used to improve irrigation efficiency and crop yields. 'We can save 20-30% water for each field that uses this technology. If we upscale, we could save up to 8 trillion litres of water annually.' Initial costs are high, but there are many long-term benefits. 'Water availability for agriculture will be an enormous problem in future. And with about 60% water wasted through seepage and evaporation, irrigation efficiency needs to be improved.' Technologies must be combined with other practices to achieve the SDGs, says Ludwig. 'Instead of rice and sugarcane, food crops requiring less water, like beans and maize, can be used.' Supplying farmers and policymakers with more accurate information is equally important. 'If people know it will rain tomorrow, there's no need to irrigate today.' Simple and cheap devices such as soil moisture sensors and apps for better weather forecasts are useful.

'Most water-use scenarios for the Indus focus on water for irrigation. Those developed in the SustaIndus programme also include water demand from industry, households and energy, as demand from those sectors is expected to increase,' says Ludwig. To work on this, the programme has brought together world-leading research groups on glacier hydrology, water resources and water and energy-food systems.

Alien feeling

Different institutes, including the regional institute for mountain and water resources research (ICIMOD) and the primary Pakistani agricultural research institute (PARC), have brought together different stakeholders in the basin, including water users, government ministries and farmer organizations, to discuss how to secure water and energy sources in the future.

A transdisciplinary approach is needed to achieve sustainable use of water, food and energy sources, says Ludwig. Annual workshops will be organized to facilitate co-creation and enhance support among stakeholders – a broad group of regional representatives from governments, NGOs and academia – thus ensuring that recommendations are supported within the Indus basin. Physical meetings, postponed due to COVID-19, are needed to build up relations and trust.

There is room for improvement on linking the work of the different PhD students, says Ludwig. 'This should be stimulated from the beginning – different disciplines speak different languages. Also, practitioners in the field have different perspectives. Farmers need water next week. They are less interested in future water scenarios.' Khalid has found the interdisciplinary approach very useful. 'It takes time to understand each other and at first, I felt a bit like an alien as an applied research scientist among all those modelling experts. But I learnt a lot. We also discuss a lot and find common areas we need to examine more deeply. Things I didn't think about before.' ■



The programme contributes to these SDGs



Limiting the effects of drought rather than the causes

Drought is more than simply a lack of water. The impact that drought has depends on how we deal with the phenomenon and some groups of people are more vulnerable to drought than others. New research in Brazil is developing and testing tools to create a better drought monitor – one that monitors not only the availability of water, but also the actual impact of a lack of water. The aim is to enable better management of drought.

Drought affects more people than any other hazard, and its impact is likely to increase. When we think of drought, we usually think of a lack of rain or groundwater, but how much someone is affected by drought depends on more than just the availability of water. For example, a farmer who has a well and can use groundwater for irrigation is less vulnerable than a farmer who depends on rain to water his or her fields, explains socio-hydrologist Pieter van Oel. He is programme leader of the INREF Diagnosing Drought programme, in which three PhD students from different disciplines are doing research on drought in north-eastern Brazil.

The new philosophy of the programme, which the researchers developed jointly, is to analyse drought in the

same way that doctors diagnose a patient. Van Oel: 'A doctor first looks at the symptoms, and then at the cause. In the area where we are doing research, drought is combatted mainly by trying to prevent a shortage of water, by building reservoirs with large dams and pipelines. The three PhD students in this programme are researching solutions that are more focused on limiting the effects of drought.'

The research is still ongoing, but the first results are already emerging. One PhD student, a hydrologist, has already shown that the effects of low precipitation are not the same everywhere. When it starts raining again after a drought, reservoirs in lower lying areas fill up later than those higher up. The effects of drought therefore last

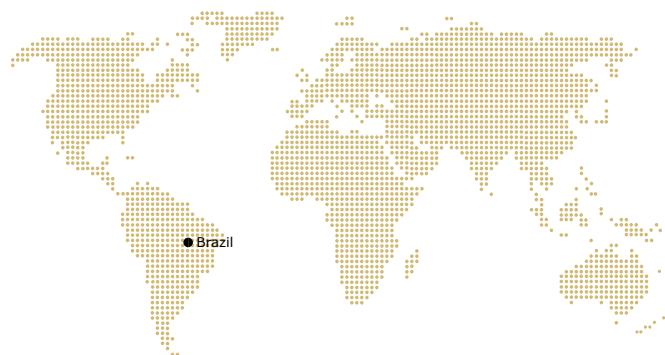
longer for some than for others. Another PhD student, a public administration researcher, showed that there are two different approaches in government policy plans. One involves fighting drought by building dams and canals, the other is learning to live with drought by making people more resilient, for example by subsidizing the seeds of drought-tolerant crops, or limiting crop losses. Brazilian policy is moving towards coping and adaptation, and is thus becoming more proactive.

Developing tools

The researchers want to support this trend and to this end, the PhD students and their supervisors are working together to develop new tools. An example is a three-



▲ A truck delivers drinking water to villagers in Brazil.



Title Diagnosing Drought for dealing with drought in 3D: Toolbox for increasing drought preparedness of actors in water and climate governance, starting from north-eastern Brazil

Duration 2019-2023

Number of PhDs 3

Wageningen University chair groups involved

Environmental sciences: Water Resources Management (WRM), Hydrology and Quantitative Water Management (HWM), Social sciences: Public Administration and Policy Group (PAP)

Partners Research Institute of Meteorology and Water Resources – FUNCEME, Brazil; Federal University of Ceará – UFC, Brazil; Brazilian Research Agricultural Corporation, National Research Tropical Agroindustry Center – EMBRAPA, Brazil

Co-financed by NWO-WOTRO Science for global development

Website <https://3ddd-project.org/about/>

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dimensional relief map that is combined with a computer simulation and a board game. Van Oel: 'Researchers can use this to discuss different solutions or scenarios with stakeholders in the field, such as farmers or policymakers. The 3D model makes it possible to empathize with the other person.' Researchers worked on this with partners in Brazil: FUNCEME, the Brazilian meteorological and hydrological institute, and EMBRAPA, the Brazilian centre for agricultural research. For the partners, it was an introduction to citizen science. In the future, the meteorological researchers want to make more frequent use of measurements or information from those in the field. Residents already report rainfall figures and water levels in the reservoirs, but in the future FUNCEME wants to use data from them for monitoring drought impacts as well, such as harvest loss and water quality.

Drought monitor

Working in an interdisciplinary way has added value to this research, says Van Oel. 'Talking to people from different disciplines and from different organizations leads to new insights. Moreover, it is great fun.' This approach also brought the partners FUNCEME and EMBRAPA together, says Van Oel. Previously, they could not agree on whether water scarcity should be addressed by building more dams or by making different use of water. Now they are getting together to discuss these matters and understand that they have to find new ways jointly.

The tools the researchers have developed will contribute to the existing Brazilian drought monitor Monitor de secas, which informs policymakers in the event of a crisis due to

'Talking to people from different disciplines and from different organizations leads to new insights. Moreover, it's great fun'

extreme drought. Affected municipalities then receive emergency aid, such as trucks with water.

Currently, the monitor uses data on water levels in the reservoirs. The researchers want to use the tools to develop new, contextualized indicators for the monitor: ones that do more justice to people's actual vulnerability, which is very variable and depends on the locality, says Van Oel. For example, drought can increase the price of food, which is a bigger problem for poorer people. Contextualized indicators show when and where drought is an obstacle to human welfare development. 'With better monitoring, the people who really need it can be helped. The ultimate impact is that people on the ground become more aware and less vulnerable to drought.' ■

- Several water depth gauge boards were placed here in north-eastern Brazil to measure the level of this water reservoir. The water level is lowering due to drought.



Synthesis

In this synthesis, we draw lessons from the experiences of the INREF programmes described in this publication. First, we highlight the societal impact of INREF programmes. These programmes help stakeholders to see the bigger picture, offer appropriate solutions that fit the local context and empower stakeholders and local researchers. Next, we discuss the added value of interdisciplinary and transdisciplinary research and education, for example how integrated approaches can result in better research questions and help scientists avoid developing tunnel vision. The INREF programmes show that being open to a plurality of perspectives yields unexpected insights. And listening to stakeholders' perspectives creates ownership among end users of the research. We also discuss some of the dilemmas associated with interdisciplinary and transdisciplinary research, such as scientific excellence versus societal impact, and the time investment needed for these kinds of research and education programmes. The chapter closes with several recommendations for future interdisciplinary and transdisciplinary research and education programmes.

Societal impact of INREF

Stakeholders who see the bigger picture support solutions that are more appropriate for the local context

One of the major changes that many INREF programme leaders referred to in this publication, is that the programmes contributed to the stakeholders having more nuanced and integrated views of the problem. This shift has positive effects for the citizens living in the areas where the research takes place. For instance, the Competing Claims, Eco2 and BESTTuna programme all contributed to broadening the scope of nature management among influential NGOs such as WWF, from looking at nature and wildlife only to also incorporating a livelihoods perspective. Eco2, which was implemented

together with Nature Conservation Egypt, found that bird hunting in Egypt is interwoven with cultural and socio-economic traditions. Most poor households along the Nile borrow money from merchants or middlemen, which they need to pay back in birds. 'We found ourselves not in a good position defending birds versus human lives, and realized we cannot solve this problem ecologically unless we understand and solve the socio-economic complexities too,' says Marc Naguib, Eco2 programme lead.

Similarly, research done in the Co-Innovation for Quality in food value chains (CoQA), Suspense, Diagnosing Drought, SmartInAg, SustaIndus and BESTTuna programmes has contributed to more nuanced policies and strategies of (local) governments. The Diagnosing Drought programme in Brazil developed contextualized

indicators that show when and where drought is an obstacle to human welfare development, which enables local governments to target support to those areas and people who need it most. The Suspense programme, which researched the palm oil sector in Indonesia and Thailand, came up with nuanced and integrated solutions such as intercropping of palm oil with other crops, which, in Indonesia, has increased both biodiversity and farmers' income. It also clarified the confusion between the Indonesian government, international NGOs and European governments about what sustainable palm oil actually means in practice, thereby creating mutual understanding and more appropriate policies and regulations to manage palm oil plantations. Jos Bijman of the CoQA programme looks back: 'I believe the government in Benin generally gained a more nuanced perspective and a better understanding of what drives actors and what limits them in achieving quality assurance in food chains.'

Transdisciplinary research can be empowering

Involving local communities, farmers and other stakeholders in the development of solutions has often proven to be empowering. In EVOCA in Rwanda, community members were engaged in the development of technologies to collect and report on mosquito species and malaria incidence. Farmers in Ethiopia participated in the design of digital innovations using smartphones. This approach enhanced ownership and increased confidence in the use of technologies among these communities. In BESTTuna, a co-created certification system to monitor

fish quantity in Indonesia also had an empowering effect, as it enabled often illiterate fishers to take control over their own data. This certification system is now being implemented in other countries as well.

Another form of empowerment that became apparent was the voice that INREF research gave to previously marginalized groups or perspectives. For example, the Competing Claims programme in Southern Africa ensured that the needs and views of weaker parties, in this case poor smallholder farmers living in or on the edge of conservation areas, were taken seriously for the first time in nature conservation efforts.

Lastly, doing interdisciplinary and transdisciplinary research also empowered the PhD students who participated in INREF. Many of the alumni of the Suspense programme now occupy influential positions, leading large programmes, or advising the government at the highest level. Conversely, a high-ranking official from the Indonesian Coordinating Ministry for Economic Affairs is now doing doctoral research at Wageningen University.

Agenda-setting research

In many cases, INREF-funded research turned out to be agenda setting. The Panama Disease programme has been a driving force in creating awareness about the importance and complexity of this disease which threatens banana production globally. INREF has put Wageningen University on the map as the leading expert



in this field and kick-started companies into investing millions in combatting the Panama disease. 'But we still need to convince such investors that the real solution for this problem is not just a new resistant banana variety; it needs interdisciplinary research,' says programme leader Gert Kema. Likewise, the concept of competing claims, coined by this programme, is now used widely in the scientific literature and has inspired many new, large research programmes that share the view that nature conservation cannot be viewed through an ecology lens alone.

In the case of Suspense, it was not only the content but also the way of working that increased the influence of researchers and partners involved in the international palm oil policy arena. According to programme leader

Otto Hospes: 'Showing respect for partners in the South has been key to opening up previously tense relations in the palm oil sector. As a result, Wageningen University has become a world leader in international policy discussions on palm oil.'

Added value of interdisciplinarity

Avoiding tunnel vision, better research questions

Key to INREF is the idea of researching an issue from different angles to devise better solutions. Involving different scientific disciplines helped to overcome biases and better refine the research topic in many programmes. In the EVOCA programme, collaboration between entomologists and social scientists in Rwanda helped to

identify the linkages between the technicalities of malaria mosquito surveillance and communities' motivation for, perceptions of and barriers to contributing to fighting the disease. In the Forefront programme, the scientists involved concluded that the concept of ecosystem services was not very helpful for identifying land use strategies that reconcile biodiversity and the needs of local actors who depend on natural ecosystems. The concept of ecosystem services places nature in opposition to humans, and thus turns nature into something that humans can benefit from. However, humans are part of nature and influence nature. The INREF research came up with alternative, more integrated ways to explore how to turn these potential trade-offs into synergies in Brazil and Mexico. This was only possible because they formed an interdisciplinary team of researchers who learned to look beyond their own expertise.

Future-proof researchers

All INREF programmes worked with PhD students, who were trained to do research in an interdisciplinary manner. Without exception, INREF programme leaders consider this an important ingredient of the success of their programmes. As Thom Kuyper, the Forefront programme leader, puts it: 'Educating a new generation of young scientists in a way that equips them to address complex issues is really the greatest impact of a programme like INREF. We now see organizations such as NWO-WOTRO following our example.'

The PhD students within INREF learned to understand their research topic from diverse angles. Uncomfortable as this may have been in the beginning – most students are trained in one discipline – the majority of INREF alumni admitted that it helped them to become better, more future-proof researchers. They acknowledge that

the wicked problems they work on can only be addressed by integrated approaches, as this quote illustrates: 'At first I felt a bit like an alien as an applied research scientist between modelling experts. But I learned a lot, especially about things I did not consider important before. After spending more time together, we found common areas that need further exploring. We would not have discovered this if we had been working in isolation from each other.' (Jamil Muhammad Khalid, PhD student in the SustaIndus programme).

Added value of transdisciplinary research

Integrating local knowledge to arrive at more appropriate innovations

In nearly all the programmes, not only scientists but also non-scientific actors were involved in framing the research question. In most cases a kick-off workshop, sometimes preceded by an integrated scoping study, was conducted to jointly define the problem and set shared research priorities. In the case of Resilient Reefs, the research team, which included natural and social scientists, owners of tourist lodges, fishers and other community members, literally spent ten days together on a boat. The expedition was anything but a holiday – it functioned as a real pressure cooker. Not only were the participants obliged to build relationships and mutual trust, they also literally 'dived into the reef' together. Joint action like this at the start of the programme increases trust and ownership among local actors, which is crucial for the longer-term uptake of research outcomes. The Smart Indonesian Agriculture programme invited representatives of farmers unions, dairy organizations, the animal health authority, government, university, milk collection centres and researchers to a design workshop

and posed the question: 'What do we need to make the dairy and fisheries sector in Indonesia working systems?' Based on the conclusions drawn and priorities set during this workshop, the programme is now developing integrated solutions, such as smart techniques that help farmers to diagnose and treat their animals when health issues occur.

Some programmes integrated indigenous knowledge to arrive at more appropriate innovations for the local context. In EVOCA in Ghana, a co-design process helped to integrate indigenous knowledge about weather and climate with advanced digital forecasting systems. Also under the EVOCA programme, the Rwanda malaria case made use of context-specific knowledge and skills of community members to develop technologies for collecting and reporting on mosquito species and malaria incidence.

Plurality of perspectives – unexpected insights

Researchers, policymakers, and many others, are likely to be caught in their own version of the truth. When people or departments work in silos, this often results in ineffective solutions and policies. INREF research is characterized by opening up different angles to understand an issue. This requires an open attitude and working across science cultures as well as societal cultures. Rutgerd Boelens (River Commons): 'As a researcher, you have to be open to other views. Some communities see the river as an animated landscape, with river gods in it. You have to be open to that and understand how particular beliefs, norms, traditions, or power relations shape people's behaviour.'

In some cases, this attitude of openness to alternative explanations resulted in surprising scientific

breakthroughs. The Terra Preta programme was initiated to gain a better understanding of the famous fertile black soils in the Amazon, which had long been a mystery to science. Contrary to expectations, the research revealed that the diversity in tropical forests in the Amazon is because the Amerindians actively created them by burning plants and trees, centuries ago. This confirms the idea that, in those times, mankind worked with soil in a much more constructive way than we do now.

While being open to different viewpoints might sometimes be confined to the conceptual level, it can also result in practical solutions. In Diagnosing Drought, researchers developed a 3D model that can be used to discuss different scenarios with stakeholders in the field, such as farmers or policymakers. The 3D model enables stakeholders and researchers alike to empathize with the other person's viewpoint. For the partners in Brazil (government agencies FUNCEME and EMBRAPA), this 3D model was an introduction to citizen science, whereby citizens and researchers contribute their own knowledge and capacity. Similarly, the SESAM programme develops and uses serious games: 'These allow researchers to better grasp the situation and motivation of local actors, but also give local actors a better understanding of how their actions affect their surroundings,' says Erika Speelman, SESAM programme leader.

Creating ownership by listening to stakeholders' perspectives

Involving stakeholders in the research process is also a way to create awareness about the importance of the topic and build commitment to acceptance of the results. 'Listening to stakeholders increases our understanding of potential tensions and conflicts in society in relation to the



topic,' mentions Cees Leeuwis, leader of the EVOCA programme. Here, co-design of technologies proved to be key. Involving users in the design of digital innovations enhanced farmers' confidence in their capacity to use and benefit from smartphones. The need to listen to local stakeholders is also emphasized by Fulco Ludwig, leader of the SustaIndus programme: 'Farmers need water next week. They are less interested in future water scenarios. Our research should meet their needs as well as those of regional stakeholders.' To this end, the programme organized a series of workshops to discuss dilemmas and potential trade-offs, and build consensus on how to proceed with the research. Likewise, one of the researchers in the Competing Claims programme in Mozambique assisted people who had to resettle due to the encroaching wildlife in the newly declared nature conservation area in adjusting their farming practices to

more sedentary agriculture on the small lands that they were allocated. She used her scientific outputs to support the negotiation of better compensation for the people that had to be resettled.

Diversity among INREF programmes

To conclude, there was a high level of diversity in how interdisciplinary and transdisciplinary research was practised in the programmes of phase III and IV of INREF. While some sought integration of insights from different scientific disciplines at the end of the programme, others started with an integrated problem definition. Where some programmes encouraged individual PhD candidates to integrate methods from social and natural sciences, others emphasized the importance of monodisciplinary

expertise and looked for integration at programme level. Moreover, the motivation for stakeholder engagement varied among the INREF programmes. Some programmes perceived stakeholders as recipients of a technology and were motivated to consider the needs of end-users. Others saw stakeholders as non-scientific experts, with their own relevant knowledge and capacity to contribute to solving the problem. And yet other programmes saw stakeholder engagement as an effective strategy to create political leverage for their research.

Challenges in doing interdisciplinary and transdisciplinary research

Monodisciplinary scientific excellence versus societal impact

All INREF programmes are convinced of the value added by working in an interdisciplinary or even transdisciplinary way. But most programme leaders acknowledge that this is also very demanding for the PhD students. 'In many cases, we ask too much of individual PhD students. They need to excel in their own discipline, use methods and knowledge from other disciplines, and have good contacts and cooperation with non-academic partners,' concludes Otto Hospes. Sijmen Schoustra, Fermented Foods coordinator, adds: 'A PhD thesis is [still] aimed at disciplinary excellence. This does not always match with doing integrated research.' This implies that, in some cases, doing integrated research may be at the expense of academic excellence in one discipline. This is not only challenging for PhD students who want to build a career in academia. It also requires supervisors that are willing to compromise on their disciplinary depth. Those pursuing a tenure track are not valued for doing

interdisciplinary or transdisciplinary research. Interdisciplinary journals are scarce and have a lower citation index. 'Societal impact is not on the checklist and thus not rewarded in the tenure-track system,' says Schoustra. Indeed, interdisciplinary work can only be effective if the researchers believe in the power of it, as Henk Hogeveen (Smart Indonesian Agriculture) found: 'The most challenging part lies with the academics. We had to do quite some missionary work to convince our fellow scientists about the value of interdisciplinary research.'

Scientific integrity and political interests

The issues addressed by INREF are so-called wicked problems, characterized by a multitude of perspectives, where information can be confusing and values of stakeholders conflicting. It is therefore logical that some stakeholders will be less eager to collaborate or may be disappointed in the direction the research takes. This was the case in the Competing Claims programme for instance, where some parties were not so happy to see how INREF researchers revealed the impact of the nature parks on local communities. Some researchers even received threats. In this context, involving stakeholders in the research process was a way to create space for this research and room for acceptance of the results.

In the case of BESTTuna, the scientific integrity of some of the findings were challenged by stakeholders with opposing views. Simon Bush recalls: 'We published quite some articles with conclusions that were inconvenient for both companies and NGOs, and even our own partners in the project. We assessed the way of working of Dolphin Safe Tuna label, and basically concluded that the label was less credible than other labels such as MSC. We were

challenged and had to account for every result, and every method that we used. That really drove home the value of organizing our data well.' Yet, some programme leaders concluded that working with partners and integrating perspectives is not a guarantee that power issues will be resolved in a satisfactory way, or that the resulting innovations are always fully inclusive.

Time investment and dedication

Supervising a PhD student in an interdisciplinary manner generally requires more time, dedication and communication than supervising a conventional PhD. Different scientific disciplines speak different languages, and need a common (new) language to understand each other. The student and supervisors must exchange and learn from each other before they can come to a common understanding of the research problem and research methods. In many cases new – integrated – research methods were developed solely for the specific problem at hand. Consequently, most PhD trajectories took longer than four years and budgets were generally not sufficient. Some of the programme leaders recommend having fewer PhDs for the same budget, which would allow each PhD project to achieve higher quality.

INREF and interdisciplinary education

PhD students funded by INREF receive interdisciplinary and transdisciplinary training, through their supervisors, and through the courses they follow as part of their education. This has had an effect on PhD evaluation in general at Wageningen university. New evaluation categories for interdisciplinary and transdisciplinary PhD research have been introduced, inspired by INREF experiences.

The INREF programmes also impacted other aspects of higher education, at MSc and BSc level, at Wageningen University and partner universities. There are many examples of regular BSc or MSc courses that have gradually become more interdisciplinary due to the influence of INREF: an integrated master's course on land has been introduced, and a master's course on nutrition now also includes agronomic aspects, says Maja Slingerland, programme coordinator of Missing Middle and Competing Claims. Some Graduate Schools have also developed a postgraduate course on the concepts and practices of interdisciplinary research. Lastly, interdisciplinarity is being achieved at the level of MSc thesis work, where students have PhD candidates from different fields as their supervisors. It is fair to say that INREF has helped create the space for interdisciplinary courses to flourish.

However, monodisciplinarity still dominates the way we teach and produce knowledge and reproduce these disciplines. A truly interdisciplinary approach to education has not yet spread beyond a relatively small number of highly motivated students, lecturers and researchers. 'The experiences from this programme could be used in a more institutional way, so that more education and research become interdisciplinary,' says Thom Kuijper. He suggests this might be done by allowing MSc students to do a minor or major outside their own study programme, or by offering more freedom of choice in courses.

Recommendations

Synthesizing the lessons learnt from the 17 INREF programmes of Phase III and IV has resulted in several recommendations for future research that aims to take an integrated approach.

- **Do integrated scoping studies**

Many INREF programmes started with an integrated scoping study, where researchers were immersed in the complexity of the local situation and met with local partners and stakeholders. In Competing Claims, PhD students engaged with farmers, nature park rangers, NGOs and local research partners to explore and locate the competing claims in the landscape. Maja Slingerland: 'This creates engagement and motivation, and ensures that research is done on real and relevant topics. The PhD students get a sense of ownership and can operate as a cohort towards a joint set of stakeholders in their research location.' The boat trip undertaken at the start of Resilient Reef had a similar aim.

- **Start with the stakeholders**

Stakeholders are crucial when it comes to implementation of scientific insights. Therefore, many INREF programmes started with a kick-off workshop to identify their perspectives and needs. The Fermented Foods programme invited stakeholders to list their top five priorities and then matched these with the scientists' top five, and the research was based on the combination. River Commons also sat down with key actors. Rutgerd Boelens: 'We aim for a horizontal research partnership: the inhabitants, farmers and fishers determine what the research should be about and together we co-create new river knowledge. We scientists can integrate our academic knowledge with their knowledge.'

- **Invest in team building**

To really develop an understanding of how the system works, teamwork is needed. 'Team building takes much more than occasional exchange through PowerPoint presentations,' says Cees Leeuwis of EVOCA. 'To get them to work together and develop a joint understanding of how technological and social components interact, we sent the students to the field together to jointly do interviews.' In Missing Middle, the team started off by drafting a joint paper on the science underpinning the purpose of the project.

- **Take interdisciplinary supervision seriously**

Most PhD students were supervised by at least two supervisors, one from a technical and another from a social science discipline. The amount of time this requires should not be underestimated. Patience and openness, on the part of students and supervisors, proved to be key. Some INREF programmes recruited a postdoc researcher who helped with the integration of the different findings. This was a positive experience. Postdoc researchers also organized exchanges between PhD students, supervisors and partners, to ensure that different viewpoints were taken into consideration.

- **Budget sufficient time for deliberation and co-design**

Like supervision, co-design and stakeholder collaboration cost time and are resource intensive. Listening to all perspectives, deliberating on what approach to take, and iteratively developing research methods require programme leaders and other researchers to balance stakeholders' interests.



- **Use seed money projects to build a common vision**

Seed money projects funded by INREF were seen as especially useful for research consortia to build a coherent programme. 'With the help of an INREF seed money project, we could invest time in really getting to know each other and gradually build a mutual understanding of the problems in the Banana sector,' says Gert Kema. During this period, Kema also engaged several partners from the banana industry, who managed to almost double the budget for the INREF research programme, enabling them to cover the high costs of laboratories and banana production.

- **Make use of the sandwich construction**

INREF works with the 'sandwich construction', where PhD students are hosted by WUR and a university in the Global South, and costs are split between the two institutes. The experiences with this construction are mixed. Some programme leaders found that this financial requirement makes it difficult to recruit suitable candidates for the complex task of doing an interdisciplinary PhD. Others are more positive: by covering 50% of the costs, the Southern universities make a real investment. These institutes are then also highly motivated to make sure that the research is relevant to them. Lisa Becking: 'In turn, it forces the Wageningen researchers to really think along with the partners about what they want from the research and how it links to the field.'



Conclusions

It is clear that the wicked problems addressed by researchers in INREF funded programmes require collaboration between different disciplines and between science and society. Apart from collaboration being needed to gain insight, it is crucial if research is to have impact and deliver meaningful solutions in the lives of real people. Without collaboration, research results will not be rooted in reality, or they may be incomplete due to a relevant scientific discipline not being involved.

This booklet has also shown, however, that doing interdisciplinary and transdisciplinary research and education can be challenging and time consuming. Not only for the early-career scientists who need to learn to cross borders, work with stakeholders, *and* excel in their primary scientific discipline, but also for programme leaders, who acknowledge that it generally takes more time and effort, and requires commitment and dedication to overcome misunderstanding and confusion, and balance interests. Despite this, the words the researchers most often used when asked about their experience of interdisciplinary and transdisciplinary work were *fun* and *wonder*. Embracing the unexpected makes their work exciting and meaningful.

The challenges our society faces are unlikely to become less complex. To be prepared for the future, continued investment in interdisciplinary and transdisciplinary research and education is required. We need to develop our capacity to do interdisciplinary and transdisciplinary research, which will involve not only building the capacity of individual PhD researchers, but also that of postdocs

and professors, and Wageningen University as an institution. Continued support for interdisciplinary and transdisciplinary research will also improve Wageningen University's position as a world expert in specific research areas and in international research networks – think of Competing Claims or Panama Disease – bearing in mind that this would not have been possible without the learning space that INREF provided to develop such integral approaches.

'Embracing the unexpected makes the work of researchers exciting and meaningful'

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Established in 2000, this ambitious fund addresses development-related challenges around the world and embraces a systems approach. In cooperation with partners and stakeholders, researchers work on devising real solutions through interdisciplinary and transdisciplinary research.

This publication chronicles the 17 major research and education programmes implemented through INREF over the past ten years, illustrating how these programmes have made a difference in tackling complex challenges in the global South. It also draws lessons on how to perform such groundbreaking forms of research.

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