Norad's recent investments in *icipe*

Combatting Arthropod Pests for better Health, Food and Climate Resilience (CAP-Africa project, July 2018 – June 2023

Research thrust	Key achievements
Global health – to reduce the burden of malaria and emerging infectious diseases.	Malaria cases reduced in Jabi Tehnan district, Amhara Region, Ethiopia, due to integrated vector management (IVM) interventions; mosquito and malaria cases decreased in target areas in Ethiopia through human-animal-plant health interventions; findings and policy recommendations were generated on malaria, agriculture and gender. Knowledge that urban populations of *Aedes aegypti* mosquitoes in Kenya are inefficient vectors of the East African yellow fever virus strain; but *Ae. bromeliae* mosquito is a competent vector. The risk of dengue fever transmission in Kenya could be related to urbanisation correlating to patterns of *Ae. aegypti* abundance, survival and blood feeding rates on people.
Education – to train at postgraduate level for leadership in scientific research, development, policy, and technology dissemination.	A total of 14 graduates (8 MSc, 6 PhD) and 41 peer reviewed articles produced; 116 early and mid-career scientists (98 female) acquired science skills/knowledge through workshops and training courses; 15 research managers (33% female) from national and regional partner organisations were trained in managing research and innovation intellectual assets; 19 training events were conducted; 1756 farmers (50.3% female) were trained directly and about 3 million indirectly via the media; 5 new institutions were introduced to, and trained on icipe technologies; 28 technology learning sites were established. In total, 1069 people (35% female), comprising students, extension workers, young and mid-level scientists, gained skills and knowledge on the three research thrusts.
Climate change – to fill critical gaps in knowledge on the impact of climate change on ecosystem services and invasive pests, and to deploy climate-smart technologies to improve food security and system resilience.	Potential use of *Metarhizium anisopliae* fungal isolates against melon fly, *Zeugodacus cucurbitae*; optimal temperatures for the development and survival of the tomato leafminer, *Phthorimaea absoluta*, were determined and modelled, and areas of the pest's suitability and increase globally, predicted. Two parasitoids of *P. absoluta*: *Bracon nigricans* and *Stenomesius* sp., were identified in Kenya and their habitat suitability modelled; areas of suitability and further risk of invasion of the fruit tree mealybug, *Rastrococcus invadens*, projected in East, West and Central Africa; and high risk of invasion and potential for establishment of the fruit fly, *Bactrocera zonata*, in Kenya, Tanzania and Uganda noted. Population genetics study of the citrus pest, *Diaphorina citri*, in eastern Africa revealed different sources of origin between Kenyan/Tanzanian and Ethiopian populations. Climate-smart push-pull technology adopted by 63,656 farmers in eastern Africa, sustaining cereal-livestock farming, helping to address fall armyworm infestation menace, and to mitigate human and environmental health risks of pesticide use; production and distribution of the technology's intercrops, *Desmodium* and *Brachiaria,* bolstered in partnership with private sector actors; key benefits of the push-pull technology (2019-2022) indicate benefits to 550 000 farmers (56% female); public awareness, capacity building and policy support on climate-smart and third generation push-pull technologies enhanced; and odour-mediated basis for reduced stemborer infestation in the push-pull technology system elucidated. The role of nudging in scaling agricultural technologies demonstrated.

icipe is a partner in three projects supported by Norad.

Malawi Digital Plant Health Service with National Public Ownership (MaDiPHS, June 2022 – June 2027)

Provide a tool for targeted and efficient pest and disease management of selected crops in Malawi. **Led by the Norwegian Institute of Bioeconomy Research (NIBIO), in partnership with *icipe,* International Institute of Tropical Agriculture (IITA); Pennsylvania State University, USA; Food and Agriculture Organization of the United Nations (FAO); and Total Land Care (TLC), Malawi.**	*icipe* will: contribute to the establishment of a digital agricultural plant health service in Malawi, in alignment to similar international systems; lead a work package on decision support systems using ecological niche and other models based on pest and crop phenologies; develop pest and disease models for use at farm level; verify and support the adaptation of best-bet integrated pest management tools, and training on pesticide risks; and provide programme management and coordination.

Within CAP-Africa, in 2020-2021, *icipe* received supplementary six-months funding for two complementary research components.

Research area	Key outcomes
Insect-based climate-smart waste recycling into nutrient-rich biomass for livestock feed and organic fertiliser	Knowledge on organic waste substrates on gut microbiota of black soldier fly; demonstration of the effect of the insect's larvae in mitigating methane emissions from organic manure; excellence of black soldier fly-composted organic fertiliser on soil health growth, crop yield and nutrient quality of vegetables and economic returns. Black soldier fly larvae meal as a promising alternative source of protein in poultry industries and aquafeed; higher economic returns and egg nutrient quality by replacing fishmeal/soybean meal with in poultry production; high acceptability by farmers of insect based diets in sustainable livestock production and consumption of products. Black soldier fly larvae-based feeds boost healthy bacteria in the gut health of poultry. High nutritional content of the larvae beetle, *Oryctes boas,* and methodology for its mass rearing; influence of culture and other determinants on the choice of insects for consumption and for use as feeds.
Increase health and livelihood of target communities in Kenya by improving the knowledge on the use of social bees as key pollinators for crops and producers of hive products	Knowledge advanced on African stingless bees, specific species that are superior pollinators of certain crops, and pollination influencing factors. Stingless bees honey quality determined by physicochemical and phytochemical constituents, and by species and geographic regions. Understanding of dominant and conserved symbiotic gut microbes of eight stingless bee species from across Africa and the microbiota clustering differently with strains from other continents, providing insights into stingless bee host-microbe co-evolution and adaptation.
Implementation of biorational control of major Afro-tropical arthropod vectors of livestock diseases for improved food security, employment and livelihood.	Improved Stomoxys (stable and houseflies) and tsetse fly trapping through cutting edge science including: development of a novel nanobead dispensing system for attractants that significantly enhances catches of Stomoxys; information on visual responses of tsetse and biting flies to colour; and the use of blends of compounds that mimic the signature scent of trypanosome infected cow urine; and creation and testing of a potent compound blend that selectively captures infected tsetse flies. Molecular survey of tick pathogens from coastal Kenya revealing abundance of diverse tick species, infected with many pathogens of veterinary or zoonotic importance, such as *Ehrlichia minasensis*, *Rickettsia africae*, *Theileria parva*, *T. velifera* and *Coxiella burnetii*.

*15 articles published in high impact peer-reviewed journals; 12 MSc students and 6 interns trained.

Market assessment to determine suitability of insect farming as a viable livelihood opportunity for employment and self-employment in Dadaab (October – December 2021)

Funded by the Norwegian Refugee Council (NRC), the initiative identified appropriate and viable and available waste streams to support insect farming in the Dadaab refugee complex, which connects north-eastern Kenya and southern Somalia.	*icipe*'s market assessment to determine the potential for developing and promoting community-led sustainable and cost-effective black soldier fly larvae farming enhanced the production and use of the insects in poultry feed and frass fertiliser; provided a well-researched roadmap for local black soldier fly farming for both the local market and commercial off-takers; strengthened the ability of refugees to be self-reliant through increased income and food security, while reducing the environmental footprint of the poultry feed supply chain.

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in sub-Saharan Africa (FASA, November 2022 –April 2027)

Led by WorldFish in collaboration with *icipe*; Swedish University of Agricultural Sciences (SLU); Aller Aqua Africa and the West and Central African Council for Agricultural Research (CORAF).	*icipe* with the support of strategic scaling-up partners and stakeholders, will: esnhance integration of best practices for insect-based feeds for a sustainable feed sector, and adoption of new knowledge on nutrient requirements of improved strains of tilapia and African catfish; enable local millers and farmers to improve the quality of local ingredients, produce novel, cost-efficient feed formulations and improve aquaculture productivity and resilience; develop databases and digital solutions for farmers to formulate and adapt new local feeds on a "real-time" basis; reach 2,000 farmers, directly and indirectly, enabling them to access, test and use novel fish feeds and feed solutions.