Our contribution to fulfilling the UN's SDGs

SDU

IMADA's work on **mathematics and statistics** lays the foundation for understanding the dynamics that govern the world's financial systems.

For instance, we have expertise on modelling stochastic differential equations, which are fundamental to understanding temporal processes that have a strong random component, such as financial systems.

A better understanding of the financial systems is essential to a greater understanding of the market fluctuations that sometimes spiral out of control, leaving millions unemployed and in poverty.

SDU

Department of Mathematics and Computer Science

Even in developed countries, food bank organisations for food redistributions struggle to improve their operations and efficiency.

At IMADA, we have expertise that can decisively contribute to the development of technologies enabling more **efficient operations**, such as:
→ Building apps to help collect and deliver donated food.

→ The apps use optimisation algo-rithms to route the trucks and fair division algorithms to allo-cate the donated food to different charities.

2 ZERO HUNGER

SDU✦

3 GOOD HEALTH AND WELL-BEING

1/2

Contributions from **mathematics and statistics** are of utmost importance in many health-related matters. For example, we apply different methods:
→ Modelling disease dynamics such as using renormalisation group approaches to investigate the spreading of COVID-19.
→ Combining stochastic population dynamics models with epidemiological models to predict the impact of COVID-19 in various fields.

Furthermore, IMADA's research on **algorithmic cheminformatics** involves large and complex networks of chemical reactions and answers important questions and challenges in research, industry, society and help answering fundamental health-related questions.
Examples are:
→ Understanding the regulation of metabolic networks in humans.
→ Planning and optimising chemical synthesis in industry and research labs.
→ Modelling the fragmentation of molecular ions inside mass spectrometers.
→ Developing personalised medicine.
→ Probing hypotheses of the origins of life.

SDU

Department of Mathematics and Computer Science

The Centre for Quantum Mathematics has undertaken an enormous endeavour to understand our world and the universe on a quantum level. When a unification is achieved of the relativity theory of Albert Einstein with the non-relative subatomic world, we will have the tools to revolutionize our technologies and make 'quantum leaps', e.g., within ongoing **research on protein and RNA folding** and with recent focus on topological quantum computing, which offers a great potential for enhancing the computational power with focus on modelling many macro-molecular biological processes.

IMADA contributes by developing **AI technologies** to improve the well-being of people and the involvement of citizens around health issues. For example, we are currently engaged in developing an app for a local municipality that aims at alleviating the **anxiety of people with dementia** and their caregivers when situations of wandering and getting lost arise. The app will be able to:

→ Automatically detect and make it possible to alert the nearest volunteers to provide immediate help.

→ Match volunteers and people with dementia for participating in social activities together.

Project example: IMADA participates in **FeatureCloud**, a novel artificial intelligence (AI) platform based on a groundbreaking new cloud infrastructure to integrate local AI globally without the need for any transfer of primary medical data – totally anonymous by default.

Department of Mathematics and Computer Science

IMADA delivers **quality education every day**, with more than 700 students enrolled and more than 90 MSc and BSc students graduating every year. IMADA partakes in various outreach activities at high schools where students from IMADA engage with local and regional high schools. IMADA also organises **further education training in cybersecurity** to lift the competence level of IT professionals and companies, with particular focus on supporting SMEs.

IMADA develops tools to **optimise the administration of educations**.

Such tools are able to:
→ Schedule courses while maximising the possibilities for student attendance.
→ Allocate students to projects in a resource-optimal, fair and effective way.
→ Schedule exams while maximising the time available for preparation between exams.
→ Allocate instructors to courses matching preferences.
→ Allocate classrooms.
→ Make long-term plans about the needs for infrastructure.

Activity example: IMADA has been co-organising the **Danish Championship of Cybersecurity** aimed at 15-25-year-olds, including training sessions with more than 300 registered high school students.

4 QUALITY EDUCATION

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SDU

Department of Mathematics and Computer Science

Building research-based knowledge about quality in **STEM education** is a key focus point at IMADA.

A guiding value is that children, young people and life-long learners have the right to continuously build research-based knowledge about their world.

Several departmental, cross-departmental and cross-institutional research initiatives advance learning about and engagement with nature, science and technology.

IMADA hosts the **Laboratory for Coherent Education and Learning (LSUL)**, which is a strategic collaboration in research, innovation and education between SDU, University College Lillebaelt and University College South Denmark. It brings together students, researchers and practitioners in STEM (Science, Technology, Engineering and Mathematics) education.

LSUL also provides students and teachers with tools and skills for identification of questions and **concrete real-life problems**. Societal challenges, e.g. energy efficiency, resource usage analyses and the environ-ment are addressed through inter-disciplinary and trans-disciplinary education.

4 QUALITY EDUCATION

2/2

SDU

Department of Mathematics and Computer Science

At IMADA, we are fully committed to diversity and inclusion with respect to race, national origin, **gender**, individuals with diverse abilities and LGBTQ+. As part of the University's engagement to contribute to the UN's Sustainable Development Goals, it works strategically with **Gender Equality**.

IMADA actively participates in this work through the University's five-person **Gender Equality Team** working with systemic changes and gender statistics in close cooperation with the faculties and units, including the central Gender Equality Committee and the local Gender Equality Committees.

Initiatives: IMADA actively coordinates and participates in '**IT Camp for Piger**' aiming at increasing the uptake of women in IT education programmes at university level. It is part of the larger collaboration amongst universities (Aalborg University and Aarhus University) in Western Denmark (**IT-West**).

SDU

Department of Mathematics and Computer Science

IMADA's research has wide applications within affordable and clean energy.

Our **computation** group supports innovation by means of state-of-the-art modelling methods for **aerodynamics applications**.

IMADA's research contributes to **plan energy production** with strong competences in solving various forms of optimisation problems and **resilient network design**, e.g.:

→ Common planning problems in **energy production** such as co-generating between plants.
→ Power companies have to optimise the **inventory of fuels, such as biomass**.
→ On the distribution side, companies owning the power grid must **monitor and secure the bottlenecks of their infrastructure**.

Project example: The **Drones4energy** project aims to build a collaborative, autonomous and continuously operating drone system that will be offered to powerline operators to inspect the power grid accurately, frequently and autonomously.

7 AFFORDABLE AND CLEAN ENERGY

SDU

At IMADA, we collaborate with several local companies to address recurring related to **how to operate a business and plan work**. Examples are:

→ Different tasks and jobs must be carried out by workers who have the **right skills** while satisfying the working agreements for **work conditions** and taking into account the location and the movements of the workers involved.

→ **Workforce planning** is an integral task that all medium and large-size companies have to deal with to operate. This is central in **time management** and important for the **well-being of workers**, the quality of the service provided and the resource utilisation by the company or organisation.

Department of Mathematics and Computer Science

IMADA's contributions to SDG 9 on industry, innovation and infrastructure are manifold.

→ The work on **mathematics and statistics** supports innovation by means of state-of-the-art modelling methods for aerospace applications also supported by work done at the **High Performance Computing (HPC)** facilities at IMADA. The HPC facility based at the SDU eScience Center provides one of the largest cloud and supercomputing infrastructures in Northern Europe with numerous types of application relevant for industry and innovation. In 2020, IMADA became host to two new national HPC facilities especially focusing on making HPC widely accessible to researchers and industry.

→ The work carried out in **algorithmic cheminformatics** is highly relevant for future industrial applications within a range of areas, e.g., personalized medicine and agriculture.

→ The **Centre for Quantum Mathematics** focuses on topological quantum computing, which offers a great potential for enhancing the computational power with a focus on modelling in relation to **robot and drone control**.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

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SDU

→ IMADA is a leading Danish institute in **cybersecurity**, employing researchers that have already impacted both theory and best practices in the field. This includes developing **new programming tools and IT infrastructure** that make it easier, including privacy aware-ness and resilience to **to code secure software**outsider attacks.

Project example: IMADA has, amongst others, participated in the **Assessment on the Status of CyberSecurity in Denmark (ACSD)** project that aims to study and report on the existing cybersecurity and privacy protection practices used in large Danish companies and SMEs, thereby identifying the most important challenges the developers in Denmark face in developing secure and privacy-preserving solutions, and providing guidelines for securing critical infrastructures.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

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SDU

11 SUSTAINABLE CITIES AND COMMUNITIES

IMADA develops tools to **optimise** the bus line network, thereby improving service for customers and reducing CO2 emissions for the bus companies.

Moreover, we analyse **traffic data** to detect anomalies and correlations between different parts of the road network and communicate them promptly, allowing action to be taken.

We optimise:
→ **Vehicle routing in services and delivery of goods**
→ **Budgets for building maintenance**
→ **Reduce CO2 emissions of flights** by optimising their routes.

SDU

The IMADA group working on statistical theory and its application are fundamental to SDG 13. For example:

→ We work on the theory and modelling of extreme value statistics to **understand extreme events** such as those we are witnessing with climate change.

→ The **Centre for Quantum Mathematics** focuses on topological quantum computing, which offers a great potential for enhancing the compu-tational power with focus on **modelling in relation to the pre-diction of climate changes**.

SDU ✿

14 LIFE BELOW WATER

IMADA is working in collaboration with the **Interdisciplinary Centre on Population Dynamics (CPop)** and the international non-profit **Species360** to understand the demography of **marine mammals in captivity and in the wild**.

Demographic rates (specifically, survival and reproduction) are the fundamental building blocks to understanding the **dynamics of populations** in different environments.

Due to the difficulties of studying animals in **aquatic environments**, there is an unprecedented lack of demographic information for these species.

IMADA uses **novel statistical methods** we have developed to explore these demographic rates for **animals in zoos and aquariums** and how these can help inform and predict the demographic rates of species in their natural environment.

SDU

Department of Mathematics and Computer Science

IMADA, in collaboration with the **Inter-disciplinary Centre on Population Dynamics (CPop)** and the international non-profit Species360, is contributing to improve our understanding and our ability to counteract the current **biodiversity crisis**.

Specifically, we are developing **novel statistical methods** to understand survival and reproduction; that is, the demography of a large number of species of **terrestrial animals and plants**. Many of these species are endangered and of great commercial value.

From the results of these models, we construct predictive mathematical models, known as **population dynamics models**, that help us explore the risks of extinction of populations of these species in different environments. We use these models to test how alternative wildlife management strategies can improve or affect the long-term survival of these populations.

15 LIFE ON LAND

SDU

For more information

→ **Go to our website**: www.imada.sdu.dk

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