

NAKAI INTERNATIONAL ENVIRONMENTAL RESEARCH CENTRE

*Centre International
de Recherche Environnementale de Nakai*
(CIREN)



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I. PREAMBLE

NTPC is a company formed by Lao, Thai, and French (EDF) private shareholders to build and operate the Nam Theun 2 hydroelectric facility for the first 25 years of its operation.

NTPC is dedicated to running a world-class hydropower facility and to improve the livelihood of the people in the areas around the dam. <https://www.namtheun2.com/>

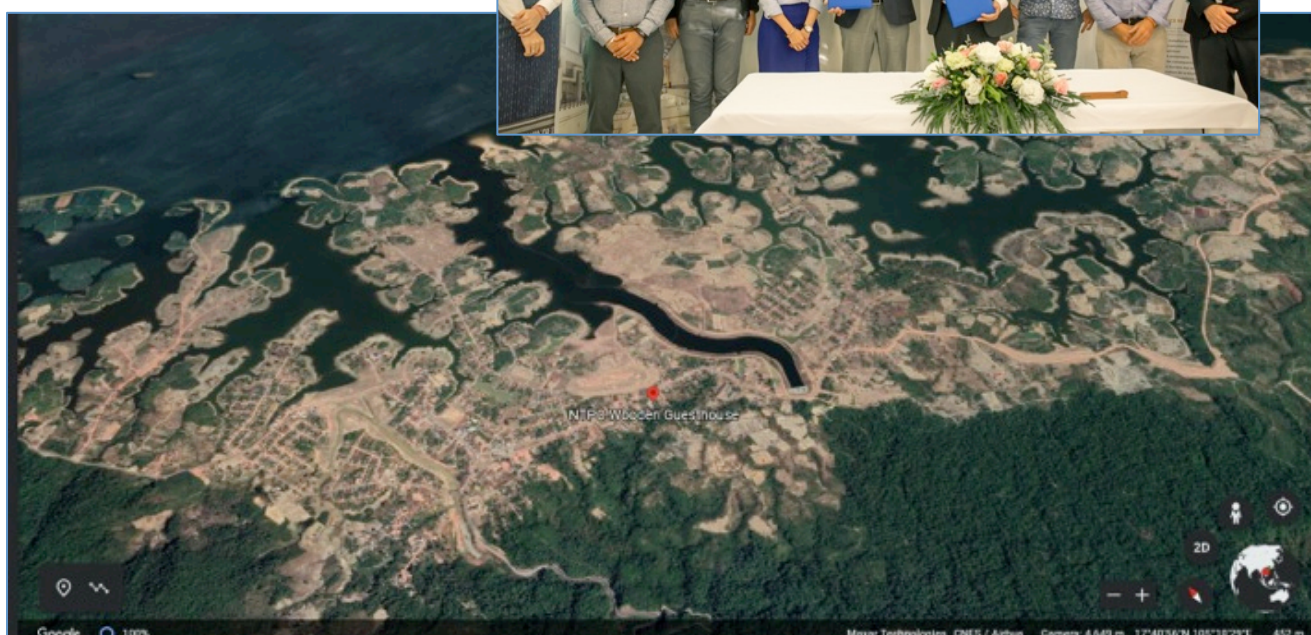
Opportunities:

1. Due to the joint actions over a period of more than 15 years between IRD and NTPC, the latter is offering a physical space in Nakai to set up an environmental observatory and a research centre.
2. E. Deharo, IRD representative in Laos, is the PI of a regional FSPI: *ONE HEALTH in practice in South East Asia* (<https://en.ird.fr/ohsea-one-health-practice-southeast-asia> budget: 940.000 euros) and is leading the CIREN project.



II. BACKGROUND

- **The collaboration between NTPC and IRD began in 2008**, a few months before the dam area was impounded and has continued since.
- NTPC's main shareholder has set up a monitoring programme of the reservoir's water quality and greenhouse gas emissions from the reservoir's right-of-way. This programme was implemented by NTPC in close collaboration with IRD and the University of Toulouse.
- The whole project involved NTPC staff together with the Aquatic Environment Lab (AELab) component of the EDF-CIH (Engineering and Hydraulics Centre) and IRD/University of Toulouse (IRD/UPS), the GET (Geosciences Environnement Toulouse), and LA (Aerology Laboratory) laboratories.
- The first stage of this collaboration consisted in setting up a state-of-the-art laboratory for monitoring the water quality of the aquatic ecosystems impacted by the reservoir as well as for quantifying greenhouse gas emissions and establishing a carbon balance in the catchment area.
- The studies on the carbon cycle and greenhouse gases were financed by EDF, the CNRS, and the University of Toulouse, and benefited from exceptional support from NTPC in the form of logistical support (land and water transport, accommodation), technical support, and the provision of the laboratory.
- The work as a whole made it possible to build a database over more than 10 years that is unique in the world for the variety of parameters measured and the duration of the measurements it contains.
- The projects as a whole have led to the publication of around ten scientific articles involving all the partners. Future publications are being prepared to disseminate, in particular, the long-awaited values of the dam's net greenhouse gas emissions (or carbon footprint).
- **The Nam Theun 2 site is an important place for training** through research on the themes of the carbon cycle and greenhouse gas emissions. The work involved 2 masters, a PhD student and a post-doc. NTPC also hosts practical training for 1st year Master students from the Hanoi University of Science and Technology (USTH), provided by AELab staff and IRD/UPS researchers/teacher-researchers.
- This fruitful collaboration was formalized by the signing of a Framework Agreement on Scientific and Technical Cooperation between IRD and NTPC on 26/11/2019 at the headquarters of the Agence Universitaire de la Francophonie (AUF) on the campus of the National University of Laos (NUOL). In the implementation of this framework agreement, special attention will be paid to technical and scientific training and the establishment of scientific collaborations at national and regional level.



III. ENVIRONMENTAL CONTEXT

Southeast Asia is a global hotspot of biodiversity currently in crisis as well as a place of threatened cultural diversity. Neglected tropical diseases are still a heavy burden for the countries of the region. Numerous zoonoses have emerged in recent decades in this region (including Southwest China) and cross-border health risks are seriously considered with the development of economic corridors and their integration into the new Silk Roads.



Inger Andersen, Executive Director of the United Nations Environment Programme, has said: "It is a failure for man to have known how to predict but not prevent". The covid-19 pandemic highlights the **failure of current strategies to anticipate zoonotic epidemics**. Indeed, the disruption of fragile ecological balances has led to the emergence of infectious diseases that are spreading to hitherto unspoiled geographical areas. To prevent another pandemic, we need to be more proactive and recognise the inextricable link between human, animal, and environmental health. We must take better account of the environmental, but also the anthropo-sociological, economic, and political components of the outbreaks in order to at least anticipate the next epidemic. We can no longer dissociate human health from animal and environmental health. A better understanding and documentation of the relationships between these 3 pillars of the "One Health" approach (promoted in 2004 by the World Conservation Society) is essential to develop future surveillance and control strategies. Nevertheless, environmental health remains the weak link in the triptych, as the bridges between human and animal health are easier to build. Then, the acquisition of diachronic series of climate, hydrology, geochemical and ecological data over years on the environment representative of the diversity of ecosystems is pivotal for risk mitigation, building integrated modelling, and for proposing predictive scenarios.



It is then crucial to move towards a shared understanding of knowledge, representations, and values held by the different actors, citizens, communities, practitioners, researchers, and decision-makers, while going beyond traditional visions of expertise and education. This approach involves porous training actions between health sciences and environmental sciences, relying on the collection and analysis of environmental data to anticipate opportunities for pathogens to colonise unusual territories and evolve in new forms. This is also in line with the ASEAN Action Plan for Science, Technology and Innovation whose main objective is, among others, to strengthen strategic collaboration between universities, research institutes, networks of centres of excellence, and the private sector in order to create an effective ecosystem for capacity development.

General Objectives of CIREN

- Set up a dedicated research and training centre in the NTPC facilities in Nakai;
- Bring together scientific disciplines to tackle crucial environmental issues regarding how the various components of the Earth Critical Zone (CZ) interact with global change, including land use and climatic changes (*CZ is defined as the thin layer between the top of the canopy and the bottom of the groundwater aquifer in which complex interactions involving rock, soil, water, air, and living organisms regulate the natural habitat and determine the availability of life sustaining resources*);
- Define standardized data collection and treatment methodologies covering environment health and linked issues;
- Strengthen structural and technical capacities for environmental impact research in Laos;
- Strengthen the acquisition and monitoring of animal, human, and environmental data;
- Set up a training package in order to promote the training of technical and university human resources;
- Pool resources and open databases to students and researchers on a collaborative platform;
- Structure applied public health research to meet the needs of the Ministry and the national health system, with a view to achieving Sustainable Development Objectives;
- Set up collaborations between environmental scientists and clinicians for the rapid transfer of results into action to reduce the risks for exposed populations.

IV. ONE HEALTH RESEARCH AND TRAINING CENTRE

Nakai international environmental research centre – a joint IRD-NTPC structure

A. CIREN - OBSERVATORY

The M-TROPICS Critical Zone Observatory in Luang Prabang (created by IRD) has established itself not only as a world-class research facility, but also as a unique training centre for students and professionals in the field of environmental sciences. **More than 200 students have been trained there.**

To meet the need for an appropriate training environment, we believe that it is now appropriate to consolidate and strengthen the training capacity developed by M-TROPICS by participating in the creation of a training and research centre, dedicated to environmental observation, within an infrastructure on the Nakai plateau, in partnership with NTPC.

The target audience will be mainly university and technical college students as well as staff from Lao academic and research institutions. More specifically, this centre will allow the implementation of a specific study programme on *in situ* observation techniques and methodologies, applicable to a wide range of disciplines, such as hydrology, meteorology, pedology, agronomy, geochemistry, microbiology, ecophysiology, etc.

In addition to offering a suitable infrastructure in the immediate vicinity of the Nam Theun 2 reservoir, this centre will offer the possibility of setting up a reference hydro-sedimentary monitoring station of the type already deployed in the M-TROPICS observatory in Luang Prabang.

As a stand-alone facility or through an extension based on the deployment of additional low-cost monitoring stations, such a facility could be used for the dual purposes of on-the-job training and data collection, which would also improve the calibration of models used by NTPC to estimate and predict reservoir recharge with direct industrial application.

In collaboration with Mounoy Development Sole Co. (<https://mounoydev.com/>), a Lao start-up led by a former IRD/NUOL student, we will be able to deploy:

- Sensors that measure a number of parameters (air and soil temperature and humidity, water levels, weather stations, etc.) with automatic remote recalibration;
- data transmission systems by telephone or radio;
- systems allowing the characterisation of soils in the catchment area in terms of "water retention and circulation" (water retention curves).
- Weather stations

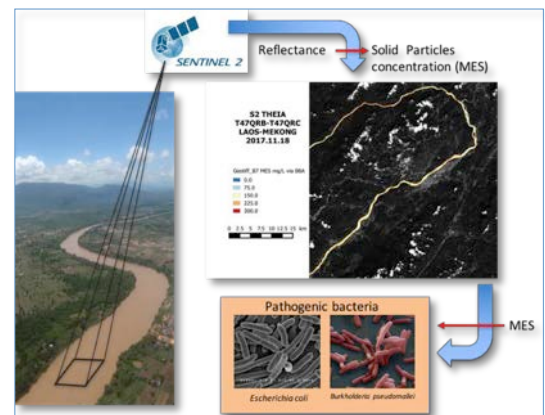
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Such a proposal responds to the need for the Lao PDR to develop the capacity of its academic and technical staff in collecting quality environmental data. Indeed, many of the Lao government's development priorities will increasingly require high quality data, that will form the basis for informed decisions and better negotiating power in the case of projects with transboundary implications.

In addition, this centre and the associated monitoring facilities will contribute to NTPC's specific need to improve the management of its water stocks, in conjunction with other initiatives such as the CNES - SCO Stock Water initiative.



B. CIREN RESEARCH PROJECTS

1. ENVIRONMENTAL HEALTH

1.1 WATER MANAGEMENT

Sensible and fair management of water resources and assessment of water availability for different uses requires a sufficient degree of knowledge and monitoring of the various dimensions related to these resources, including but not restricted to physical aspects. In addition to a general knowledge of "universal" mechanisms, there is a need for the characterization and specific knowledge of environments at the scale of the small watersheds/villages, hence the difficulty in immediately tackling a large number of villages.

Yet implementing a network for timely, good-quality, and publicly available data on water quantity and quality within the framework of the "watershed management" project, while highly desirable, requires the implementation of successive stages. First, a pilot project including a limited number of villages could be defined to assess the feasibility of such a water management system within the context of the NNP. The information provided by this pilot stage and the data collected can be used in some complementary aspects related to the conflicts resulting from competitive uses of soil and water resources.



The pilot, the aim of which is to define sustainable management options, justifies the deployment of a "sustainability science" approach, i.e. one that is interdisciplinary and integrated. As such, it could be defined based on a first scoping study that will consist in characterizing the selected catchments using existing data on static environmental parameters (e.g. geomorphology, land use, presence of other water bodies (lakes, reservoirs, wetlands, soils, geology) and dynamic environmental parameters (e.g. river discharges, climate, vegetation cover density) as well as social, economic and cultural information on villages.

In this respect, a study of the characteristics of the village populations and their living conditions will be carried out: demography, economic and social transformations (from their resettlement to the present day). Furthermore, we will document changing lifestyles as well as monitoring and helping the local population's living conditions, i.e. we will conduct tangible and intangible spatial organisation of living spaces.

The exploratory study will allow us to select the location of the soil and water management pilot project. The aims of the pilot study are, on the one hand, to monitor the basic parameters related to the ground and surface water and, on the other hand, to monitor land use and any other villagers' activities that involve soil and water use. In areas where dependence upon ground and surface water is high, such insight is essential to inform decisions regarding resource use in order to ultimately achieve food security and to develop scientifically-founded courses of action for managing the resource base. This should ideally be conducted using conventional monitoring systems involving the use of piezometers, gauging stations, and sampling for water quality indicator assessment (turbidity, suspended sediment loads, faecal indicators of bacteria loads, etc.).

Objectives

To complement the information provided by such a conventional monitoring network, a spatially denser citizen science network aiming at collecting relevant environmental observations could also be established on farms scattered in different areas, on a voluntary basis. The idea of such an approach would be to cover long stretches of the landscape / hydrological network. The principle of the citizen science approach is to create a community of participants who are also local land and water users. Low-cost data recording units (calibrated using our scientific instruments and connected to a remote database) will be provided to people who will also participate in documenting key visible indicators such as ground water levels in wells, stream levels, vegetation status, weather events, etc. at various locations in the landscape where they conduct their activity. The data sent to the database will be analysed in real time and sent to farmers as visual information that can be used as a daily decision-making support. Such a citizen science network, which will extend the pilot project described above, can vastly increase the number of monitored locations within watersheds and provide information on how climate, land and water use, and other factors, affect stream flow, ground water, and surface water quality. We also acknowledge that, to maximize its potential impact and scalability, such a project should not only include a broad-base capacity building component in environmental monitoring, but also a component dedicated to adaptive responses to land and water management issues. In this perspective the project could attempt to promote the use of climate-smart agro-ecological practices that show potential for more sustainable use of land and water resources while ensuring food-security.

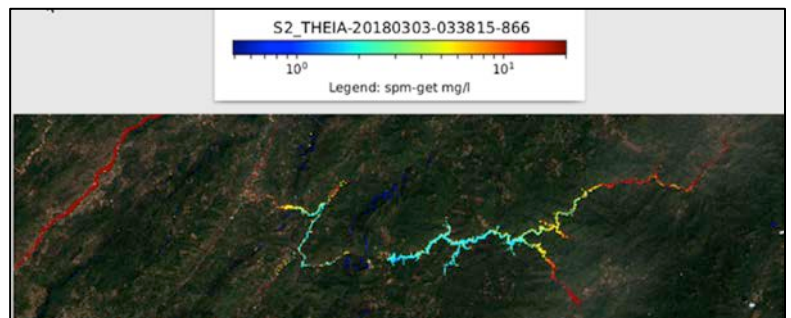
Using remote sensing imagery offers perspectives to grasp the wide-scale impact of land use and land use change on land resources, without the difficulties of accessing remote sites for measurements. The IRD team in Laos has developed, in collaboration with GET researchers (Toulouse, France), a methodology to establish statistical relationships (following calibration/validation) between remote sensing information (e.g. reflectance) and hydrological parameters such as suspended particle loads, water turbidity, sediment flux or bacterial coliform loads. Together with vegetation indices, such near-real time information could be used to relate broad scale land use to land degradation and therefore assist the decision-making process with extremely cost-effective information. It must also be noted that coupling such remotely sensed information with physics-based rainfall-runoff models such as SWAT would also allow to test land use and land management scenarios. In addition, conceptual models would be of value to validate hypotheses concerning the impact of land use changes on soil and water resources, providing hydrological and land cover data availability.

1.2 HYDROLOGICAL FUNCTIONING AND ASSOCIATED BEHAVIOUR OF IRON AT GROUND LEVEL IN THE AREA OF WATER LEVEL DECLINE OF THE NAM THEUN II RESERVOIR

During the impounding of the Nam Theun II hydroelectric dam reservoir in Laos, heavy precipitation of iron oxyhydroxides appeared on the surface of the temporarily submerged areas and in the turbine system, causing malfunctions. The project aims to document the hydrological and biogeochemical functioning of the tidal zones of reservoirs in tropical areas in order to better anticipate the environmental effects of the strong mobilization of iron and associated elements in this context.

Objectives

- Characterise and quantify different water pathways (runoff, hypodermic circulation, flooding, free surface) and their impacts on soil compositions;
- Access the redox process controlling the behaviour of iron, manganese, arsenic, and organic matter on the hydrological cycle;
- Identify the parameters managing the redistribution and solubility of these elements in the coastal soils of the reservoir.



1.3 INNOVATIVE SENSORS FOR TROPICAL ENVIRONMENTS

In the context of Global Change, stakeholders urgently need quality data to support their decision-making to assess environmental changes. To get accurate quantification of continuous (but generally small and slow) environmental changes, researchers need to collect data at a high frequency and/or simultaneously in many places. This need can be addressed through the development of (i) low-cost sensors, (ii) radio and internet transmissions even in remote areas, and (ii) cheap computers, using free statistical software able to store and process the large amount of data collected.

IRD set up the 'CAPTIVANT' project in 2018, originally based in the Lao PDR with MounoyDev as the start-up partner, with the objective of implementing a network of connected sensors providing data to researchers and information to stakeholders. One recent application of the 'CAPTIVANT' technology has been to assist with the implementation of agro-ecological practices that have a significant impact on soil biological activity and soil structure (i.e. water storage, root development, etc.). Innovative sensors are used to monitor environmental conditions during the compost process (on both real farms and under experimental conditions) in order to control the quality of the final product. 'CAPTIVANT' also includes a capacity-building component that focuses on training local stakeholders to build low-cost data loggers based on ARDUINO technology, set up networks of data loggers that can be remotely accessed and controlled, and manage data to provide readily accessible information to final users.



1.4 ROLE OF RIVER - WATER TABLE INTERACTIONS IN THE DISSEMINATION OF BACTERIAL PATHOGENS IN HUMID TROPICAL ENVIRONMENTS

Waterborne diseases pose a major public health problem in the intertropical belt. They are caused by bacteria, viruses, or protozoa. Among pathogenic bacteria, faecal bacteria of animal or human origin are responsible for diarrhoea. Their presence and destination in the environment depend on biotic and abiotic factors such as land use, soil type, and hydro-climatic factors. To date, data on the dynamic in space and time of faecal bacteria at the scale of tropical watersheds remain scarce.

In the mountainous region of northern Laos, we measured high concentrations of the faecal contamination indicator *Escherichia coli* in surface water, corresponding to 1000 MPN 100 mL⁻¹ during inter-flood periods, and up to 100,000 MPN 100 mL⁻¹. In the small Houay Pano catchment (0.6 km²) we have shown that the water tables participate in the flow of the stream by 80% on average during floods (100% during inter-floods). During periods of low water, high concentrations of *E. coli* in the stream suggest that the sediments act as a reservoir for *E. coli* and that the underground flow passing through this reservoir (lateral flow transient storage in the hyporheic zone) contributes to microbial dissemination. Consequently, the objective of this project is to understand and model the role of underground flows in the dissemination of *E. coli* using a multi-scale approach within a network of rivers in Laos (Mekong River and tributaries).



1.5 BOTANICAL SURVEY

The Indochinese Continental Region is a biodiversity hotspot but studies of its biodiversity are still very fragmentary, especially in the botanical domain. Many monocot plant families have not been studied for a century since they were first described in the *Flore générale de l'Indo-Chine* published in 1907. They play a very important role in the socio-economy of the population.

Nakai - Nam Theun's (NNT's) forest cover is extensive. Primary forest, or at least forest of outstanding quality and which most observers would characterize as 'pristine', covers most of the reserve. However, the vegetation of NNT is poorly known by scientists. There's been only a few superficial botanical studies of the area since 1995 (the work in Laos of the renowned French botanist J.E. Vidal in the middle 20th century apparently did not include sampling from the area of NNT). Among these studies, one focused on general habitat structure, two focused on tree composition on the Nakai Plateau, and three collected information from villagers on their use of non-timber forest products (NTFPs). Despite a paucity of systematic identification of the vegetation of NNT, its forests are known to be species rich, a consequence in part of its strong gradients of elevation and microclimate (and possibly soil). For example, residents of just one village in NNT (Ban Navang) named 466 local plant NTFPs they use for food, construction material, medicine, trade, and other purposes. This is more than the total local species named by 28 villages elsewhere in Laos (Foppes, 2001). The reserve undoubtedly holds undescribed species of vascular plants, and perhaps some undescribed genera. Summary reports of general biodiversity and ecological surveys of the area contain broad habitat descriptions.



In general, NNT is dominated by extensive and dense evergreen and semi-evergreen broadleaf forest and, as noted earlier, it contains forests of the highest quality and conservation importance in existing or proposed protected areas in Laos. In fact, NNT NPA may be the highest quality evergreen/semi-evergreen forest block in Laos, Vietnam, Yunnan (China) or Thailand. The predominant forest type in NNT is tropical dry evergreen/semi-evergreen forest, which transitions in some areas to mixed deciduous forest. These forest types are also found in regenerating secondary formations, most commonly near villages. Secondary habitats are most likely the consequence of the abandonment of a burn field, and probably often form part of a conscious rotational strategy adopted by villagers, wherein the regenerating forest is left to draw nutrients back to the surface for several years or even a few decades, then is cut and burned again. There are also areas of mixed broadleaf/pine forest and, at higher elevations, fagaceous and ericaceous cloud forests. Finally, NNT has two forest types of elevated conservation significance:

Wet evergreen forest: This occurs at mid-elevation (roughly 500 - 900 m) near the Vietnam border, where winter monsoon precipitations penetrate the protected area, as described earlier. Annual precipitation possibly reaches 3,000 mm, with only 1-3 months of dry season, and the air temperature is markedly lower than elsewhere in the protected area. This may be the preferred habitat of rare species such as the Saola and Annamite Striped Rabbit (*Nesolagus timminsi*). Plant endemism is expected to be high, and wet evergreen forest is the most globally significant terrestrial habitat not only in NNT, but in Laos as a whole.

Cypress forest: The conifer *Fokienia hodginsii* (Dunn) A. Henry & H. H. Thomas (Cupressaceae) occurs uncommonly on dry ridges above 1000 m. Trees can grow probably up to 40 m tall and 2 m diameter. Where *F. hodginsii* occurs it usually comprises 5-30% of the canopy and may occur in mixed associations with oaks (Fagaceae). Stands are found in at least the upper Nam Xot and Nam Theun watersheds and below the summit of the Phou Vang massif. It is an exceptionally valuable timber, and the species has been assessed as Near Threatened by IUCN. Non-forest habitats include extensive areas of brush, bamboo stands, a few small areas (the largest about 25 ha) of natural, level grassland, and minor areas of hillside Imperata grass. *Imperata cylindrica* (L.) Raeusch. (Poaceae) characteristically establishes after repeated burning and cultivating of hillsides, when nutrient exhaustion of the soil impedes regeneration of the forest. This formation is much more common in northern Laos than in NNT. ***Glyptostrobus***



pensilis (Staunton ex D. Don) K. Koch, the Asian Swamp Cypress, is classified as Critically Endangered by the IUCN Red List of Threatened Species. It is a conifer native to China, Vietnam and the Lao PDR but most of its current global population has been extirpated. Only fewer than 200 trees (which do not produce viable seeds) remain in semi-natural settings in Vietnam. The largest and only known old growth population anywhere in the world is found in Laos within the Nakai Nam Theun National Park, with about 400 trees documented. This makes the national park a priority for the global conservation of this species. However, between 2008 and 2016, already approximately 62% of the old growth trees (estimated to be between 500 and 1000 years old) documented in the Nakai – Nam Theun catchment have already been lost: in 2008, the reservoir inundated over 400 trees and in 2016, 200 were logged for the timber trade. It is imperative for the global conservation of this species to implement a restoration program.

Objectives

- Botanical and systematic studies;
- Reporting the distribution of each species;
- Species checklist and database;
- Ethnobotanical study;
- Reporting the conservation status according to IUCN criteria



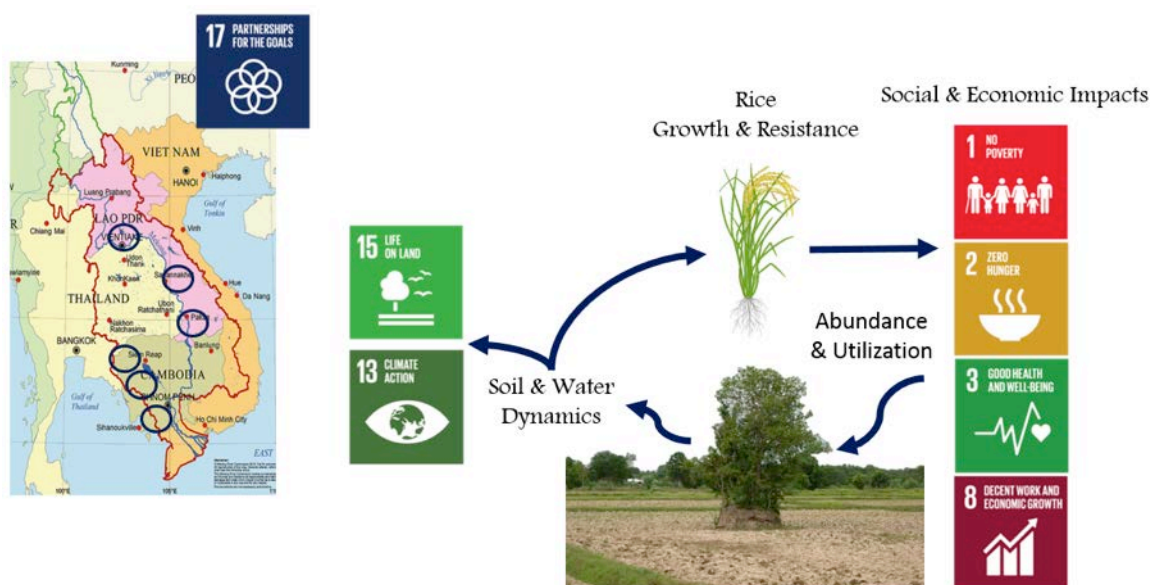
1.6 IMPACT OF TERMITE MOUNDS ON THE MEKONG BASIN AGROECOSYSTEM

Up to now, the influence of heterogeneity induced by biodiversity on the multi-functionality of agro-ecosystems and their resistance to vulnerability and environmental hazards (e.g., drought and pests) has received little attention worldwide and remains totally unknown in Laos. This project is based on previous studies where we showed that termite mounds (TM) contribute to the redistribution of water and nutrients in ecosystems, including C and Si (silicon), and that they can potentially provide numerous ecosystem services to farmers. However, these services have never been quantified. They also show that these mounds are very abundant in protected environments (>10 ha⁻¹) but the clearing of forest and intensification of agricultural practices leads to their disappearance and to the loss of the services they provide to the community. Therefore, in line with the 2030 agenda for biodiversity and ES, this project aims to provide a better understanding of the interdependence between biodiversity and human health. We hypothesize that a better understanding of the effects of these mounds on ecosystem functioning will contribute to the emergence of sustainable, multifunctional, and ecological agricultural practices in the region.

Objectives

- Qualify and quantify the ecological functions impacted by TM in terms of soil and water dynamic, C sequestration, nutrient cycling, and plant resistance to environmental hazards and yields;
- Assess the use of TM by farmers and the ES derived from their presences, in terms of incomes, food security, and access to health;
- Contribute to the emergence of sustainable agricultural practices considering the environmental, social, cultural, and economic impacts of TM.

This project aims to generate major breakthroughs in the qualification and quantification of ES provided by biodiversity in agro-ecosystems, a process always suggested but rarely quantified. For this purpose, a multidisciplinary approach will be adopted to characterize and quantify the ecological, environmental, and socioeconomic processes impacted by termite mounds, in adequacy with 6 of the 17 Sustainable Development Goals (SDGs n°1 “no poverty”, 2 “zero hunger”, 3 “good health”, 8 “economic growth”, 13 “climate action” and 15 “life on land”).



1.7 ADAPTATION OF CASSAVA PRODUCTION BASED FARMING SYSTEMS TO GREEN INNOVATION AGRICULTURAL PRACTICES

The cultivation of cassava to support factories in Saravanh and Champasak provinces, in the southern part of Laos, is an alternative commodity for farmer income. The arable area is increasing year by year, according to agricultural statistics. In 2014, Saravanh province had a total area of 19,000 hectares, with an average yield of 23.6 tons/hectare and Champasack province had a total area of 2,300 hectares, with an average yield of 25 tons/hectare. Agricultural statistics in 2018 showed that the area increased to 21,400 hectares in Saravanh Province and 16,500 hectares in Champasack Province. Cassava production has both positive and negative effects. The positive effect is that the family economy is in line with government policy, but the negative effect is soil degradation. Farmers grow cassava in the same area continuously without soil improvement for 3-4 years, causing the soil to deteriorate and obliging the farmers to move to new areas. The movement from old areas to other areas has become a burden for the government because some farmers have encroached on a large number of state-protected forest areas. Continuing to grow cassava in the same area without soil improvement

techniques will definitely degrade the soil. Some authors reported that wet yield of 35.7 t/ha, sorted 55 kg N/ha, 13.2 kg P/ha, and 112 kg K/ha. Farmers are well-aware that continuous cultivation of cassava is the cause of soil degradation, but they lack knowledge and experience in soil improvement, fertilizer management, and crop management. Soil improvement techniques and land development have not yet reached farmers in these areas. Additionally, the Department of Agricultural Land Management (DALaM) holds insufficient research data on this issue.

In order to produce 1.5 million tons of cassava per year from 2025-2030, and to generate an income for agricultural families in line with the government's poverty reduction plan, and to ensure stable and sustainable production, there is a need to conduct a field trial for soil improvement for cassava production in Laos. The result of the experiment will provide great benefits to the government and farmers. It is also important for the agricultural sector to extend and to encourage farmers to produce cassava for sale, both domestically and internationally. This research will be conducted in cooperation with IRD staff and the relevant Provincial Agriculture and Forestry Offices, especially the sections of Agricultural Land Management, which will assist in the implementation and follow up of the experimental plots, data collection, and local coordination.

1.8 IMPROVE SOIL FERTILITY BY USING VERMICOMPOST IN VEGETABLE GARDENS

The Lao government has set up a strategy for food security (both quality and quantity), aimed at securing sufficient food for consumption, the production of agricultural products for export, and the generation of income to lift farmers out of poverty by 2020.

Nowadays, the consumption of organic vegetables is gaining popularity and the market for green vegetables is in high demand. However, the production of the organic vegetables is still insufficient to meet the needs of society. At present, the public and private sectors have provided support for the production of organic vegetables by setting up small organic vegetable production groups. However, the groups' output has not met the standards of organic vegetable production due to insufficient production factors. Soil is considered to be the main factor for plant growth because it is a source of plant nutrients.

Vermicompost is the product of a decomposition process using various species of earthworms in which the resulting compost consists of plant nutrients in a form that the plant can absorb. A study showed that the amount of plant nutrients N, P, K, Ca, Mg and B in vermicompost differs depending on the material used. The vermicompost has the property of raising the pH level (Anat, 2007). It also contains humic acid, a component that affects plant growth. Due to its similar properties to the plant hormone auxin, humic acid acts as a storehouse of nutrients in humic molecules and is slowly released into a beneficial form of plants. The amount of plant nutrients, organic matter and organic carbon in the vermicompost is higher than that of natural manure and compost.



Objective

To help farmers learn about vermicompost production for soil fertility improvement.

Activities:

- 1) Data collection and selection of model farmers;
- 2) Technical training for farmers;
- 3) Setup farmer models for demonstration;
- 4) Monitoring the use of vermicompost in vegetables plots.

1.9 ADVISE THE NAKAI - NAM THEUN NATIONAL PARK IN LAW ENFORCEMENT STRATEGY.

Objective

In the past few decades, illegal poaching in the Nakai-Nam Theun National Park has led to a decline in biodiversity and to local species extinction, including several globally threatened and endemic species. In order to conserve the current remaining populations of threatened species in the area and allow animal populations to recover from past hunting pressure, it is imperative that comprehensive anti-poaching patrol system is put in place over the long-term. To do so, site prioritization is essential. Three Biodiversity Priority Zones have been identified in terms of their qualitative and quantitative biodiversity value. We propose to collaborate with current law enforcement technical teams and authorities to advise on best-practice law enforcement strategies.

Objectives:

- Support local communities in implementing innovative and sustainable approaches to bring alternative incomes;
- Preserve local traditional craftsmanship and cultural integrity;
- Reduce reliance on natural resources in Nakai - Nam Theun National Park to contribute to biodiversity conservation in the region.

Local communities in Nakai District are (1) highly reliant on natural resources for their livelihoods; (2) their food security often is dependent on foods collected in the wild; (3) their income generation is often dependent on the unsustainable harvest of natural resources; (4) they often practice unsustainable agriculture; and (5) they lack entrepreneurship capacity and technical capacity. This project aims to address some of these issues to provide alternative income to local communities.



2. ANIMAL HEALTH

2.1 Long-term wildlife monitoring program as part of the Nakai – Nam Theun National Park management plan Objective

To estimate trends in animal populations (monitoring) over time and across the landscape as part of management plans.

The Nakai – Nam Theun National Park is divided into management zones including three Biodiversity Priority Zones (BPZs) delineated based on their conservation importance at the national and/or global levels and past (and current) threat analysis. Any conservation management plan requires appropriate methods to assess its effectiveness to protect wildlife populations and ecosystems in the long-term. Monitoring wildlife populations using automated camera-traps placed in the forest is one of these methods, which we apply in Nakai – Nam Theun National Park in the BPZs. The science-based survey design applied allows the estimation of the population abundance index over time and landscape. When surveys are replicated systematically at regular time intervals (e.g. every two-three years), we can obtain trends in the abundance of wildlife species and their distribution across the national park: this facilitates an assessment of whether some wildlife populations are increasing, decreasing or remaining stable as a result of management interventions (e.g. law enforcement, community sustainable livelihood for conservation, outreach). The survey design for the camera-trapping implemented in Nakai – Nam Theun National Park follows the rationale and protocols developed by the Biodiversity Dynamic research Team at the Leibniz Institute for Zoo and Wildlife Research (IZW).



2.2 Survey and monitoring the population of the Asian Elephant (*Elephas maximus*) on the Nakai Plateau

The Asian Elephant is classified as Endangered by the IUCN Red List of Threatened Species. In Laos, the elephant population status remains little known and studied. Patchy populations have been reported across the country, one of them located in Khammouan Province (in and around the Nakai – Nam Theun National Park). Since the impounding of the Nakai Reservoir, wild elephants have moved closer to villages and there has been evidence of human-elephant conflicts. This, in turn, is leading to an increasing exposure of pathogens because, as other animals, elephants are susceptible to pathogens infecting humans. The aim of this study is to determine the size of the elephant population in the Nakai plateau, their health status, and to collect ecological (floristic, faunal) data on their environment. Genetics and metabolomics data will be combined to other ecotypic and phenotypic traits to understand and provide a comprehensive population dynamic model. The use of forefront holistic approaches should provide an unprecedented overview of Asian Elephant behaviour on the Nakai Plateau. This study will allow the design of a long-term conservation action plan in the area.



Objectives

- Provide an estimate of the current population size of the Asian Elephant on the Nakai Plateau by leading a non-invasive genetic sampling survey;
- Record the current status of their genetic diversity;
- Provide an indication of the health status of these elephants;
- Determine the floristic environment of these elephants through comprehensive sampling combined to LC-MS based chemotaxonomy;
- Determine and correlate the diet and health status of wild and domestic elephants by crossed metagenomics and metabolomics approaches and machine-learning based models;
- Establish a protocol for the long-term monitoring of the elephant population in Nakai;
- Develop an Elephant Conservation Action Plan for Nakai based on the results obtained.

2.3 Soil-transmitted helminths infections at the human – non-human primate interface

Emerging zoonotic diseases are a serious threat to public health and to animal conservation. This is especially true for non-human primates, whose close phylogenetic relationship with humans increases the risk of zoonotic transmission. Humans have always shared habitats with non-human primates (NHP), but the dynamics of their relationships have changed. Like many NHP, elephants are also threatened by forest loss and fragmentation and, unless severely hunted, an increasing number of them live in anthropogenically disturbed

habitats such as farmlands, human settlements, fragments of forest, and isolated protected areas. As a consequence, people, NHP and elephants live in increasing spatial proximity to each other. So far, several cases of pathogen transmission have been reported between human and NHP, including intestinal parasites. Because soil-transmitted helminth (STH) infections occur through ingestion/skin penetration of the infective third-stage larvae or eggs present in water, food or soil, helminthiasis are a potential zoonotic risk when humans and other animals share the same habitats. Approximately 1.5 billion people worldwide are infected with STH, especially where access to water, sanitation, and hygiene is poor. The pathology of STH infections in humans includes anaemia, growth retardation, and delayed cognitive development. Information on STH prevalence and diversity in SEA NHP is scarce, and geographically heterogeneous.

Objectives

- **Determine and compare the prevalence, intensity of infection, and genetic diversity of Soil-Transmitted Helminths infecting NHP living in pristine and fragmented/disturbed forests**

The goal of this task will be to track the evidence of STH infections across different NHP species and to identify which parameters have contributed to the evolution of the epidemiology of STH infection in the NHP under study, in order to answer the following questions:

- Is there any variation in STH genetic diversity, prevalence, or intensity of infection among different NHPs, and if so, what are the causes of these variations?
- Is there any evidence of parasite sharing among NHP species?
- Does anthropogenic disturbance affect the species richness, prevalence, intensity of infection, and the distribution of STHs infecting NHP hosts?

- **Determine the genetic diversity of the STHs infecting the human population living in proximity or far away from NHP populations**

The goal of this task is to evaluate whether there is an ongoing risk of cross-species transmission of STHs between humans and NHP and whether proximity with a sylvatic STH reservoir increases or decreases this risk, and to answer the following question:

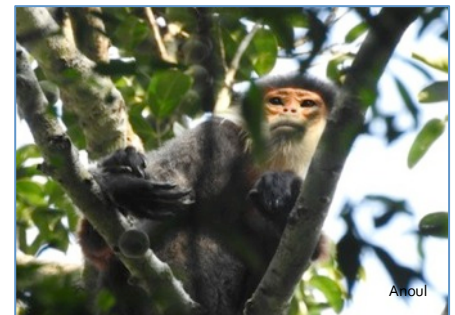
- Is there any evidence of parasite sharing between humans and NHPs, and if so, are there fewer zoonotic infections or possible divergence of STHs in human hosts with reduced opportunities for sharing with NHPs?

2.4 White-cheeked Gibbon (*Nomascus siki*/*N. leucogenys*) distribution

Objective

Investigate the distribution of white-cheeked gibbons (*Nomascus siki* and *N. leucogenys*) in the Nakai National Park.

The current taxonomic status and distribution range of the population of gibbons occurring in Nakai – Nam Theun remains uncertain. It may hold the Northern and Southern white-cheeked gibbon and/or a hybrid population. To better plan conservation actions for these species, it is crucial to know their distribution across the landscape. Because gibbon vocalizations are species-specific, our partners are recording gibbon calls in several sites in the Nakai – Nam Theun National Park and are also collecting additional gibbon call recordings from several other sites in the Annamite Mountains of Laos.



2.5 Developing innovative and cutting-edge technology to monitor gibbon populations

Objective

Produce an automated recording device to monitor gibbon populations as part of their global conservation management.

Gibbons are some of the most threatened primates in the world, due to habitat loss, illegal pet trade, and hunting for food and traditional medicine. All twenty species of gibbons are threatened with extinction on the IUCN Red List of Threatened Species: five are Critically Endangered, fourteen are Endangered, and one is Vulnerable. Effective conservation measures and actions to mitigate threats to gibbon populations require accurate and precise estimates of their abundance, distribution, and population trends. However, reliable survey methods are lacking.

Nakai – Nam Theun holds one of the largest populations of white-cheeked gibbons, but their population is rapidly decreasing. Given their current conservation status, it is crucial to take appropriate actions to protect this species, with site prioritization. However, there are still large gaps in our knowledge regarding the distribution and conservation status of populations in sites where they persist. Acoustic surveys are the most applicable method for gibbons, as they produce territorial calls that can be heard from large distances. Acoustic survey methods (with human detectors) have commonly been used to survey gibbons but there is subjectivity in the data from these surveys as they require surveyors to estimate gibbon locations without ever seeing them, resulting in

unreliable abundance estimates. There is also no existing standardized survey protocol and/or analysis method, which prevents long-term population monitoring across time and space. This project aims to produce affordable, easily deployable acoustic recorders that generate data designed for use with cutting-edge statistical abundance estimation methods, to estimate gibbon abundance.

2.6 Participatory Biological Research, Threat Analysis, and Conservation Activities for Endangered *Luciocyprinus striolatus* in the Nakai – Nam Theun National Park

Objective: Conduct a full assessment of the threats to *Luciocyprinus striolatus* in the Nakai – Nam Theun National Park and collect data on the species' current distribution, abundance, lifecycle, habitat requirements, feeding behaviour, seasonal patterns, and migrations, in order to implement holistic meaningful conservation measures for the species.

Luciocyprinus striolatus (Local names: *pa khouan-sai*, *pa kang*, *pa sak*) is a species of endangered cyprinid native to parts of Laos and China that can reach sizes of up to 2.0 metres (6.6 ft). Although very little research has been done on the species and it is listed as Endangered on the IUCN Red List of Threatened Species, it is increasingly being targeted by visiting anglers who consistently report catches of the popular game fish. The predatory fish species is known to inhabit rocky streams with fast flowing water and to shelter in large deep pools, especially during the dry season. The abundance of the species is thought to be rapidly declining due to various impacts from human activities including deforestation, infrastructure and hydropower development, low water levels, the use of destructive fishing gear, and climate change. The species is believed to be already extinct in China, which makes Laos the only country able to protect the species. However, the distribution in Laos remains little known, as do the threats it faces where the species has been confirmed. There are currently only two locations in the country where the species has been recorded: Nam Pak river, a tributary of the Nam Ou river in Oudomxay Province, northern Laos; and Nam Kading/Nam Theun river, a tributary of the Mekong river, in Khammouan Province, central Laos.

2.7 Otter surveys and species identification

Objectives:

- To identify species and population-level genetic diversity of otter species in the Nakai – Nam Theun National Park;
- To investigate the evolutionary relationships of otter species within the *Mustelidae* family;
- To determine sex-ratios based on molecular sexing of otter species;
- To investigate levels and patterns of recent gene flow levels among nearby populations based on microsatellite markers to monitor impacts of human disturbance on population dynamics and long-term survival;
- To use these data to develop follow up projects for the conservation and ecological study of otter species in Southeast Asia.

The distribution of Asian-ranged otter species remains very little known. In Laos, three species have been confirmed to occur: Asian Small-clawed Otter *Aonyx cinereus*, Smooth-coated Otter *Lutrogale perspicillata* and Eurasian Otter *Lutra lutra*. Given the global conservation status of these three species – with declining populations throughout their range due to a continuous loss of habitat, decreasing numbers of their prey, and hunting for the pet trade and pelt trade – information is urgently needed on their distribution, habitat use, and local threats in order to adopt species-specific and site-based management and conservation strategies. Nakai – Nam Theun National Park is of regional importance for otter conservation.

2.8 Biodiversity and conservation of beetles in a global change context

Laos is host to a wide diversity of insect species, among them many remain undescribed and their conservation status unknown. Beetles (Coleoptera) are the most diverse insect group, representing 25% of all described animal species globally. As such, describing their diversity and the threats they may face in biodiversity hotspots is of crucial importance. In a context where climate and land use change are strong driving forces of biodiversity decline, a better knowledge of beetles' ecology with regard to climate and habitat use, as well as robust scenarios of future climate regimes and human practices are essential to anticipate the fate of Coleoptera diversity in a changing world.

Objectives:

- To carry out surveys of Coleoptera species to gain basic knowledge of species diversity and ecology
- To map the diversity of Coleoptera with regard to various facets of biodiversity (taxonomic, functional and phylogenetic) at different spatial scales, using direct surveys and ecological models based on large scale data (climate, remote sensing, etc.)
- To produce scenarios of Coleoptera biodiversity change by coupling field data and ecological knowledge with projections of future climate and land use

2.9 Other wildlife surveys and ecological research for little-studied species groups

Objective

Conduct scientific surveys and ecological research on little known species groups to improve scientific knowledge and raise the profile of the Nakai – Nam Theun National Park as a global biodiversity hotspot.

We will conduct targeted surveys and ecological research on several other species and species groups that are little known or have not been well surveyed in Nakai – Nam Theun National Park and are of global importance for biodiversity conservation. These include birds, reptiles, amphibians, and fish. These surveys and ecological research will adopt several cutting-edge field methodologies (e.g. foot surveys, acoustic surveys, camera-traps, drones, remote sensing, radio-tracking, environmental DNA, non-invasive molecular DNA sampling etc.).



Photo N. Maury

Indicators of ecosystem health

With a high level of biodiversity, the Lao PDR has some of the most significant forest areas remaining in Southeast Asia. However, the combined loss of forest cover (estimated at nearly 55 percent) and over-exploitation of many species threatens much of Laos's wildlife. Some of these species are classified as "indicator species".

An indicator species is an organism whose presence, absence or abundance reflects a specific environmental condition. Indicator species can signal a change in the biological condition of a particular ecosystem, and thus may be used to diagnose the health of the system.

Amphibians (frogs, toads, salamanders) are considered as indicator species because they are the first to be affected by degradation of the environment. They are extremely sensitive to changes in the environment and can give valuable insight into how an ecosystem is functioning. It is claimed that more than 500 amphibian species have experienced population decline worldwide in the last 50 years, and 90 of them have gone extinct. Laos is a hotspot of amphibian and reptile biodiversity, and these animals are themselves home to a wide range of parasites.

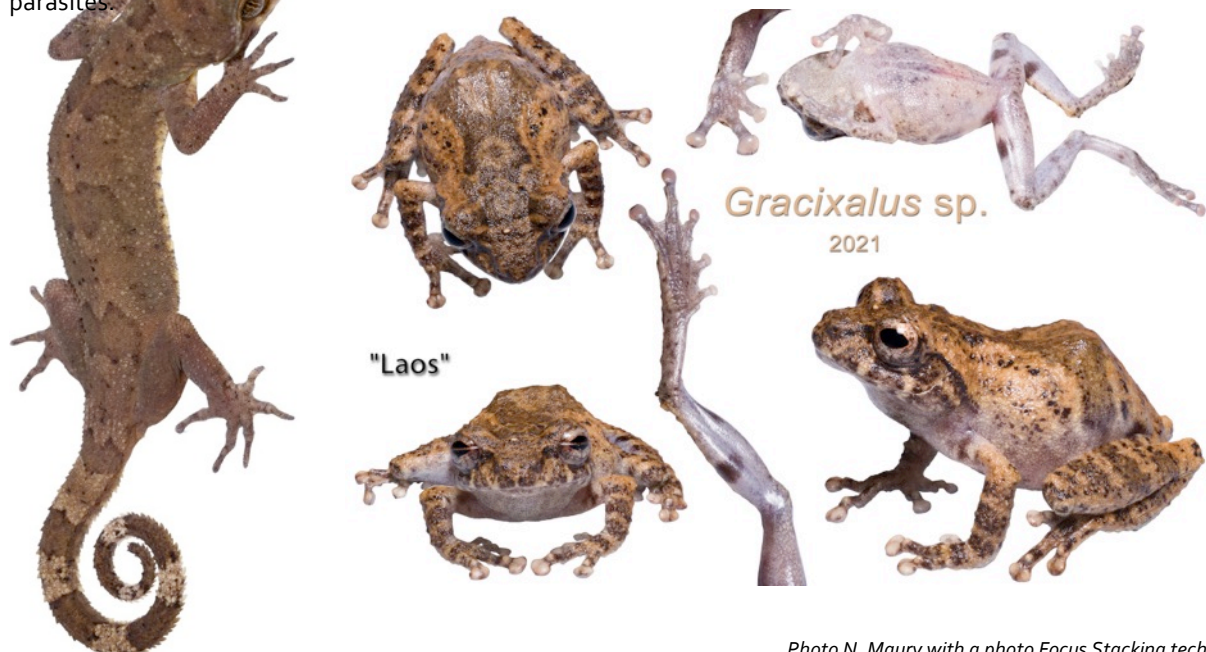


Photo N. Maury with a photo Focus Stacking technique

3. HUMAN HEALTH

3.1 Conduct socio-cultural and socio-economic research on the hunting practices of communities within the Nakai – Nam Theun National Park

Objective

Understand the socio-cultural and socio-economic drivers of hunting practices and hunting techniques used by communities in the Nakai – Nam Theun National Park and their impact on species populations and conservation.

3.2 Melioidosis

Water-related diseases are a major public health problem as well as an obstacle to development in tropical countries. *Burkholderia pseudomallei*, is an endemic environmental pathogen in soil and water in Southeast Asia. This bacterium is responsible for melioidosis, a particularly serious disease, which mortality rate varies between 20 and 50%. The acute form of the infection typically presents as pneumonia with symptoms of fever, cough, chest pain, difficulty breathing, and lack of appetite. If the infection reaches the bloodstream, symptoms include fever, headache, muscle and joint pain, disorientation, and shock. Localized skin infection symptoms include fever, skin ulcers, and abscesses in organs such as the spleen and prostate. Melioidosis can be fatal if not treated promptly. The environmental distribution of this pathogen and the burden of melioidosis remain poorly understood. Knowledge about its environmental distribution is important to our understanding of its ecology and epidemiology and to enable public health interventions.



Objective

Understanding of transmission routes is required to prevent and control the infection in humans. For this purpose, we propose to set up a multi-disciplinary program involving clinicians, clinical microbiologists, hydrologists, microbial ecologists, soil scientists, microbiologists, statisticians, and specialists in remote sensing and GIS.

3.3 Nutrition

3.31 External food environments

External food environments (EFEs) characterised by the diversity of outlets, products, their quality, convenience, and prices, have been recognised as important determinants of the dietary choices and nutritional outcomes in Low- and Middle-Income Countries (LMICs). There is considerable research interest in the mapping of EFEs using geospatial methods and to understand their influence on diets and nutritional outcomes. In rural and urban settings in LMICs, it is the interaction of households with the EFE that shapes food acquisition, consumption patterns and nutritional outcomes. Using the concept of “activity spaces”, we will develop an index of household exclusion from EFE. An innovative feature of this project will be the robust mapping of the activity spaces of individuals using wearable accelerometers and GPS devices and linking these activity spaces to food acquisition behaviour within their EFE. The community-level EFE will also be mapped by identifying all elements of the EFE that are relevant to the respondent households. The activity spaces that households occupy in relation to the EFE may be constrained by their socio-demographic characteristics, endowments, food preferences, social and cultural norms, but also the dynamics of their physical environment. The mapping of activity spaces will also capture their variation over seasons and by gender. The index of household exclusion from EFE derived from the analysis of activity spaces will be linked to nutritional outcomes by collection of dietary intake data from the same respondents whose activity spaces are mapped.

Objective

The main contribution of the index of household exclusion will be to provide a pathway from the community level EFE to the observed dietary patterns of households; to assess how households interact with their external food environment (EFE); the extent to which they participate in, or are excluded from, their EFE; and how

socio-ecological changes influence these interactions. In the context of rapid ecosystem and livelihood change, this programme of work will therefore enable us to understand nutritional behaviour, outcomes, and vulnerabilities among Lao communities. Identifying the determinants or factors that shape households' interaction with the EFE can provide insights to policy makers for shaping the development and regulation of EFEs to mitigate access constraints and promote healthier diets.

3.32 Sustainable diets, especially animal-source foods, for optimal nutrition and health of vulnerable populations.

Despite huge economic progress in the last decades, malnutrition remains highly prevalent in Laos and other countries in Southeast Asia, especially among vulnerable groups such as young children and pregnant and lactating women. Optimal nutrition is fundamental for the development of individuals and societies, and for the prevention of the double and triple burden of malnutrition in LMICs. Micronutrient deficiencies, acute malnutrition and chronic malnutrition, leading to stunting, are often found in the same households and even in the same person. Over the past decade, the political discourse on the challenge of malnutrition has grown considerably at the national and international levels and has led to commitments from governments, international organizations, and donors. One of the major current challenges is to provide people with equitable access to nutritious and sustainable diets that contribute more broadly to development and well-being. Promoting optimal food and nutrition implies guaranteeing access to diversified, healthy, and sustainable diets providing nutrients and bioactive compounds essential at all stages of the life cycle. To be sustainable, this approach implies first relying on local food resources, whatever their origins, i.e. natural and available in the environment, cultivated or purchased, and on their appropriate and fair use within families in order to better understand their role in the nutrition of populations, especially of the most vulnerable such as adolescent girls, women, infants and young children. Agriculture (agroecology) and aquaculture resources are key sectors that support food security, human health, economic growth, and jobs around the world. But these food production systems depend heavily on, and are directly affected by, the on-going climate change, especially in tropical countries where economic development and human health are of great concern.



Objective

Conduct multidisciplinary research and action on sustainable resources used by Lao populations for their food supply, nutrition, and health. Special attention will be given to the most vulnerable populations such as indicated above and to the use of locally produced fish-based products to create a sustainable food system, leading to improved nutritional status and increased revenue for households.

- Determine the nutritional status of children and women of reproductive age in target villages or communities;
- Identify the potential of multiple and integrated solutions and actions to increase access and use of resources contributing to better nutrition (diet diversity, quality, and safety) and health for all households, especially for their most vulnerable members;
- Characterise current uses of fish and develop new, innovative fish-based products to fight malnutrition;
- Determine the impact on the environment of food availability, especially fish production and catch, and create a model of sustainable fish production and use;
- Define the plan of action with priority steps, including potential specific research, to be implemented with the support of communities and policy makers.

This project will develop connections with other projects in nutrition and environment health (EFEs, cricket breeding, termite mounds).

3.33 Cricket breeding

Agriculture and forestry provide the basis for the livelihoods of around 70% of the Lao population. Nowadays, Laos is facing rapid changes driven by deforestation, land erosion, socio-economic context and climate change that jeopardize rural livelihoods in different sectors. Food insecurity is a major contributor to vulnerability, especially for pregnant women and children. Populations that are facing these threads undergo insecure livelihoods, are unable to cover their basic needs and consequently negatively impact the household quality of life, women being the first victims of this vicious cycle. Furthermore, poor villagers turn to illegal activities such as poaching, which is partly responsible for the degradation of biodiversity with the extinction of wildlife species and the emergence of new diseases (i.e. Covid19). The challenge is to adopt new products and production systems that will continue to provide sufficient nutrients and income to reduce the dependence of the ultra-poor on forest resources.

Objective

The aim of this project is first to promote cricket farming to ensure nutritional intake for vulnerable families and also to offer them the opportunity to participate in the production of high added-value compounds. Crickets are known to be a valuable protein source and “easy to grow,” but in fact cricket farming projects in Laos fail after the end of project support. The originality is the extraction of high added-value products. Promoting cricket farming is a strategy to support vulnerable peoples’ livelihoods by improving food security, sustainable agriculture, and biodiversity protection with a gender component by turning cricket farm owners into business managers.

3.4 Traditional medicine

Traditional medicine is closely allied to the principles of One Health, as it emphasises the relationship between human health and environmental concerns and overlaps with areas such as nutrition, plant conservation, and sustainable healthcare. Traditional medicine is promoted in the Lao PDR’s health policy, including as a response to the current COVID-19 outbreak, and is an important part of primary healthcare, especially in rural communities. However, in contemporary Laos, traditional medicine, for the most part, operates outside the formal healthcare context and remains a primarily non-regulated, heterogeneous, and localised set of practices. Laos is highly diverse, with an estimated 8,000-11,000 plant species, but to date only a small amount of research has attempted to map the diversity of medicinal plants in Laos and to identify pharmacologically active plants. Medicinal plant knowledge is being quickly lost in the current era, and documentation of traditional knowledge is urgently needed. Relationships between people, plants and the environment are also strongly implicated in conceptualising medicinal power and potency, and the freshness of plant materials collected by rural healers in Laos is a much-valued quality.

Nakai-Nam Theun National Protected Area is located in one of the most biodiverse regions of Southeast Asia and is one of the identified ‘Key Biodiversity Areas’ within the Indo-Burma biodiversity hotspot. It is a highly ethnically and linguistically diverse area, including Katuic (Brou, Makong), Vietic (Atel, Salang), Hmong, Lao, Saek, Yoy, Phou Thay and Meuay, most of whom are subsistence farmers and rely heavily on local biodiversity for food and medicine. This research will take an ethnopharmacology and anthropology-based approach in order to learn about the traditional medicine practices and medicinal plants collected and cultivated by people within the national park area. In collaboration with the herbarium of the National University of Laos, the Institute of Traditional Medicine and the Faculty of Pharmacy, medicinal plant use will be documented through plant collection, interviews with traditional healers and local people, participant observation, and photo and video recording.

Objectives

- Document the use of traditional medicine among peoples of the area;
- Understand the relevance of traditional medicine within local approaches to healthcare and its potential for sustainability;
- Contribute to anthropological literature on human-environmental interactions, medicinal potency and the association of socio-linguistic diversity and bio-diversity;
- Identify medicinal plant species used, including candidates for further pharmacological research

3.5 Moving beyond gendered environmental health inequities. Participatory approach, multidisciplinary perspectives, Art & science mediations

The aim of this multidisciplinary and participative research is to contribute to a better understanding of the mechanisms underlying gendered environmental health inequities, and to explore the inextricable link between human, animal, and environmental health from an ecofeminist perspective. The ecofeminist framework enables an understanding of the link between the physical and social environments and health inequities mediated by gender and socioeconomic status. It analyzes how gender power relations create inequities in access to resources/health, the distribution of labour and roles, social norms and values, and decision-making. By recognizing that the exploitation of nature and the social institutions of human oppression overlap, ecofeminism expertly analyses the historical, experiential, material, symbolic, and theoretical connections between the twin oppression of women and nature. We wish to analyze these issues in the health domain, in seeking both a deep understanding of the interrelations between the physical environment, oppressive social structures, and women’s concrete, everyday experiences and the creation of spaces for the voices and agency of women and men with different positionalities.

Within this theoretical frame, the main objective is to facilitate on-site ‘conscientisation’ or awareness and to analyze how multiple structural power inequalities shape embodied experience for those oppressed by them, which offers potential for creating change.

Objectives

- Design a participatory / collaborative / action research, based on diversity in its membership, origins, knowledges, methods, and practices, by associating academic and non-academic actors in the co-construction of a joint project;
- Highlight social and cultural dimensions of knowing, and advocate for new perspectives on qualitative observation through the inclusion of marginalized voices and through the use of innovative research methods;
- Reveal the underlying logic that connects environmental exploitation on the one hand and gendered health inequities on the other;
- Through art and science mediation initiatives dedicated to stakeholders and the general public, contribute to promoting a supportive environmental health, particularly for low-income women.

3.6 Education

We will engage in an interdisciplinary and intersectorial study of education, which plays a central role in the Lao national development agenda. In a mixed-method research design, we will examine (1) the pathways from education to health beliefs and practices, (2) the heterogeneous experiences of education and learning in the context of rapid ecosystem and livelihood change, and (3) the wider role of education in influencing the linkages between communities, administration, and nature.

In pursuing this research programme, we will relate to the broader framework of socio-physical activity spaces and consider not only how learning materialises among populations experiencing ecosystem and livelihood changes, but also how education more generally shapes the relationships between individuals, their communities, human services and the government, and the natural space surrounding them. In this framework, local populations may experience ecosystem changes, for instance through a reconfiguration of collaborative relationships also evolving gender relations within communities. Externally induced change may also alter relationships between communities and human services, for instance through displacement and land titles. Ecosystem interventions such as hydropower generation also influence the relationship between populations and the natural space, among others in the way people (and non-human members of the natural space, i.e. animals) can navigate the physical space and how humans value and derive meaning from their environment.

Education is a key element that shapes and is shaped by this socio-physical activity space: We will investigate the consequences of education for the relationship between learners, their communities, human services, and nature (e.g. how learning entails new pathways of relating to and navigating natural space), and conversely, how changes in the activity space (e.g. ecosystem, livelihoods) introduce variability into access to education and the experience of learning. One area of educational impacts that we will focus on is health practices and beliefs. Our premise thereby is that education does not automatically and deterministically shape health-related practices and beliefs, but that this relationship is subject to external factors such as social norms or political pressure. The heterogeneity introduced by such factors potentially causes unintended behavioural consequences that could resolve but could also aggravate healthcare inequities.

This research will use a mixed-methods design under a participatory research paradigm. A quantitative component will help us understand the relationships between education and health behaviour at a scale that is representative for local communities (primary survey research) and wider regions of the Lao PDR (secondary quantitative data analysis using UNICEF multiple indicator cluster surveys). A qualitative component will enable a close-up inspection of community-administration-nature linkages, the educational practices in the study communities, and local forms of health action and the meaning behind it. Given the social and ethnic heterogeneity and the varied experience of ecosystem and livelihood changes in the study sites, the research programme will also use art-based methods in cooperation with creative companies to produce participatory and locally grounded knowledge on these topics.

Objectives

- Understand the role of education in influencing the linkages between communities, administration, and nature;
- Examine the heterogeneous experiences of learners undergoing formal education;
- Explore the relationship between formal education and health practices and beliefs in the ethnically diverse setting of rural Lao PDR;
- Stimulate socially inclusive and context-sensitive educational policy and practice in response to ecosystem and livelihood change;
- Contribute to synergistic resource allocation for human development in the Lao PDR.



C. Non-exhaustive list of IRD staff and Units ready to be involved in the CIREN program

- Dr Alain Pierret, soil biophysics
- Dr Christian Hartmann, soil science / pedology
- Dr Eric Deharo, Pharmacist Parasitologist
- Dr Frank Wieringa, nutritionist
- Dr Jacques Berger, nutritionist
- Dr Karine Peyronnie, Geographer
- Dr Olivier Ribolzi, soil biophysics
- Dr Pascal Jouquet, soil science / pedology
- Dr Sabrina Locatelli, Molecular Biologist
- Dr Stéphane Bertani, Molecular Biologist
- Dr Pascale Hancart-Petit
- Mr Norbert Silvera, electronics / hydrology
- Ms Anne Pando, Molecular Biologist
- And others....



Non-exhaustive of Research IRD units involved: EES, Mivegec, GET, Qualisud, Prodig, LAERO.(UMR-s.994)....

D. Non-exhaustive list of Institutions ready to be involved in the CIREN program

- National University of Laos
- DALAM
- Lao Ministry of Health
- Lao Ministry of Education, Science and sport
- University of Health Sciences
- Education Consulting Compagny
- Association ANOULAK: <https://www.conservationlaos.com>
- University of Warwick (U.K.)
- University of Reading (U.K.)
- Chang Mai University (Thailand)
- Université Paris-Est Créteil (France)
- Khon Kaen University (Thailand)
- Turtle farm: <https://www.nathanaelmaury.com/ferme-de-tortue>



Credit photo: all photos IRD (except those mentioned)

E. PLAN OF THE BUILDING AND LAYOUT OF SURFACE

