

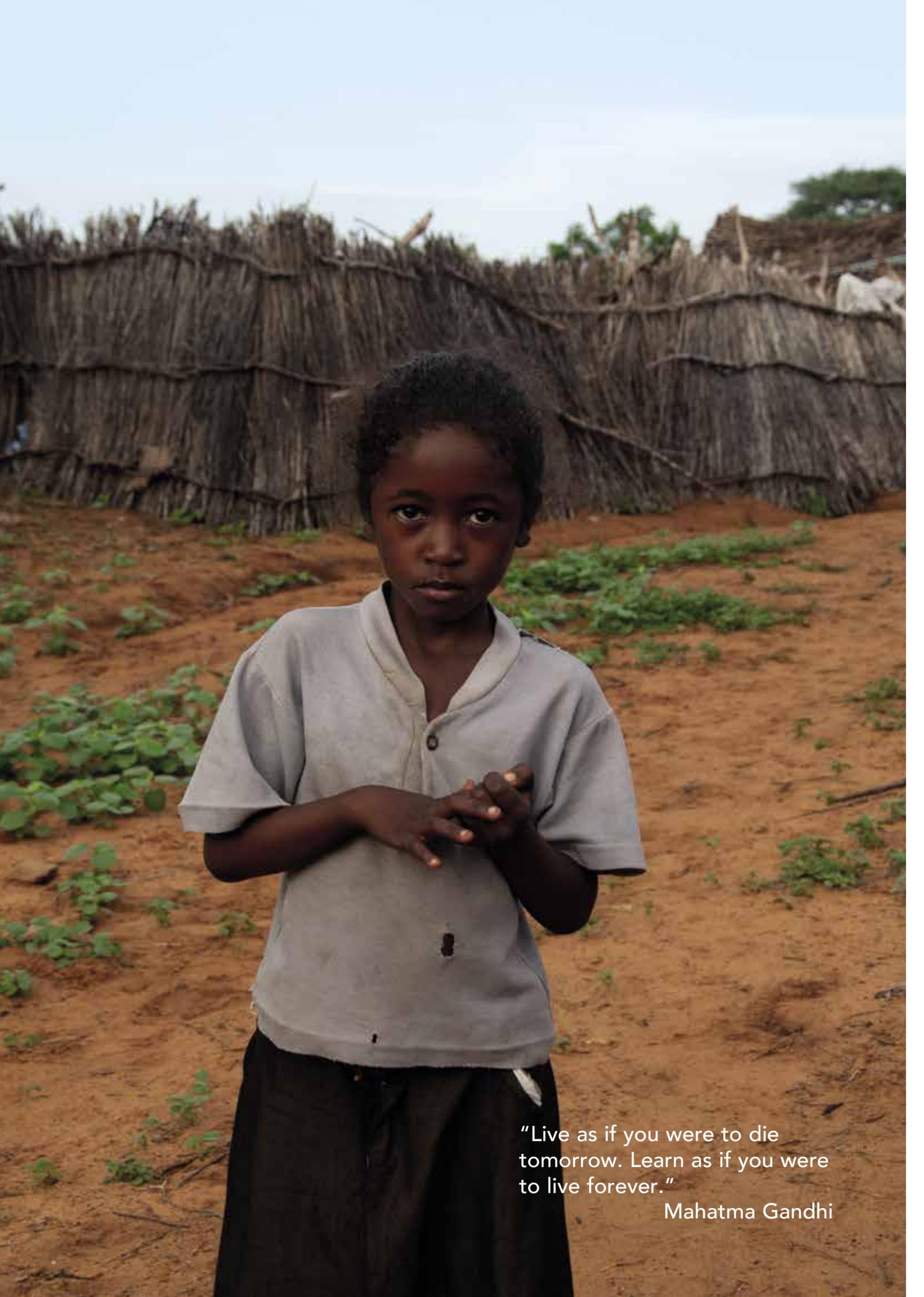


# REPORT 2022

Nestlé Foundation

for the study of problems of nutrition in the world





"Live as if you were to die tomorrow. Learn as if you were to live forever."

Mahatma Gandhi

**FOCUSED AND GLOBAL** – THE FOUNDATION FOR THE STUDY  
OF THE PROBLEMS OF NUTRITION IN THE WORLD

**HUMAN RIGHTS** – BASED FOCUS AND PRACTICE

**RESEARCH** – HIGH-IMPACT RESEARCH FOR DEVELOPMENT

**INNOVATION** – FOR SUCCESS

**LOCAL CAPACITY BUILDING** – AS A BASIS FOR IMPROVEMENT

**SUSTAINABILITY** – A KEY MISSION

**ENDURABLE NUTRITION** – THE PRESCRIPTION FOR SUCCESS

**PUBLIC HEALTH** – ORIENTED

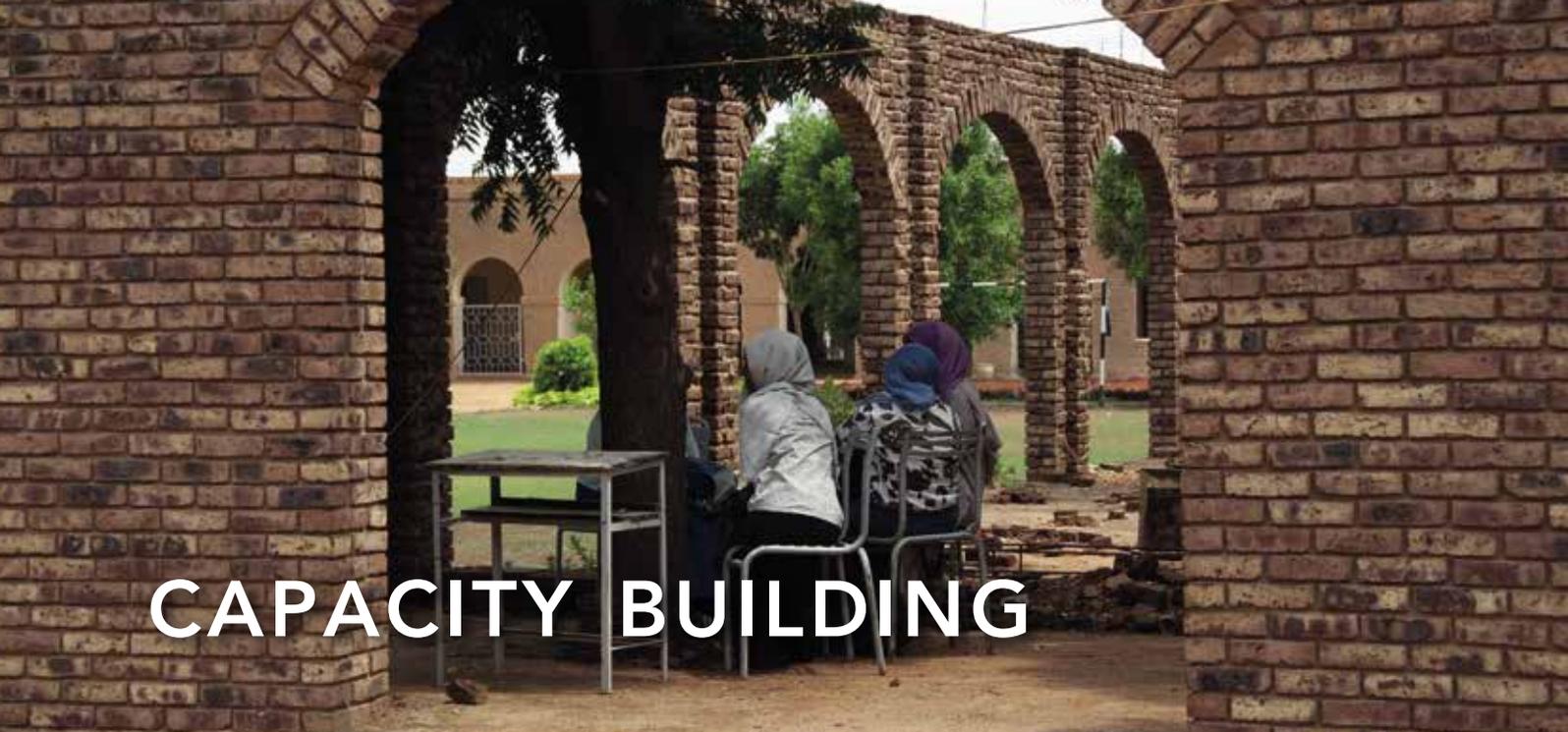
# THE FOUNDATION AT A GLANCE

**EVIDENCE-BASED** – PROACTIVITY

**PARTNERSHIP** – FOR LONG-TERM SUCCESS

**SOLUTION** – ORIENTED ACTION RESEARCH

**enLINK - ing** FOR A BETTER WORLD



**CAPACITY BUILDING**



*enLINK-ing* FOR A BETTER WORLD



**PUBLIC HEALTH ORIENTED**

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# PRESIDENT'S MESSAGE

As I address the readers of this Annual Report, our world has reached yet another all-time high in people on this planet who do not have access to adequate food, now almost a third of the overall population. The increase is equivalent to that of the previous five years combined. In 2020, 41 million people in 43 countries were at risk of famine, up from 27 million in 2019 (UN, 2021). This is certainly due to the COVID pandemic and its effects as well as the ongoing war in Ukraine, but those are not the only factors.

The report illustrates that climate change and industrial food production, with the resulting loss of biodiversity, also contribute in major ways. In the tropics, prevalence of underweight increased by 0.6 for every one degree temperature increase. Droughts everywhere have led to critical water shortages, so water needs to be preserved. Cow milk has a water footprint of up to 4,700 litres per kilogram of powder, yet despite that only 42% of children under six months of age are breastfed. Exclusive breastfeeding is best for the child's health and growth and could also save water and reduce CO<sub>2</sub>, but often mothers are too malnourished to provide adequate breastfeeding. Research has successfully shown that supplementation of missing nutrients both directly or via industrial enrichment works, but on its own cannot correct malnutrition in the world

as multiple factors contribute. For example, large-scale iron supplementation alone does not cure anaemia. Industrial exploitation of land to produce food certainly increases production but as recent events have shown, storage and distribution are challenging, and today a large proportion of people are lacking crop supply because local production is not possible, as local crops are replaced with export-oriented agricultural production, which also exacerbates water shortages. Thus, as outlined in this report, urgent solutions are needed to address the planetary crisis of climate change and biodiversity loss leading to increased incidence of food insecurity and malnutrition.

The Nestlé Foundation continues to invest in research aimed at providing local solutions to problems of malnutrition with a focus on sustainability.



Petra S. Hüppi  
President



One of the Foundation's main aims is the transfer of scientific and technological knowledge to low-income countries.

The Foundation advances nutritional science both by supporting nutrition research projects in established institutes and universities and by giving focused support to existing nutrition schools and educational programs. The promotion of local capacity for independent, implementable research is a central aspect of our activities.

To further fulfil the mandate of the Council and also encourage sustainable improvement in nutrition, a proactive, strategic area of activities was introduced in 2004: the enLINK Initiative. This encompasses a set of interrelated efforts:



# PROJECTS INITIATED BY THE FOUNDATION

## THE enLINK INITIATIVE

- **Promoting local capacity for nutrition research**
  - Anchoring of research capacity and innovation
  - Promoting local generation of research ideas
  - Promoting local ownership and empowerment
  - Discouraging donor- or sponsor-driven research
  - Promoting critical-evidence-based thinking and research
  - From idea to implementation: Assistance from the germ of a research idea and project through its sustainable implementation
- **Strengthening expertise and know-how**
  - Promoting access to information
  - The enLink library
  - Promoting local knowledge exchange and generation
  - Needs-based, targeted assistance
  - Network-system capacity building
  - Promoting and furthering of researchers' stamina
- **Nestlé Foundation Research for Development (NFR4D) program**



# THE enLINK INITIATIVE

Sustainability and public-health relevance have been and will remain key aspects for all activities of the Foundation. Research projects need to result in short- and long-term public-health implementation. Knowledge and know-how have to be sustainable at all levels of the population, meaning that the knowledge has to be implemented and become part of daily life. Knowledge has to trickle down to the population.

The vast experience of the Foundation's Council members as well as the Foundation's past activities led to the creation of the enLINK Initiative in 2004, an initiative which illustrates the proactivity of the Foundation regarding its core issues.

This initiative focuses on information transfer in the area of nutrition and malnutrition as well as on the resolution of specific research questions and their implementation at the public-health level. The core competence and activity of the Foundation is the support of nutrition research in low-income countries. The enLINK initiative is an add-on to our key activities to improve the research capacity.

The name enLINK comes from the old English verb "to enlink", meaning "to chain together" or "to connect, as by links". The analysis of the semantic relations of "enlink" reveals related words which illustrate our central concepts and aims: to connect, to join, to associate, to unite, to tie, to conjoin.

Our mission is to link and join cultures; to associate and conjoin institutions and people locally to study and diminish the problems of malnutrition globally.

Malnutrition can only be solved by "enlinking" –connecting–different strategies and approaches. Malnutrition has to be addressed universally by joint strategies which address many levels, looking at the level of medical issues (such as infection) and hygiene

(such as water quality), proposing changes at the level of agriculture as well as in the society at large, and, last but not least, working to improve the level of education and information.

## The enLINK Initiative has five main levels:

1. **exploration in nutrition** – building practical research capacity: This is the main purpose and aim of the Foundation.
2. **education in nutrition**: This level of the enLINK initiative also implies the creation of research-based evidence and subsequent transfer of the knowledge to the population.
3. **the enLINK library**: At present, after having shipped 217 library trunks to 34 countries, only digital content is provided (free of charge) in the enLINK digital library ([www.enlink.org](http://www.enlink.org)).
4. **endurable nutrition**: All activities should be implemented and sustainable.
5. **Nestlé Foundation R4D initiative** – research for development (**NF-R4D**): Sustainable, targeted, concerted support of young researchers and their institutions.

The digital enLINK library is currently offering free full-text access to a few nutrition journals and more than 30 e-books—many of them indispensable classic textbooks—in the newest editions available. This digital library is accessible free of charge to registered users who all receive a personal password; registration is also free as long as the applicant comes from a low-income country. The library is continuously updated



“Don’t find fault.  
Find a remedy.”  
Henry Ford

and adapted to specific needs and in response to user feedback. Evidence and content which end up in textbooks are usually more practice-related than the research knowledge from latest findings, which is published in research journals. Therefore the weight of the library lies more in the e-textbook section to assure a good basic knowledge transfer as well as knowledge accessibility. A solid knowledge of the physiology and pathophysiology of nutritional sciences is the cornerstone for the development of nutrition research focused on basic needs and designed to drive concrete improvements.

The approach of the Foundation in the enLINK initiative reflects the need for multidimensionality to solve the problems of under- and malnutrition. Knowledge and know-how are the basis and beginning of every and any improvement.





# THE enLINK CIRCLE

## ABOUT HOMOGENIZATION

Homogenization plays a key role in food processing and represents an important and crucial procedure contributing to improved food quality, nutriture and finally health. According to the Merriam-Webster Dictionary the word “homogenized” has two meanings: First, “having its particles uniformly small and evenly distributed: subjected to homogenization” and secondly “uniform in structure or composition: homogenous”<sup>1</sup>. The etymology of the verb “homogenize” stems from the Medieval Latin word “homogeneous” and the Greek word “homogenes”, meaning “of the same kind”. The word is composed of “homos”, signifying “same”, and “gemos”, signifying “kind, gender”<sup>2</sup>.

During recent decades, homogenization or, if you prefer, homogeneity became a worldwide phenomenon in many aspects of living and non-living matter, but not always for the better. Some readers might think in the context of the homogenized world of the popularized term “globalization”, which points in the same direction. The origin and first use of the term “globalization” is not completely clear; the term was used infrequently as early as the 1940s but gained a kind of revival in an article published by the Harvard Business School professor Theodore Levitt entitled “Marketing Myopia”, pointing to strategies for expanding business and profit opportunities<sup>3, 4</sup>. The title of the latter article unintentionally hints at the deeper insights of the concept of globalization: “myopia” also refers to a mindset of “not seeing the bigger picture”<sup>5</sup> and thus the title of Levitt’s article might even be regarded as a kind of unwanted projection or forecast of the unequal world we live in today—many of the promoters of a homogenized and globalized world seem to be myopic regarding those human and planetary domains where homogenization

is hardly taking place, for instance in education, health care or also peace building.

As everybody knows, globalization bears positive and negative aspects and as a function of the globalization theory economic, political or cultural issues—to mention a few—are all too often only myopically addressed. The dominant use of the term globalization is in the context of economics, mainly market opportunities. Looking at today’s globalized world the open-eyed observer realizes that our blue planet is steadily becoming “of the same kind” and accordingly the term “homogenization” might be more appropriate than “globalization”.

Homogenization of milk and other products is welcomed, while many other forms of homogenization are less welcomed and interestingly enough, as already mentioned, do not occur in all aspects of life. For instance, food security, human rights, education, availability of and accessibility to basic medical care, socioeconomic equality, gender equality, political stability and peace building, mutual respect, personal self-determined agency and many more are unfortunately often not on the list. Maybe some readers are able to explain the causes for the latter constellation. In view of the very unequal and one-sided homogenization one can even speak of “myopic homogenization” or “myopic globalization”.

A few examples should be briefly addressed: In the 2018 Annual Report of the Foundation, the role ecosystem services plays in human health, including nutriture, was discussed. Ecosystem services depend heavily on biodiversity. The continued loss of biodiversity is well known and is globally discussed



by the international community, yet as we all know so far with limited success. Currently more than 30,000 plant species are globally threatened with extinction and up to 50% of the plants are endangered<sup>6</sup>. There are more than 1,750 seed banks around the world trying to preserve what is not yet lost, but there are irreparable gaps in these collections<sup>7</sup>. The reduced genetic diversity of agricultural crops (even down to the level of the home garden) has been known for many years. This trend is further reflected in that less-profitable crops are no longer listed in the Garden Seed Inventory and that new commercial varieties appear increasingly in this listing<sup>8</sup>. Not surprisingly, roughly forty seed companies are in charge of 85% of the global seed market, and only ten companies account for 70% of the seed market value and thus determine what is planted and finally what is eaten<sup>9</sup>. Similarly, more than twenty years ago the FAO warned in a report<sup>10</sup> that more than 75% of plant genetic diversity has been lost since the beginning of the century and that farmers can only grow a handful of commercial high-yielding varieties. Further, in 1999, approximately 75% of the global food supply was generated by only twelve plant and five animal species<sup>10</sup>. The 1999 FAO report was, as today's situation confirms, apparently ignored as this dangerous trend continues. The more recent FAO report entitled *The State of the World's Biodiversity for Food and Agriculture*<sup>11</sup> mentions that of the more than 20,000 edible plants, fewer than 200 remain to contribute to our daily food and only nine crops account for more than 70% of our daily food<sup>12</sup>. Half the global harvested area is planted with cereals<sup>13</sup>. To further illustrate these worrying trends: only four crops (rice, maize, soy, wheat) deliver 60% of the consumed energy globally, and similarly, four crops (sugar cane, maize, wheat, rice) account for approximately half of the global primary crop output<sup>13</sup>. No wonder that such a homogenized and concentrated agricultural system is fragile and is loaded with many unwanted side effects.

Another consequence of planetary homogenization is reflected in the trends of the global burden of disease patterns<sup>14</sup>. We all know that non-communicable diseases (NCDs) are spreading all over the world into the most remote places with a dynamic which is comparable to that of the most contagious infectious diseases of the past. In view of the pathogenesis of the NCDs it has been suggested to use the more appropriate term "transmissible chronic diseases"<sup>15</sup> or "acquired chronic diseases". The "contagiousness" of a NCD-promoting lifestyle has been reported in different studies published in high-impact journals<sup>16, 17</sup>. The contagiousness could facilitate the identification of causal drivers of the transmission and thus establish efficient preventive actions. Thanks to modern medical research, infectious diseases have been

eliminated or are at least somehow under control in many—but unfortunately not all—parts of the world. These are indeed incredible achievements, which cannot be judged in view of their high impact and positive health effects. NCDs have replaced infectious diseases, despite the old human wisdom not to "replace one devil with another". Remembering the COVID pandemic it is obvious that infectious diseases can spread globally at a rapid pace. The same apparently applies also to the NCDs.

The largest percentage of premature cardiovascular deaths is now happening in low-income countries<sup>18, 19</sup>. This is caused by the higher susceptibility of these populations due to different factors which range from genetic factors, socioeconomic factors, and insufficient medical infrastructure to specific mechanisms related to metabolism. This predisposition has been conceptualized in the "capacity load model of chronic diseases"<sup>20</sup>. The causal mechanisms of the latter model bear the potential of modulation. The treatment costs of the different chronic diseases are very high and seem to drive most health care systems into bankruptcy—even in richer countries.

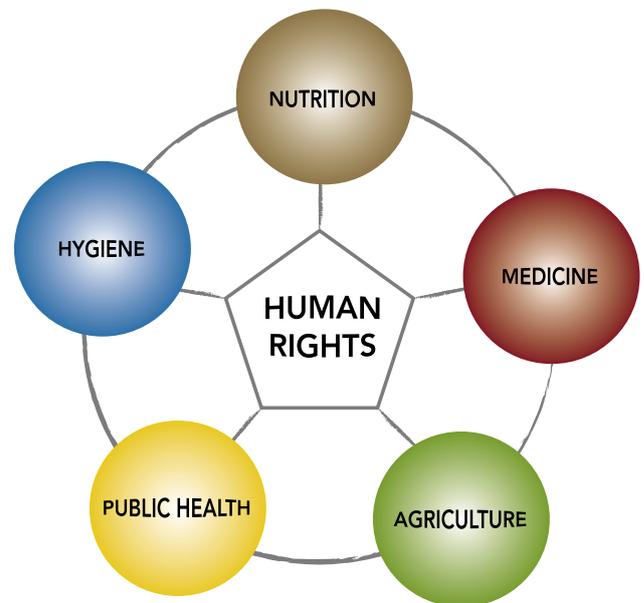
To control NCDs, the recommendation to consume more fruits and vegetables is repeated like a mantra. The basic idea and concept are indeed very much correct; however, in view of the present food system and rather limited crop varieties and availability, such recommendations are too simplistic and need additional holistic strategies. The variety of commercially available vegetables and fruits is rather limited in view of the at least 6,000 edible plants. Further, if everybody would implement the recommendations to eat more fruits and vegetables, there would be a global shortage due to insufficient production<sup>21</sup>. Insufficient and dysfunctional supply of health-promoting food is a well-known and ever-more prevalent phenomenon in many countries<sup>22, 23</sup>. Any recommendation should be attainable and affordable for anybody and everybody<sup>24</sup>. The aforementioned trends and constellation from biodiversity loss to changing disease patterns underline the need for a diametric change in the modern food system and lifestyle, so that the societal priorities and needs can be achieved<sup>25</sup>. Whether these aims are achievable is still questionable and even the UN Special Rapporteur on the Right to Food, Professor Michael Fakhri (University of Oregon), underlined that the last UN food summit was rather disconnected from people's real needs<sup>26</sup> and most likely also from planetary needs.

Reviewing the research activities of the Nestlé Foundation during the last 57 years, it can easily be recognized that the supported research projects were quite heterogeneous and in agreement with the





local needs. This is not surprising since all research projects were suggested and owned by local researchers familiar with the local possibilities and needs. All projects used local food and local know-how to build local capacity and agency. All projects addressed key aspects for need-oriented research with the aim of a sustainable local improvement and enduring capacity, as also reflected in the enLink circle (see Figure 1).



**Figure 1**

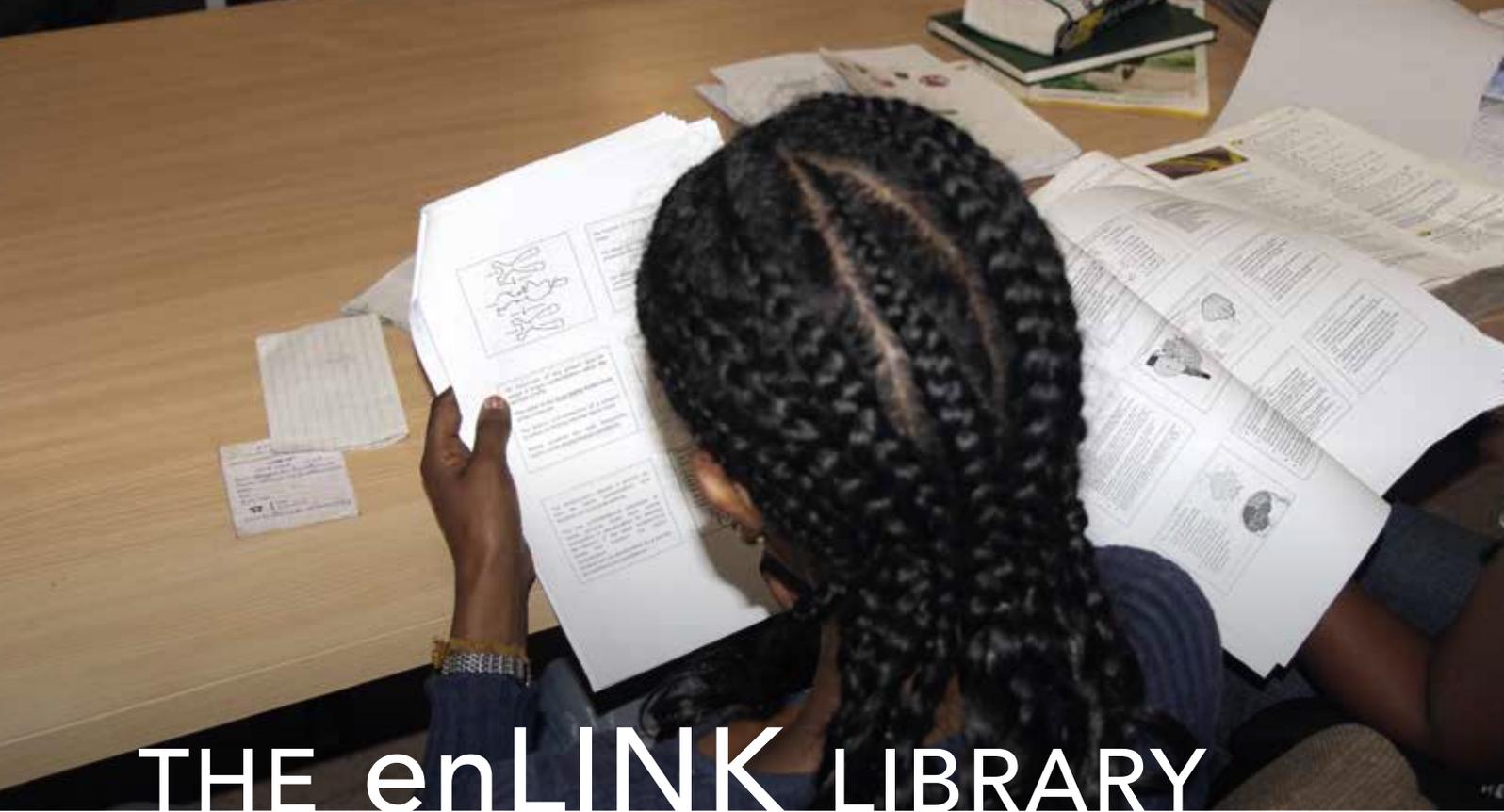
The enLINK circle: The five central elements for a better livelihood–human rights represents the key to success.

In the foreword of the aforementioned 2019 Report on biodiversity, the FAO General Director José Graziano da Silva stated that “parts of the global report make somber reading”<sup>10</sup>. In view of the present global dynamics it can be speculated that there is a high risk that 2019 was the last report of this kind, since there will be hardly anything left to preserve; resilience and plant variety have disappeared<sup>27-29</sup>. Not surprisingly hunger, food insecurity and malnutrition are again on the rise<sup>13</sup>. COVID-19 is often blamed for the latter trend, and while surely a significant factor, the major driver for these trends are the rampant and increasing economic inequalities (which were present already before the pandemic) leading to a further exacerbation of hunger and food insecurity<sup>13</sup>.

It can be hoped that the homogenization process will expand to all basic human needs. Nobody is ready for more somber reading.

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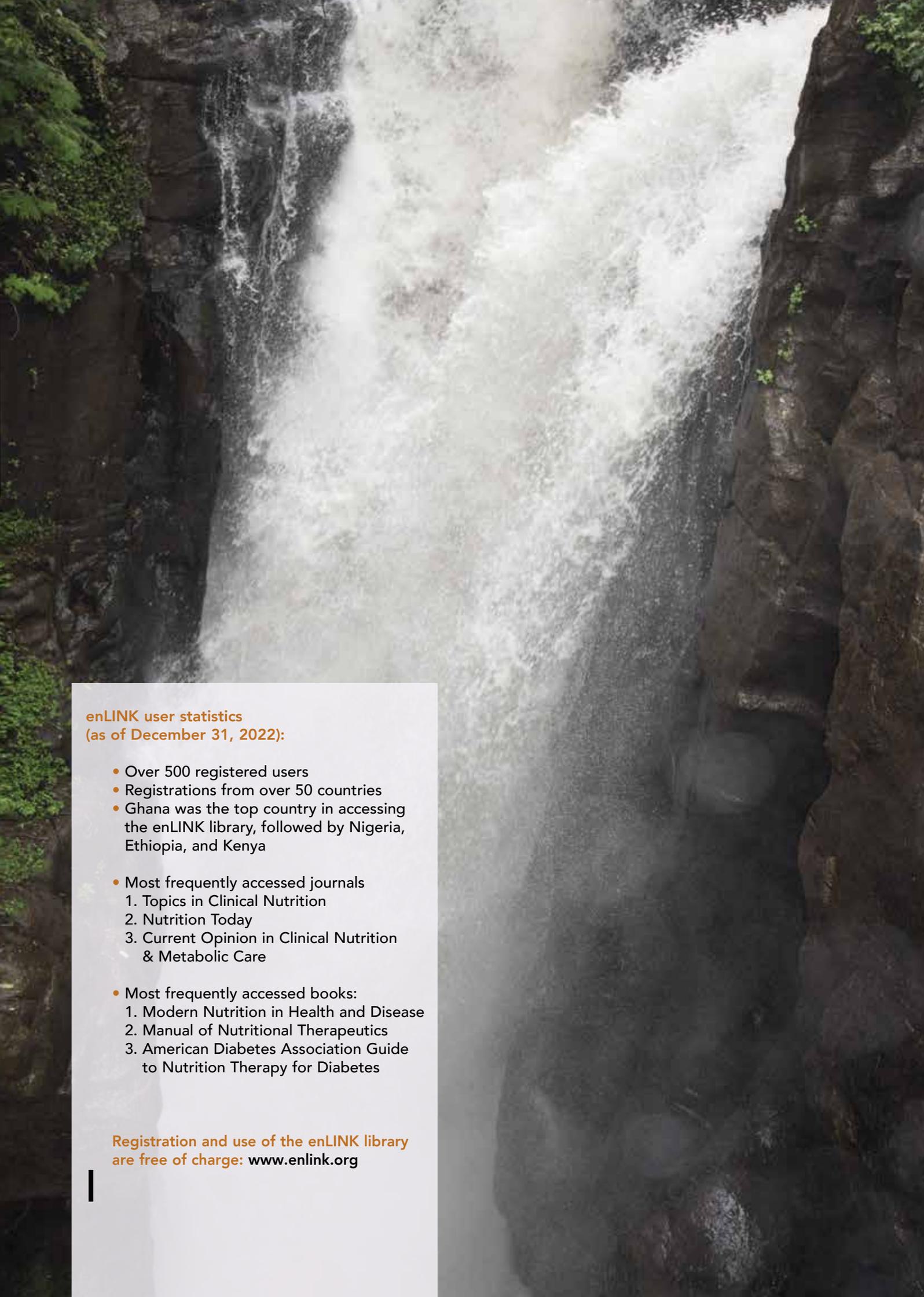
# THE enLINK LIBRARY

Also during the year 2022 the digital enLINK library remained a very welcome basic information source for users in low-income countries, yet—compared to e-library usage in Europe or the US—one cannot get rid of the impression that access in the Southern hemisphere is considerably lower than in the North. This observation is valid for the enLINK library as well as also for other digital tools such as digitalized education, e-learning or also educational and private e-reading practices. These differences are caused by many issues, primarily by the omnipresent digital gap between the North and the South, but also due to the cost and pricing of educational digital content.

Regarding the pricing model, the enLINK library of the Foundation is a pioneer in nutrition research, since the entire content with over 30 e-books and a few journals is offered free of charge for registered users (see [www.enlink.org](http://www.enlink.org)). Another often forgotten advantage of the enLINK library is that the library operates without the use of any tracking cookies. We are interested in offering state-of-the-art educational content to students and researchers in low-income countries—nothing else—since everybody deserves education.

The enLINK library was created more than a decade ago following the global trend of digitalization. Nevertheless for a quite long period the Foundation offered digital content as well as traditional paper books with the enLINK trunks. Retrospectively one must acknowledge that this blended approach is most likely better than a pure digital approach. Books will not disappear—similar to pen and paper.

Several hundred years after the invention of book printing the whole world is experiencing an explosion of digitalization of nearly all aspects of life; particularly in the realm of education as the paper book is displaced by digital books. “Old-fashioned” book reading becomes e-reading. Learning becomes e-learning. Commerce becomes e-commerce. Even life becomes e-life, and so on; you name it, there’s an e-version. As many of us know, the digitalization of the world has many advantages and facilitates life. However, as we should remember, “there is no free lunch”. What is the driver for the replacement of paper books with digital books? “Modern times” and also cost. Print versions of scientific journals disappear as well as many books—often with the argument of the high costs of paper and printing. An easily understandable argument. Less understandable is the cost of e-journals and e-books, which are often nearly identical. Sometimes a paperback book is even cheaper than an identical e-book. When it comes to cost and pricing of nearly anything, business and profit are more important—even in the educational sector. In view of the non-existing physical nature of digital products, the initial producer (in the case of e-books the publisher, although this term should become obsolete in the face of digitalization) determines a fixed price. Per definition profit has to increase and so once more—many people become excluded. A no-go in the area of education—especially for education in the global south where the digital gap is still wide or in certain areas even widening.



**enLINK user statistics**  
(as of December 31, 2022):

- Over 500 registered users
- Registrations from over 50 countries
- Ghana was the top country in accessing the enLINK library, followed by Nigeria, Ethiopia, and Kenya
- Most frequently accessed journals
  1. Topics in Clinical Nutrition
  2. Nutrition Today
  3. Current Opinion in Clinical Nutrition & Metabolic Care
- Most frequently accessed books:
  1. Modern Nutrition in Health and Disease
  2. Manual of Nutritional Therapeutics
  3. American Diabetes Association Guide to Nutrition Therapy for Diabetes

Registration and use of the enLINK library are free of charge: [www.enlink.org](http://www.enlink.org)

One can only hope that the paper book is not disappearing completely. The argument of the “wear and tear” problem of a book is simply a marker of a widely read book—even a kind of quality measure. An advantage of a classic paper book is that many individuals can read it without being registered and tracked. As we well know, there is a surprisingly fast and higher “wearing and tearing” of IT infrastructure, which needs to be replaced regularly at increasingly high costs (not affordable for many individuals, less so educational institutions—the latter even in the “richer” global North). Amazing that IT is aging so fast—in medicine accelerated aging would lead to an extensive work up of any patient—not so in IT. Again, this aging and fast non-functionality of IT tools is an inborn part of the business model (in medicine one might diagnose an inborn error of metabolism, which can often be treated—apparently not so in the IT field).

In the past the Foundation offered a huge number of enLINK book trunks (see former Annual Reports). The move to the digital library had various reasons—the time trend but also—to be frank—costs. However, based on a small inquiry we are fairly convinced that the books in the over 200 enLINK trunks are most likely read by more students and researchers than the available e-books in the enLINK library.

The variable enLINK access rates are also due to lacking and costly connectivity while not on a university campus. Not surprisingly, the highest enLINK library access rates were from Ghana, a country with a rather good internet penetration rate and also in the lower range of pricing per gigabyte of mobile data. Further, this country has a comparatively active group of nutrition researchers and promoters of nutrition research.

Also during the last year the classic textbook *Modern Nutrition in Health and Disease* had the largest numbers of hits, reflecting the importance of this “bible-like” basic knowledge source. Out of the few scientific journals offered, the access was highest for review-type journals—reflecting reader preferences but also the need to get complete, holistic information about a specific topic. Further, during the reporting period two manuals of therapeutic nutrition showed the highest access rates, one of them addressing the nutritional therapy of diabetes. This increased usage of diabetes-related resources parallels the increasing rates of obesity as well as diabetes in Africa in recent decades and the ongoing tsunami of diabetic patients. The globalization of metabolic diseases is a reflection of the globalization of modern food and modern lifestyles—including digitalization. Maybe a walk to the university library or any public library might be a good idea—for the energy balance and also for knowledge acquisition.

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# NEW RESEARCH PROJECTS

In 2022 the Council decided  
to fund 13 research projects:



BREASTFEEDING

NUTRITION EDUCATION

MALNUTRITION

PRECONCEPTION NUTRITION

COMPLEMENTARY FOOD

VITAMIN A

# NEW RESEARCH PROJECTS

DOUBLE BURDEN OF MALNUTRITION

NON-COMMUNICABLE DISEASES

# BREASTFEEDING

**Effect of breastfeeding education and support provided to male partners on optimal breastfeeding practice in Ethiopia: A cluster-randomized controlled trial**

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Optimal breastfeeding practices are essential for child survival, growth and development, and for the health of mothers. Male partners have an important but often neglected role in the promotion of breastfeeding practices and interventions that target male partners are often not implemented. This cluster-randomized controlled trial will evaluate the effect of breastfeeding education and support provided to male partners on optimal breastfeeding practice in South Ethiopia. The intervention will be provided to mothers and fathers by trained village health workers. The husbands in the intervention group (as compared to routine) will receive antenatal and postnatal breastfeeding education and support. The intervention package will comprise 1) antenatal and postnatal breastfeeding education, 2) specific take-home print materials, and 3) individual home visits. Improved optimal breastfeeding practice is expected.

# NUTRITION EDUCATION

**Developing a nutrition educational program for burn survivors in Ghana: A pilot study**

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The metabolic effects of severe burns require an optimized nutritional support so as to improve patient outcomes and avoid secondary problems. Nutrition educational programs to ensure that burn survivors understand their ongoing nutritional needs and how to plan their diet are lacking in most developing countries. This study proposes to develop and evaluate the preliminary effects of an educational program for caregivers of pediatric burn survivors in Ghana. After a systematic review of the literature, a qualitative study targeting pediatric burn survivors will be undertaken to explore their perceptions regarding the nutritional needs of their children. Focus-group discussions will explore the nutritional needs of burn survivors and the feasibility of implementing a nutritional educational program. The results of this project should result in a locally adapted nutrition educational program, which will finally be tested in a pilot study.

# IRON FOLIC ACID SUPPLEMENTS

Empowering Weekly Iron-Folic Acid (WIFA) supplementation program for adolescent schoolgirls in high-stunting areas

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Adolescence presents a second window of opportunity for establishing healthy lifelong nutrition. Iron-folic acid supplementation is an intervention provided to pregnant women and adolescent girls to reduce the prevalence of anemia among these groups. It is one of the efforts to accelerate the alleviation of stunting in Indonesia as an integrated stunting-reduction intervention. By increasing stunting awareness among school-going adolescents, the implementation of WIFA supplementation is a potential way to induce behavioral change and improve lifelong nutrition and health to overcome stunting. This study will assess the knowledge and attitude of adolescent schoolgirls regarding the causes and consequences of anemia and the benefit of WIFA supplementation. Further, the knowledge and nutritional issues related to iron intake and status will be assessed in the study population as well as in the parents. In the second year of this project an intervention study will apply and test the gained knowledge to empower the implementation of WIFA supplementation through behavioral change education. The results of this study will hopefully lead to an improvement of the health of adolescent girls which can then be disseminated countrywide.

# OUTCOMES IN MALNUTRITION

Growth and development outcomes in severe acute malnutrition (SAM) children discharged from nutrition rehabilitation centers (NRC): A community-based follow-up study

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SAM (severe acute malnutrition) affects globally approximately 20 million preschool-age children. The National Family Health Survey (NFHS) revealed that 7.5% of children under five years of age in India and 6% in Uttar Pradesh are severely wasted. This trend is continually becoming worse as evident in the NFHS, which reports that 7.7% of children under five in India and 7.3% in Uttar Pradesh are severely wasted. Nutrition Rehabilitation Centers (NRCs) have been established by the government specifically to treat children with SAM. The NRCs have reported successful rectification in growth curves in SAM. Most studies conducted on children admitted to NRCs focus on immediate recovery, i.e., change in anthropometric parameters either during the stay at the NRC or at the follow-up completion. There are hardly any long-term outcome studies of SAM. Post-discharge outcomes such as clinical relapse, morbidities, ongoing SAM, and mortality are poorly understood and underestimated. In this community-based prospective follow-up study among post-discharge SAM children it is planned to assess the growth, development, relapse, morbidity, and mortality outcomes over a year after discharge with the aim to identify the risk factors for poor longer-term outcomes.

# RURAL WOMEN'S NUTRITURE

## Implementing a nutrition training package for rural women farmers in Tanzania

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Nutrition education training is one of the most sustainable, operative and cost-effective interventions to combat malnutrition and food-related diseases. The aim of this project is to implement an already developed and piloted nutrition training tool for rural women farmers in the district of Chamwino (supported by a Nestlé Foundation grant). The study will be a continuation of a previous study (Phase 1), which comprised qualitative and quantitative research methodology in three stages. The needs assessment (stage 1) involved gathering qualitative and quantitative data regarding the nutrition knowledge, attitudes and dietary practices (KAP) of rural women. In stage 2, the findings of stage 1 were used to develop a tailored, pictorial, culturally acceptable nutrition-training package. In stage 3, the training package was piloted in five villages. The materials were rated suitable for improving nutrition knowledge and practices. In the proposed phase 2, five villages will be involved. The implementation will be done for three months and will be assessed through a process evaluation. The impact of the nutrition-training package on the nutrition KAP of the rural women will be assessed. It is expected that the study will lead to an increased capacity in knowledge, attitudes, practices, behaviors and awareness of women rural farmers to respond to nutrition matters and requirements related to the household members. A sustainable improved nutrition status and health of household members in rural areas is the final long-term aim.

# COMPLEMENTARY FOOD

## Improvement of iron and zinc bioavailability in complementary food of children 6-23 months in South Kivu (DR Congo)

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Micronutrient deficits are widespread in developing countries like DR Congo (DRC) and peak during the complementary feeding period. In DRC, young children's diets consist mainly of tubers and cereals, with few animal products, despite a large diversity of local resources. This monotonous plant-based diet can lead to inadequate micronutrient intakes. South Kivu has one of the highest rates of stunting among children under five (48%). It is crucial to know the nutritional quality as well as the bioavailability of iron and zinc in the most frequently consumed complementary foods. The aim of the project is to improve the bioavailability of iron and zinc in complementary foods prepared from local products and evaluate the impact of their consumption on the nutritional status, iron and zinc status of children aged 6 to 23 months in South Kivu. To assess the baseline nutritional status and the diet of children, a study including 425 infants was conducted in South Kivu. The most commonly consumed complementary foods were identified, and samples were collected. An enriched complementary food will be developed, using local products rich in iron and zinc such as dried fish powder and/or soybean. Two cooking methods to improve the bioavailability of iron and zinc will be studied: torrefaction and extrusion. Finally, an intervention study to assess the impact of consumption of this fortified food on nutritional status, anemia, iron and zinc status of children aged 6-23 months in South Kivu will be conducted.

# PRECONCEPTION NUTRITION

**Effects of maternal preconception nutrition on offspring body composition and cognition in adolescence**

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Periconceptional nutrition may play a key role in determining accretion of lean relative to fat body mass in the next generation. Similarly, mental health and economic productivity are related to cognitive functioning and educational attainment, both of which may be influenced by exposures at the time of conception and through pregnancy and early childhood. This study is uniquely positioned to evaluate the long-term effects of preconception nutrition on early adolescent body size and composition, intellectual functioning and academic achievement by adding a new wave of data collection at ages 10-11y to the PRECONCEPT study. In the parent study 5,011 women were enrolled and randomly assigned to pre-pregnancy folic acid (FA-control), Iron-Folic Acid (IFA) or Multiple Micronutrient (MM). Women who conceived were followed through pregnancy and the offspring (n=1599 live births) have been followed through age 2y (n=1,400) and at 6-7y (n=1321). It was shown that weekly MM and IFA preconception supplementation improved maternal and infant iron stores as well as maternal mental health among at-risk women. Most importantly there was an increase in offspring linear growth and motor development at age 2y in the MM and IFA groups compared to FA only, and higher intellectual functioning at age 6-7y in the MM group. In this study a comprehensive set of measures during early adolescent years will be added, such as: 1) child size and body composition and 2) child cognitive functioning along with academic achievement and learning environment. These data will allow to clarify the role of preconception nutritional status on growth and development from conception through early adolescence.



# VITAMIN A DEFICIENCY

Impact of the consumption of spirulina on the vitamin A status of mother-newborn couples:  
Chadian approach to the traditional food "Dihé"

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Vitamin A (retinol) deficiency (VAD) is one of the major endemic causes responsible for high morbidity and mortality following various attacks and infections, particularly in pregnant women, newborns and children. A blood vitamin A concentration of less than  $0.7 \mu\text{mol} / \text{L}$  is defined as a deficiency. The lack of adequate intake of vitamin A or its precursors is the major cause of VAD. Large intervention campaigns have tried to fight VAD by providing a diversified or even fortified diet in vitamin A (red rice, for example). Unfortunately, over time, there are no convincing results because these campaigns offer these populations an unusual and unsustainable diet. In Chad, VAD could be explained by the low consumption of foods rich in retinol such as animal liver, vegetables and fruits. Very paradoxically, in Chad a food particularly rich in a precursor of vitamin A is available: spirulina "Dihé". This green algae is in fact an important source of beta-carotene presenting an important factor of conversion into vitamin A (conversion factor 4 to 1). This is why a study was initiated to evaluate a population living in the same region of Lake Chad to determine whether consuming spirulina has an impact on blood parameters representative of the status of vitamin A. After promising published results on the general population of women, this current clinical and observational research project aims to: 1) study the impact of the consumption of spirulina on the biological parameters of the vitamin A (retinol) status of a cohort of mother / newborn couples; and 2) to establish a proof of concept on the contribution of the consumption of spirulina during pregnancy to combat vitamin A deficiency.



A close-up photograph of a hammer striking a nail into a piece of wood. The wood's surface is covered in peeling, cracked red paint, revealing the natural wood grain underneath. The hammer is positioned diagonally, with its head on the left and handle extending towards the right. The lighting is dramatic, casting shadows and highlighting the textures of the wood and paint.

# DOUBLE BURDEN OF MALNUTRITION

Effect of double-duty interventions on the double burden of malnutrition among children under five years in Debre Berhan City, Central Ethiopia: A cluster randomized controlled trial

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The double burden of malnutrition (DBM) is an emerging public health problem among children under five years due to the inevitable consequences of nutritional transition. Addressing these two contrasting forms of malnutrition (undernutrition + overnutrition) simultaneously brings an enormous challenge to the food and nutrition policies of developing countries like Ethiopia. Children under five are more vulnerable to DBM, especially during the first year of their life, due to high growth and inadequate diet. Hence, there has been a paradigm shift in thinking to reduce its effect on the health of children. However, interventions that are presently used to address these different kinds of malnutrition are implemented through different strategies which are isolated and not integrated with each other. Therefore, double-duty interventions can tackle the risk of both nutritional problems simultaneously in an integrated approach through nutrition behavior change communication. The main aim of this study is to assess the effect of double-duty interventions on the double burden of malnutrition among children under five years in Debre Berhan City, Ethiopia. A cluster randomized controlled trial will be conducted among 674 under-five children (337 for each group).

# EDIBLE INSECTS

## Safety aspects of edible grasshoppers consumed in Benin: Case study of malanville

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Much attention is being paid to the potential of edible insects for diversifying diets and improving food security in many parts of the world. In the extreme north of Benin, Malanville, a significant amount of grasshoppers are gathered, processed, stored and redistributed to local markets. They are used as an alternative protein source to overcome the high cost of fish and supplant meat and contribute to nutrient intake. Despite the socioeconomic and nutritional importance of grasshoppers in Benin, no information exists on the safety aspects of traditionally stored edible insects. Similarly, the processing and storage conditions that guarantee a better quality of the product remain a field of investigation to be elucidated. In this study, quality will be assessed along the entire food chain in two-pronged approaches: (a) assess the microbiological quality of grasshoppers along the entire food chain (harvesting, handling, processing, distribution, sale, and consumption); (b) assess the level of alteration of grasshoppers sold in different markets (stability parameters). Samples of fresh, processed, and processed and stored grasshoppers will be collected from local markets and households for laboratory analyses. The data analysis includes (1) mapping of the actors involved in the grasshopper chain and (2) safety aspects (microbiology and stability parameters) data. The findings will be used to raise awareness of the local population regarding safety aspects of harvesting, processing, storing and consuming grasshoppers and their quality preservation and stabilization.

# PROTEIN-ENERGY MALNUTRITION

## Impact of a bean-based soup flour containing vegetables and sweet potato on children in Rwanda

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A three-month feeding trial of 6- to 23-month-old malnourished children in the eastern province of Rwanda is planned. They will be provided with a bean-based composite soup containing 70% red kidney beans, 15% amaranth leaves, 10% sweet potato and 5% orange carrots. These ingredients are locally grown, affordable and nutrient-dense. The children will be fed once a day, five days a week. This project will target Protein Energy Malnutrition (PEM) on moderately wasted children because severely wasted children are hospitalized. The developed and pretested soup is expected to address the problem of PEM based on its composition (20.58% protein, 59.08% carbohydrates, 2.93% fat and 351.78 kcal energy). The soup will be enhanced by adding oil while cooking. This will also enhance the absorption of fat-soluble vitamins and contribute to calorie needs. If feeding trials succeed, the strategy will be proposed to the government of Rwanda and it is planned to teach this approach to community kitchens. At the research level, the flour will be processed by small-scale food processors as it was done for sensory evaluation. Sensory evaluation testing was done by mothers of young children; they were able to objectively taste the soup and the flour formulation was the most acceptable.

# COMPLEMENTARY FOOD

## Formulation of nutrient-rich recipes for complementary feeding of infants and young children in Douala, Cameroon

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Malnutrition in all its forms is still increasing in Cameroon as in other sub-Saharan countries. Children in their first 1,000 days of life and beyond are vulnerable, due to their mothers' nutritional status. The main causes of malnutrition are poverty, insufficient knowhow, inappropriate feeding, lack of variety and quality of food combined with frequent infections during pregnancy, lactation and complementary feeding. The most frequently deficient nutrients are iron, zinc, vitamin A and proteins. These nutrients are found in some local/traditional foods comprising legumes (beans, soya beans, groundnuts), mushrooms, spirulina, date palm and animal products. It is hypothesized that appropriate formulation of nutritious food could help to improve dietary diversity score and nutrient intakes to reduce malnutrition among children, during the first 1,000 days and beyond. The objective of the present research project is to formulate and characterize nutritious recipes for optimal complementary feeding. The formulation of three recipes containing lime juice are planned: 1) yellow corn, soy beans, carrot, date palm; 2) orange-fleshed sweet potatoes, beans, spirulina, mushroom, date palm; and 3) squash, groundnut, date palm fish powder containing the essential nutrients in sufficient amounts. The complementary foods are in full agreement with the FAO/WHO recommendations (400Kcal/100g dWt) and provide adequate amounts of vitamins and minerals. The main components of the recipes will be pretreated by fermentation and/or germination for better digestibility and bioavailability of main nutrients. Formulation and chemical analyses (macronutrients and micronutrients, antinutrients) on formulated recipes will be determined. Acceptability test of formulated recipes (each available in a sweet and spicy variation) will be performed. It is expected that the dietary diversity score and nutrient intakes of children will increase.

# NON-COMMUNICABLE DISEASES

## Improving knowledge of prevention of non-communicable diseases among children in Morogoro, Tanzania

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Diet-related non-communicable diseases (DR-NCDs) used to occur in adults, but are now seen in children too due to the growing burden of obesity. Two-thirds of premature deaths in adulthood from DR-NCDs result from unhealthy behaviors established at school age and adolescence. DR-NCDs increase simultaneously with overweight and obesity due to physical inactivity; diets with high amounts of sugar, fats, and salt; inadequate fruits and vegetables, alcohol intake, and smoking. Hence, knowledge of the prevention of risky behaviors is the key for health promotion. The school provides opportunities for health promotion among children; however, DR-NCDs are not featured in the normal school curriculum and children's current knowledge may be low. This creates a need to develop an intervention for enhancing knowledge without interrupting the normal school curriculum activities. The aim of this project is to assess the prevalence and knowledge gap for designing an intervention to improve knowledge of the prevention of DR-NCDs to cover the identified gaps. A pre- and post-training study will be conducted in the Kilimanjaro region using qualitative and quantitative methods among secondary school students aged 10-17 and their respective teachers. Face-to-face interviews will be conducted among students using questionnaires to establish knowledge gaps on prevention of DR-NCDs. Blood pressure, blood glucose, nutrition status and dietary intake will be assessed using standard procedures. Key informant interviews will be conducted among teachers to capture information on any DR-NCDs prevention actions that are in place and suggest the best ways of imparting knowledge to students. After identifying knowledge gaps, a training program will be prepared and conducted. Finally, post-training evaluation will be conducted using a post-training questionnaire.



# OTHER ACTIVITIES

One of the major aims of the Nestlé Foundation is the transfer of sustainable capacity-building knowledge to low-income countries through the promotion of nutrition research. Only local capacity with meaningful equivalent partnering assures sustainable local improvement. Despite the interconnected, economically globalized world, each region and country has its particular cultural and societal food-related characteristics, which have to be preserved. Heterogeneity in culture, education and food assure innovation and sustainability. During 2022 the main activities focused on continuing support of nutrition research projects, and only a few general and specific capacity-building activities were supported, to the extent allowed by the local COVID-19 situation. There is evidence of potential negative long-term consequences of COVID-19 on research in Africa. The Foundation again demonstrated flexibility in all kinds of assistance according to local situations and circumstances.

# CAPPA



## DISSEMINATION OF RESEARCH RESULTS      NFR4D STUDIES

As the world recovered from COVID-19, scientific conferences started to take place in person again. As in pre-pandemic times, the Foundation supported young researchers and PhD students from Africa, allowing them to attend courses (such as the African Nutrition Leadership Programme, ANLP) or international scientific conferences such as the International Union of Nutritional Science (IUNS-ICN 2022) meeting in Tokyo. Unfortunately, Foundation-supported scientists from different African countries could not attend the IUNS-ICN conference due to not completely comprehensible visa restrictions. Fortunately they were able to present their research findings thanks to prerecording of their talks and presentations.

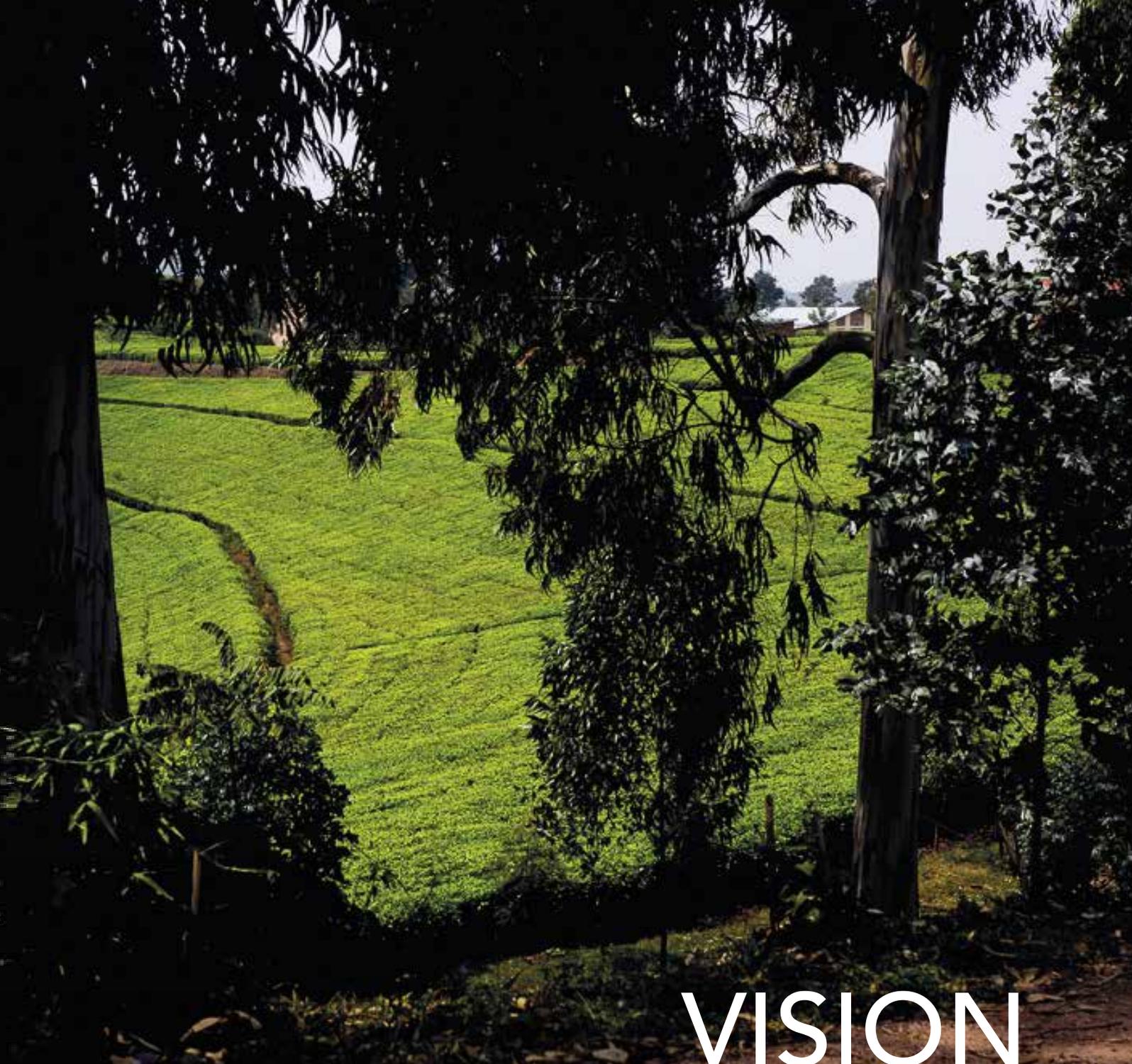
As in the past, during this reporting period the Foundation has continued to cover publication fees and page charges in different journals for research projects supported by the Foundation.

The ongoing NFR4D project at USSEIN University in Senegal is advancing, and the whole USSEIN and multidisciplinary as well multi-institutional collaborative team made progress in the further institutional development as well as the planned research project. It seems that thanks to the motivation and efforts of the whole Senegalese team, they have largely been able to compensate for the COVID-19 induced delay and gap. The planned study entitled "Development of complementary foods based on local products to improve iron status of school-age children in Senegal" should start in the local school in Kaolack with field activities in fall 2023.



The world is in turmoil and haunted by increasing warfare with devastating political, social, cultural and economic consequences. These developments of the last months have led to more hunger, more displacement of millions of people, and rampant poverty the world over. Financial means are rechanneled, leading to a further increase in the hunger funding gap with disastrous local and global consequences. The fight for food and land promotes large-scale land acquisitions, leading to more food insecurity and environmental deterioration, as outlined by Prof. Marc Mueller based on a time-trend analysis of land acquisitions during recent years. Understanding historic issues, such as those outlined by Prof. Bjornlund and

colleagues, might help to understand the basis of persistent and increasing food insecurity in the Sub-Sahel and assist in implementing causal solutions. Dr. Christina Berti and colleagues bring us back to our daily work by addressing the nexus between child malnutrition, food systems, and climate change. The fourth article in this section by Prof. Jananee Muralidharan and Prof. Anura Kurpad using the example of iron deficiency reminds us all, not to forget physiology and food. Nutrient supplements should not be confounded with food and, as we should know, a pharmacological approach will not solve the problems of nutrition. It is time to give food a chance – as the authors mention.



# VISION

LARGE SCALE LAND ACQUISITIONS

CONTINUED FOOD INSECURITY

MALNUTRITION, FOOD SYSTEMS, & CLIMATE

IRON DEFICIENCY: BEYOND THE NUMBERS



# LARGE-SCALE LAND ACQUISITIONS

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## THE HIDDEN COSTS OF LARGE-SCALE LAND ACQUISITIONS: THREATS TO FOOD, WATER, AND ENVIRONMENTAL SECURITY

Large-scale land acquisitions by foreign investors have become a global phenomenon, with over 45 million hectares of land—approximately the size of Morocco—acquired through transnational deals for logging and agricultural production since the turn of the century. This phenomenon has accelerated since the late 2000's when interconnected shocks in climate, food production, and international finance led to the emergence of what many describe as a “global land rush”, which is bound to be exacerbated in the wake of rising food prices and ongoing global supply chain disruptions due to COVID and the war in Ukraine<sup>1</sup>. While proponents of these acquisitions argue that multinational companies are better positioned to improve production and increase crop yields, those who oppose the acquisitions argue that they encroach on natural resources, lead to displacement of local farm workers, and can have a negative impact on local residents, including giving rise to livelihood losses, social instability, and violence in those regions.

To evaluate that tradeoff, we conducted a series of studies<sup>2-4</sup> focusing on 160 large-scale land acquisitions across four continents between 2005 and 2015. The studies used satellite imagery, agricultural surveys, hydrological modeling, and

household dietary datasets to determine the impact of the land acquisitions. The results showed that large-scale land acquisitions by foreign investors aimed at improving global food security have often had sizable detrimental impacts in terms of food, water, and environmental security for local communities.

In some regions such as Latin America and Eastern Europe, where countries are considered middle-income, investors purchased land in intensified agricultural areas where crops were already export-bound, and local residents already consumed food from global markets<sup>2</sup>. As a result, these land deals did not change much and did not increase crop production or cause more damage to local food insecurity than what was already taking place. However, in Africa and Asia, the research showed that land acquisitions increased the area of land under commercial agriculture<sup>2</sup>. The ensuing transition from local staple crops such as cassava and millet to export-bound crops such as wheat and flex crops for potential use as biofuel likely caused a negative impact on household diets<sup>1</sup>. We persistently observed a marked decrease in the dietary diversity of children in communities surrounding the acquired land<sup>2</sup>.

Moreover, the land acquisitions have also led to the depletion of water resources in many areas, threatening water security and food production. For instance, the Omo River in Ethiopia, which flows into Lake Turkana, has sustained the livelihood of tribal populations for hundreds of years. However, large-scale land acquisitions in the region could threaten water resources hundreds of kilometers downstream and affect local farmers and indigenous populations living along the Omo<sup>3</sup>.

Using hydrological models to simulate the future cultivation of the 160 considered land deals and the water needed to irrigate those crops, the studies found that water use in close to two-thirds of the deals will be unsustainable, causing competition for water resources. As commercial agriculture depletes water resources, independently owned farmlands and local populations will be left without sufficient water<sup>3</sup>. Blue water scarcity creates competition with local water users, leaving all the communities that rely on the same water without enough for their own crops.

While these acquisitions may be targeted at agriculture in response to global food crises and a growing interest in renewable fuels, they also pose a threat to biodiversity and forest cover in the Global South. Using high-resolution satellite data, we quantified where forests were being removed and whether rates of forest loss were significantly higher within land investments. For land investments in Asia, there was a significant jump in the rates of loss after the acquisition of land<sup>3</sup>. In many deals in Africa we found that the enhanced forest loss tends to happen

before the land acquisitions occur, suggesting that these investments may be taking advantage of places where there has already been clearing<sup>4</sup>.

Finally, we also sought to understand what would happen to the biodiversity of vertebrate species (amphibians, mammals, reptiles) in areas that have been placed under contract but have not yet been fully exploited for their intended agricultural use. We found that 91% of the investments would be expected to result in a decline in species richness, with 39% of land deals falling at least partially in biodiversity hotspots<sup>4</sup>. This places these areas at high risk of biodiversity loss and highlights the need for these factors to be considered when foreign land investments are made.

To mitigate the negative impacts of large-scale land acquisitions, there needs to be greater transparency and accountability in the process of acquiring land. Governments and investors should ensure that the rights of local communities are respected and that they are adequately compensated for any loss of land or resources. There should also be a greater emphasis on sustainable land use practices that prioritize the needs of local communities and the environment.

In conclusion, large-scale land acquisitions by foreign investors aimed at improving global food security have often had significant negative impacts on local communities. While they may increase the area of land under commercial agriculture, this can lead to a decline in dietary diversity, water scarcity, deforestation, loss of biodiversity, and displacement of local communities. Greater transparency, accountability, and sustainable land-use practices are necessary to mitigate these negative impacts and ensure that the rights of local communities are respected.

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# CONTINUED FOOD INSECURITY

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## WHY FOOD INSECURITY PERSISTS IN SUB-SAHARAN AFRICA

The phrase 'food security' was introduced in 1974 following the Sahel and Darfur famines. The concept initially focused on the production and availability of sufficient food. However, these and subsequent famines were caused by government failure to manage storage and distribution systems in response to regional droughts. The definition of food security now encompasses physical and economic access to sufficient, safe, and nutritious food to meet people's dietary needs and preferences for an active and healthy life.

Prior to colonial times, food insecurity in sub-Saharan Africa (SSA) was generally transitory and caused by droughts, floods, pests, or conflicts<sup>1,2</sup>. Complex

endogenous agricultural, social, and trading systems interacted to mitigate food shortages, including extended family networks. Agricultural water management played an integral part in this system.

In a recent article<sup>3</sup>, we substantiated that today's food insecurity and poverty are linked to the colonial focus on export crop production and the integration of African farming into global agricultural production systems. This process disrupted the complex endogenous production systems, including the extensive areas of productive land under agricultural water management. Maize became a dominant staple even though it is low in essential amino acids. It was encouraged as it provided more calories per unit of land than the traditional staples of millet and sorghum and it was less labour-intensive. Hence, more land and labour were released for export crop production.

The focus on export production continued post-independence. In combination with the delivery of US-subsidized grain as part of development aid, African nations' dependency on imports increased and their food supply became vulnerable to global events such as commodity price fluctuations, exchange rate manipulations, climatic adversities, and supply chain disruptions.

Industrial and large-scale mechanized production systems aimed at increasing productivity, such as those introduced by the Green Revolution, focused on developing varieties—mainly of maize, wheat, and rice—that produced high yields in response to the intensive use of petrochemical inputs and water. These crops were often not the preferred staple foods and were less nutritious than traditional varieties and staples. Traditional rainfed crops, such as pulses and small grains, were neglected. Current attempts to improve nutrition by artificially adding vitamins in the milling process seems inappropriate as existing village mills are incapable of doing this. Transferring processing to larger mills will increase costs and transport, take business away from the villages, and place the access to nutritious food out of reach for those who need it most. Large-scale mechanized production of food or non-food crops for export, such as sugar and cotton, has also reduced the demand for labour. In combination, these developments have reduced the production of preferred nutritious staples and leafy greens, forced smallholders off their land, and reduced labour demand in rural areas. This has reduced both physical and economic access to food and resulted in migration to urban slums and across borders, where there are poor and insecure livelihood options.

Considering that up to 80% of the rural population in SSA depends, at least in part, on smallholder

production for food security and income, the process of reducing poverty and increasing food security must start by integrating smallholders' production into the local market economy. Stimulating rural economic growth opens opportunities for producers to value add and generate local jobs and business opportunities<sup>4</sup>. In SSA, this cannot be achieved by using imported inputs to increase yields<sup>5</sup>. Locally available and cost-effective approaches are needed<sup>6</sup>, such as intercropping, integration of nutritious traditional crops, crop-livestock integration, regional grain storage facilities, financial and nutritional literacy training, and value-adding processes. These approaches require strong community engagement and accountability in governance structures, especially supporting the role of women; extension services; and market integration, enabling farmers to make their crop selection in response to market signals.

In the long term, it is unlikely that all smallholders can become viable, and land consolidation is needed to allow productive farmers to expand and specialize. This process is politically sensitive in SSA where private land title is uncommon, and many unviable farmers are reluctant to forego customary land rights due to the complex set of benefits derived from farming and the lack of alternative livelihood options. Forcing the process would generate a wave of rural to urban migration. Land consolidation therefore needs to take place in tandem with the creation of alternative livelihoods and land reforms providing smallholders with secure land tenure.

It has been widely argued that agricultural production in SSA has underperformed since independence and per capita production has declined. If the objective of increased production is food security and poverty reduction, it is critical that we consider how best to measure agricultural production and access to food. Organizations such as FAO measure agricultural production in monetary terms, which is largely based on remote-sensing and economic estimates. In SSA, lack of data about regional production and trade and the predominance of informal markets neglects the importance of smallholders, which makes such measures highly unreliable and speculative. Further, a sole focus on monetary value disregards the complex system of benefits which are derived from agricultural production: for example, farming and home gardens producing food for home consumption, the sale of surplus produce to cover other household expenses, and homesteads providing a place to live. Evaluating the adequacy and growth of agricultural production solely in monetary terms is, therefore, an inadequate approach to informing agricultural policies to eliminate poverty and food insecurity.

In closing, five critical interventions are needed to change the current trajectory of increased poverty, food insecurity, and malnutrition:

- i) measures of food and agricultural production which incorporate the ability of the agricultural sector to meet local food and nutrition needs, generate local economic development, and reduce impacts on ecosystems;
- ii) solutions to release African nations from their crippling debts and the restraints on their ability to develop agricultural policies in pursuit of local health, education, and nutrition objectives;
- iii) realistic and manageable mechanisms to finance urgent public investments;
- iv) international trade agreements to prevent the dumping of subsidised food in Africa; and
- v) data collection and governance structures to facilitate the integration and monitoring of domestic food production, storage, and distribution systems, and connect farmers to domestic supply chains and local value-adding processing.

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# MALNUTRITION, FOOD SYSTEMS & CLIMATE

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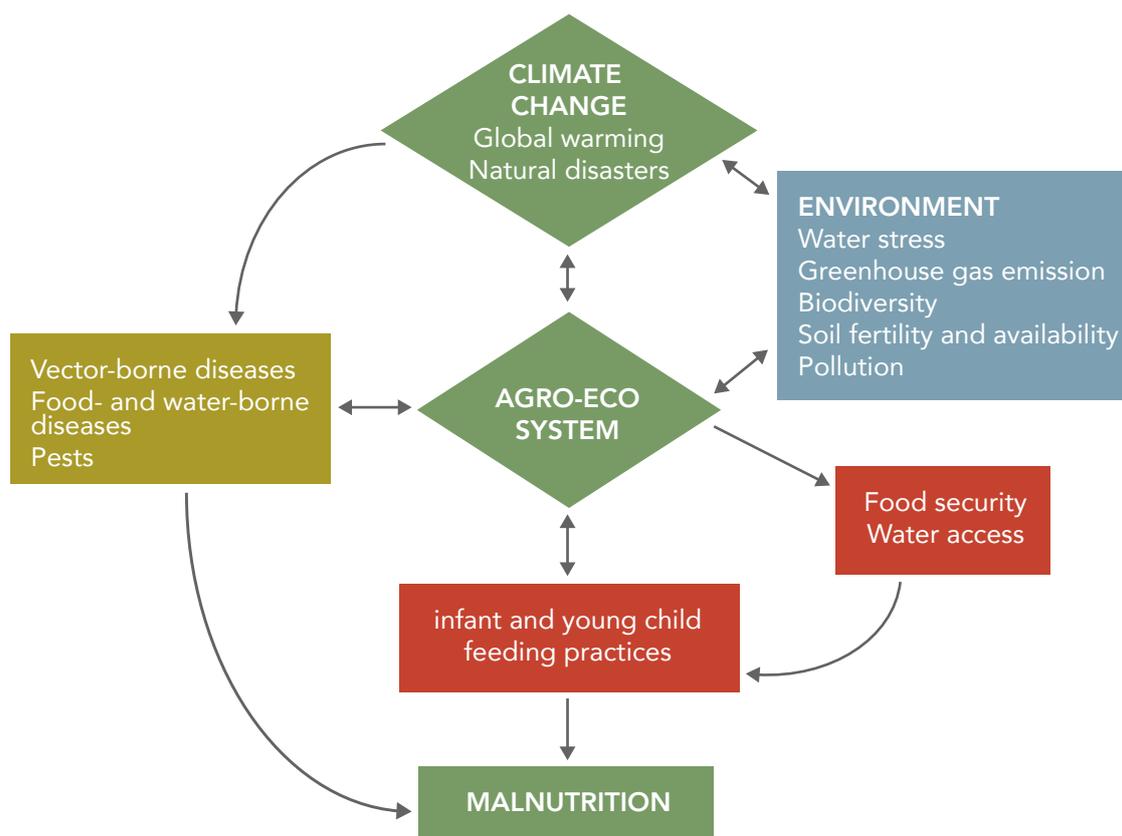
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## THE INTERLINKAGES BETWEEN CHILD MALNUTRITION, FOOD SYSTEMS, AND CLIMATE CHANGE

Child malnutrition continues to be a societal challenge that exacerbates inequalities and exerts short- and long-term effects on individual health. The way global warming and current food systems interact with each other may help explain persistent high rates of child malnutrition<sup>1</sup>. Governments, civil society, and private sectors that participate in food system-related policymaking are trying to put in place measures to tackle obesity, undernutrition, and climate change. These three elements are considered the pandemics that constitute what has been termed the global syndemic<sup>2</sup>. Nevertheless, two questions remain unanswered. To what extent are current policies capable of creating a favorable and tailored environment for food systems that promote the health of children aged 0-23 months? Notably, are purely market-oriented approaches able to stimulate demand for a nutritionally adequate food environment that addresses the needs of children aged 0-23 months?

**Figure 1**  
The interlinkages between malnutrition, food systems, and climate change.



The emerging double burden of malnutrition in both high-income countries and low- and middle-income countries (LMICs) affects the paediatric populations and translates into the coexistence of undernutrition along with overweight, obesity, and other diet-related non-communicable diseases. Figures about these trends over the globe remain alarmingly high among children under five years. In 2020, 45.4 million suffered wasting; at least 340 million suffer from micronutrient deficiencies, with the highest prevalence in LMICs<sup>3</sup>; and the proportion of overweight has risen in LMICs from 33 million in 2000 to 39 million<sup>4</sup>. International authorities set recommendations for Infant and Young Child Feeding (IYCF)<sup>5</sup> to tackle malnutrition in all its forms, but breastfeeding rates and duration remain suboptimal across the globe (only 42% of children under the age of six months are breastfed).

Nowadays, most hotly debated issues revolve around decision-making that promotes environmentally healthy, sustainable dietary patterns able to both tackle malnutrition and halt the worrying climate change trends. The food-system approach came into prominence in the last decade with a twofold objective: to cast the spotlight on food systems' actors, mechanisms, and policies involved in the establishment of food supply chains "from farm

to fork"; and to create the rationale to implement corrective measures for governments, civil society, and the private sector to counter malnutrition and the current unsustainable patterns of food consumption and production that engendered the triple planetary crises of climate change, biodiversity loss, and pollution.

Although the holistic food-system approach allows an analysis of the elements that impact specific interconnected issues (e.g. malnutrition and climate change), existing food systems policies do not address specific age groups' needs, such as those of children aged 0-23 months<sup>1</sup>. To date, only the UNICEF and GAIN's Innocenti framework<sup>4</sup> have linked food systems to children's and adolescents' well-being. However, the framework does not entail specific guidelines regarding policy to enable environments that promote children's diets.

The relations between food systems, nutrition, and the climate are complex, with environmental changes acting as both a driver and an outcome of food systems (figure 1)<sup>6</sup>.

Among drivers, agricultural fields occupy nearly 40% of global land, and food production is responsible for up to 30% of global greenhouse

gas (GHG) emissions and 70% of freshwater use<sup>7</sup>. From 2000 to 2016, GHG emissions from livestock increased by 14% and that from poultry by 58%<sup>8</sup>. A remarkable amount of food (13%) continues to be lost post-harvest, before reaching retail markets, or is wasted (17%). At the consumer level, this figure is estimated to amount to 121 kg per person each year<sup>9</sup>. As to formula feeding, the production of 1 kg of milk powder uses 4,700 L of water and emits 21.8 kg CO<sub>2</sub>-eq of GHG<sup>10</sup>. Exclusive breastfeeding could save 105,280 L of water and 488 kg CO<sub>2</sub>-eq. Furthermore, the environmental cost of infant formula includes the deforestation of land, loss of biodiversity, the extensive use of materials for packaging, the high-demand use for energy resources in manufacturing, and GHG emissions from transportation.



The outcomes of climate change bring devastating effects to the agro-ecosystem and food and nutrition security, worsening YCF practices and intensifying nutrient deficiencies, chronic undernutrition, and vulnerability among children<sup>1</sup>. These effects are amplified in low-income food-deficit countries<sup>11</sup> due to the inability of markets to supply agricultural products, including livestock, to the entire population.

Recent cycles of droughts and cyclones in Latin America have caused a coffee crisis in Honduras, a loss of almost 80% of the maize harvest in Guatemala, and a 50% drop in the sorghum, sunflower, and corn harvest in Mexico. In 2019, cyclones destroyed crops, seed stock, fisheries, and infrastructure across Mozambique, Malawi, and Zimbabwe. Sub-Saharan countries lost 20–60% of animals during the past two decades on top of the reduction of cereal production due to recurrent and prolonged droughts. In Asia, a 50% decrease in rice yields and a 30% drop in wheat and maize yields are forecast by 2100<sup>12</sup>. Increasing temperatures cause pests to spread to new locations and affect further crop yields<sup>13</sup>. In India and sub-Saharan Africa, drought conditions are associated with underweight and wasting prevalence<sup>14</sup>. In the global tropics, the underweight prevalence increased by 0.6 percentage points per 1°C as a consequence of the warmer El Niño Southern Oscillation<sup>15</sup>.

Food quality is also directly affected due to the rising levels of carbon dioxide that diminish protein concentrations in wheat, barley, rice, and potato crops<sup>16</sup>, and long-chain polyunsaturated fatty acid content and iron in seafood<sup>17,18</sup>. Global warming makes tropical, temperate, and arid forests vulnerable, and nearly 23% of intact forests have now reached a critical threshold<sup>19,20</sup>. The changing conditions of climate also favor the spread of vector-borne, foodborne, and water-borne diseases, particularly threatening children<sup>21</sup>. WHO estimates that climate change will cause an additional 48,000 deaths in children under 15 years due to diarrheal disease by 2030<sup>22</sup>.

Multi-sectoral and radical changes involving the public and private sectors, civil society, and non-governmental organizations are needed to rethink food systems, halt climate change effects, and tackle child malnutrition. Governments and donors must promote climate-resilient agriculture and IYCF practices<sup>23</sup>. Improving access to safe water and sanitation and strengthening the health systems in LMICs can reduce the risk of water-borne diseases and advance nutrition screening and services<sup>24,25</sup>. A food system recalibration is mandatory for the planet and human health. A switch toward a healthier and more sustainable dietary pattern, a waste reduction in the production-consumption cycle, pricing policies, and safety social nets are fundamental actions to decrease child malnutrition in critical areas.

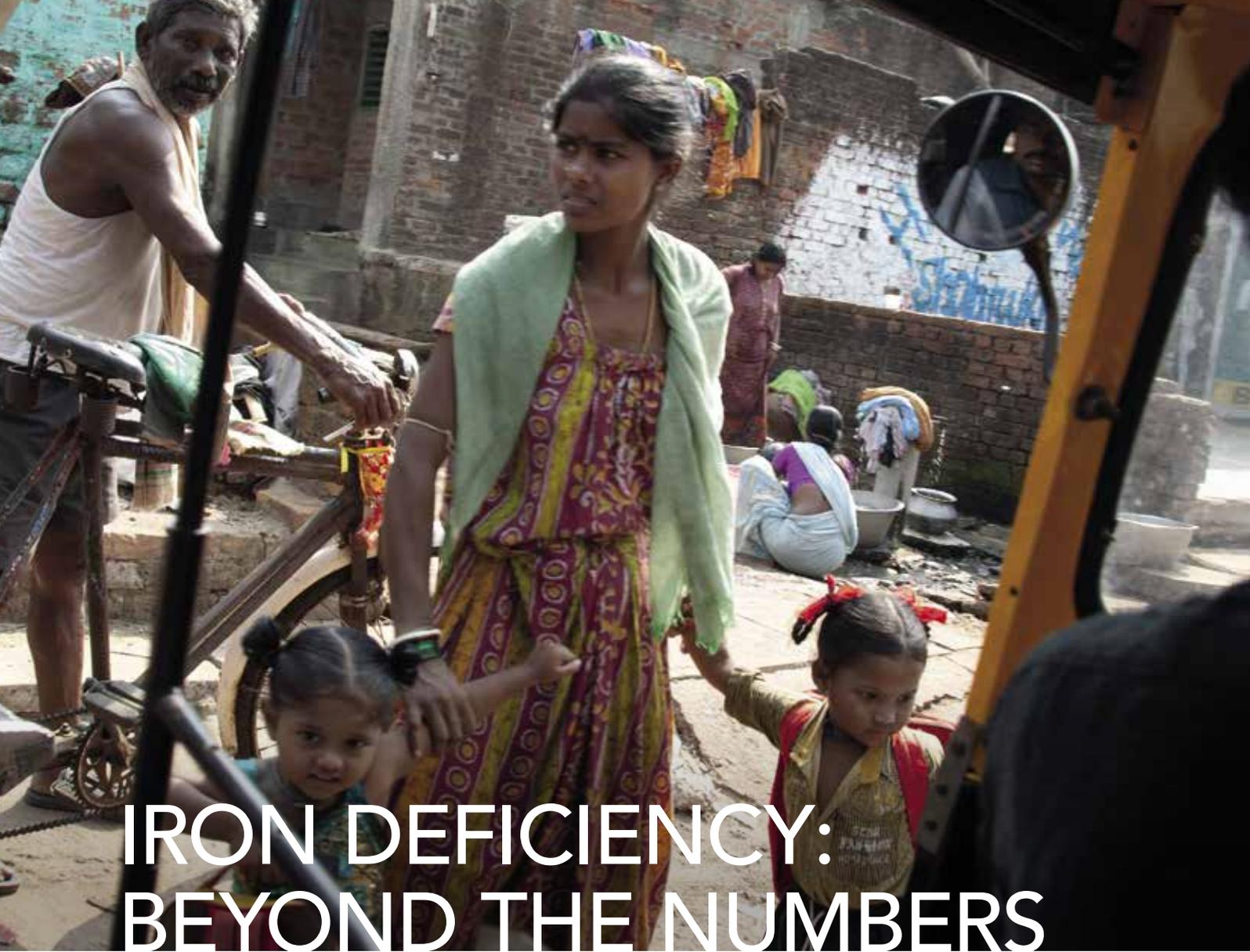
Time is running out! Countless children's lives depend on our ability and readiness to achieve all of these changes.

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# IRON DEFICIENCY: BEYOND THE NUMBERS

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## IRON DEFICIENCY ANAEMIA IN INDIA: LOOKING BEYOND THE NUMBERS

### Anaemia in India: An Incomplete Picture

The National Family Health Survey (NFHS), conducted every five to ten years, gathers essential health data and chronicles trends in the state of health of the country. In contrast to the previous NFHS-4 conducted in 2015-2016<sup>1</sup>, the most recent NFHS-5 conducted in 2019-2021<sup>2</sup> revealed that anaemia prevalence has changed in an apparently unfavourable way, rising from 53.2% to 57.2% in women of reproductive age (WRA) and from 58.6% to 67.1% in children. There may be many reasons for this.

The haemoglobin (Hb) cut-off used to diagnose anaemia may be excessively high for India given that the current WHO Hb cut-off is derived from the statistical analysis of the Hb distribution in Western healthy populations (fifth percentile of the normal distribution)<sup>3</sup>. This is a crucial factor to consider when interpreting the NFHS data. If India-specific cut-offs culled from our demographic data were applied, the national anaemia prevalence may be lower<sup>4,5</sup>.

The NFHS-5 collected data from 707 districts with representation of all 28 states and eight union territories in India across the two phases. Despite this granularity, the aetiology of anaemia was not documented and the method of Hb estimation used may be technically flawed as capillary blood samples from a finger prick or heel prick were used instead of venous blood. This flaw is illustrated in a study from Uttar Pradesh, which showed that for simultaneously measured blood samples in WRA, the anaemia prevalence using capillary blood was 59.2% as compared to 35.2% when using venous blood<sup>6</sup>. This difference was also observed in another national survey in Indian children (called the Comprehensive National Nutrition Survey, CNNS), which was carried out in 2016–2018<sup>7</sup>. Here, a venous blood sample was utilised for Hb estimation, and the results showed a lower prevalence of anaemia, roughly half (30.7%), than that predicted by the NFHS in the same population<sup>1,2</sup>. Additionally, in CNNS, iron deficiency (ID) was found as a cause for anaemia in only 30% or lower in the population studied, and counter-intuitively ID was higher in an urban, wealthy population.

### The way forward

#### *Delink nutrient supplementation policies from simple anaemia prevalence*

The current strategies to tackle the high prevalence of anaemia have focused on increasing iron consumption, since dietary ID is thought to be the main contributor to anaemia. However, as the CNNS data shows, the causes of anaemia are multifactorial<sup>7</sup>. Possible deficiencies of protein and other erythropoietic elements like folate and vitamin B12, in addition to hereditary causes like thalassemia and sickle cell anaemia, are also crucial. Poor hygiene and environmental factors like air pollution with PM 2.5 particles may also be contributing factors to the prevalence of anaemia<sup>8,9</sup>.

Despite this, multiple simultaneous interventions to boost only iron intake, like the mandatory iron fortification of rice; voluntary iron fortification of salt, wheat and commercial food products; and weekly supplements of iron-folic acid (IFA) tablets to children and WRA, have been introduced to overcome the perceived ID in the population<sup>10</sup>. None of these might work to expectations: for example, studies using the stable isotopic method in toddlers have shown that as iron absorption from the diet increases, the iron losses increase proportionally<sup>11</sup>. Even in children with ID, while supplementation increased iron absorption by 3.8 fold, it was followed by a 3.4 fold higher increase in losses<sup>12</sup>. In addition, a systematic review of all trials performed with fortified rice concluded that it is unlikely to prevent anaemia in the population<sup>13</sup>.

### Stop unbalanced policy initiatives

Policy initiatives that target single specific nutrients, like iron, in response to anaemia, without any knowledge of cause, or any knowledge of whether dietary iron is inadequate, is a knee-jerk reaction backed by weak evidence. Instead, innovative solutions which introduce precision in public health such as economical point-of-care devices to enable specific aetiological diagnoses of anaemia with appropriate interventions at the individual level must be sought.

An over-enthusiastic unbalanced layering of identical nutrient interventions to boost intake, as in the case of iron, also has its own dangers. (14) One clear danger is that excess iron intake and increased body stores (ferritin) can increase the risk of diabetes or dyslipidaemia<sup>15</sup>. Excess iron can also increase oxidative risk to those with hereditary anaemias<sup>16,17</sup>, and adversely affect the composition of the microbiome in children who eat iron-fortified food<sup>15</sup>.

### Give food a chance: it is the most pragmatic way forward.

The current Indian recommendation for the daily iron requirement for WRA is 15mg/day, and this is easily satisfied through a balanced diverse diet. A case in point for food versus specific nutrients is the recent finding that the cessation of the midday meal during the one-year COVID lockdown, in 2020–2021, resulted in an increase in anaemia prevalence in South Indian school children; yet the prevalence of iron deficiency did not increase during this period in these children. This demonstrates the importance of a mixed diet supplying multiple erythropoietic micronutrients and favours whole-food over single-nutrient supplementation<sup>19</sup>.

### Don't forget the environment

A negative association between anaemia prevalence and improved sanitation has been observed, suggesting that poverty alleviation, with improvement of hygiene, and adequate prevention and treatment of childhood helminthic infections, is a critical part of reducing childhood anaemia prevalence<sup>20</sup>. This role of subclinical inflammation is supported by data from the CNNS, which shows that inflammation and 'other' unknown causes, rather than just nutrient inadequacy, were major contributors to prevalence of anaemia in primary school students and adolescents<sup>7</sup>.

### The future

Future anaemia-prevention strategies must focus on precision, moderation, and community involvement through education. As the nature of anaemia is heterogenous, a one-size-fits-all interventional approach must be eschewed in favour of implementing precision in public-health strategies

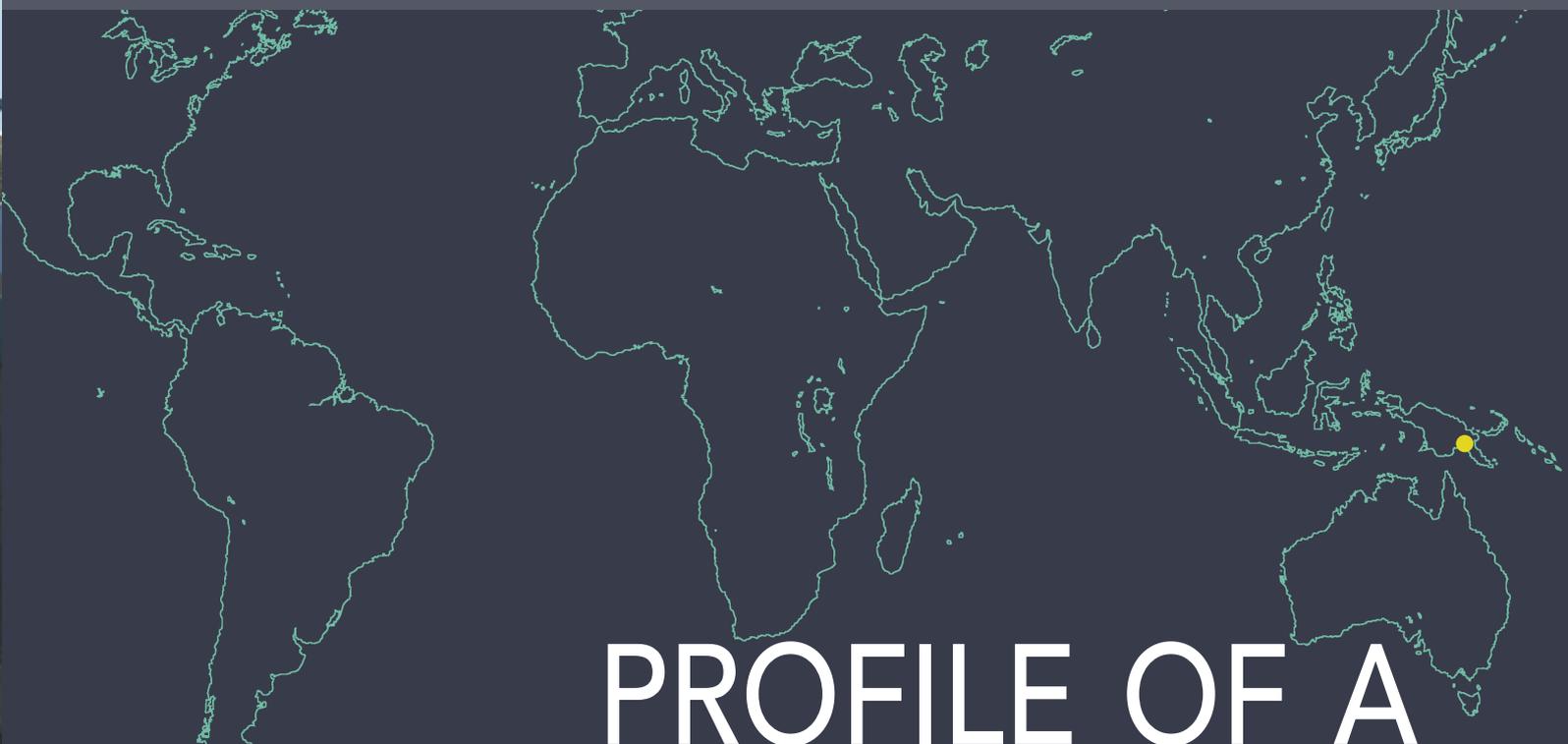
to maximise benefit to the vulnerable population and minimise risk to the healthy population. Instead of the popular and ever-present lament and focus on iron as a silver bullet, multipronged strategies like diversification of diet, identification and correction of the cause of anaemia, and overall improvement in hygiene and sanitation must be practiced.

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# PROFILE OF A NUTRITION INSTITUTE



# PAPUA NEW GUINEA

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Executive Officer, New Ireland PHA

## PAPUA NEW GUINEA: RICH CULTURES, LANGUAGES AND RESOURCES—BUT POOR NUTRITION

Papua New Guinea (PNG) is in the southwestern Pacific, bordering Indonesia and just north of Australia. Both in size and population, it is one of the largest countries in the Pacific region. PNG has a high fertility rate and rapidly growing young population totaling around nine million. Its cultural, geographic, and nutrition situations make nutrition development challenging.

PNG's cultural riches include about 850 tribal groups and over 800 languages, but this diversity, combined with strong tribal identities, leads to complex cultural dynamics. The large gender gap also contributes to these cultural forces, making gender-based and other family violence major social determinants of health, with profound impacts that exacerbate socioeconomic challenges facing many vulnerable groups. Education levels are still low and only rising slowly, with the educational gender gap possibly increasing.

PNG's rugged geography is rich in natural resources, with 80-85% of its population in remote rural areas in four geographic regions. The southern and northern coastal regions are mostly riverine and swampy, with some higher, drier land as well. The islands region is made up of island of different sizes, some volcanic and others small, isolated atolls. The highlands region is the most populous and rugged. These regions are connected only by a few roads, with small dinghies necessary in riverine areas, and the islands only reached by sea or air. Only a few

# PAPUA NEW GUINEA

## AREA

Total:	462,840 km <sup>2</sup>
Agricultural land:	2.6%
Arable land:	0.7%
Forest	63%

## POPULATION

Total (July 2022 est.):	10,329,931
Urban population (2012):	13.7%
Under age 15:	52%
Median age:	24 years (Male 24 years / Female 24 years)
Net migration rate (per 1000) (2022 est.):	0
Rate of urbanization (annual rate of change, 2021 est.):	2.9%

## POPULATION GROWTH RATE

Total (2018 est.):	2.35%
Total fertility rate (2022 est.):	3.92 children born/ woman

## GDP

(per capita, PPP) (2019 est.):	USD 2,742
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## LIFE EXPECTANCY AT BIRTH

Total: 69.4 years
Male: 67.7 years / Female: 71.2 years

## MORTALITY RATES

Neonatal mortality rate:	21/1000
Infant mortality rate (at birth):	36.9/1000
Under-five mortality rate:	43/1000
Maternal mortality rate (2017 est.):	145/100,000 live births

## MICRONUTRIENT DEFICIENCIES

Households consuming iodized salt:	60%
Vitamin-A two dose coverage:	34%
Children under the age of 5 years underweight (2009/11):	27.8%

## OTHER PARAMETERS

Population below poverty line:	40%
Rate of urbanization (rate of annual change):	2.9%
Mother's mean age at first birth (2016 est.):	21.9 years
Contraceptive prevalence (2016/18):	36.7%
Health expenditure (% of GDP, 2019):	2.3%
Physician density per 1000 population (2029):	0.07
Immunization, measles (% of children ages 12-23 months, 2012):	38%
Proportion of children < 5 years sleeping under insecticide-treated bed nets:	52%
Total adult literacy rate:	62%
Population using improved sanitation facilities, total:	23.5%
Population using improved sanitation facilities, 2015, urban:	57.8%
Population using improved sanitation facilities, 2015, rural:	18.2%
Adult HIV prevalence rate (2021 est.):	0.9%
Obesity adult prevalence rate 2016):	21.3%
Internet penetration rate (% of the population, est.):	18%
Literacy (total):	64.2%
Early initiation of breastfeeding:	55%
Exclusive breastfeeding:	60%

roads reach large parts of the highland, which are also reached by air, albeit in some districts only via small airstrips, and then by foot.

This geography presents logistical and technical challenges to health-service access and delivery and data collection, making it impossible to obtain representative statistical health and other development surveillance for the country. The most recent Demographic and Health Survey (DHS) reported only about 13% of births were registered, and most deaths and their causes, particularly in the rural areas, go unregistered.

Epidemiological and nutrition transitions associated with urbanization gradients are proceeding, with the non-communicable diseases mostly seen in urban areas but also already common in peri-urban areas. However, communicable disease, including TB, malaria and undernutrition, still dominate the rural areas, with the fourth highest rate of stunting globally. Today's mostly urban diabetes was first diagnosed in the 1960s.

With such formidable social determinants of health, the already overwhelmed and fragile health system is weak, especially with respect to nutrition. Development benefits rarely reach the less educated rural and some urban poor. The health statistics are hardly improving. With about 43% of rural health posts closed, primary health care has been discontinued for most in those areas. Most recently, resources have been diverted from other diseases and maternal and child health to respond to COVID-19.

PNG nutrition should play a positive role in health and development. However, PNG diets depend on a food system currently unable to supply foods and diets adequate for optimal health. Many of the rural and also the urban poor are food insecure. The diverse food sources of PNG's dispersed population are primarily traditional for the majority rural population of subsistence farmers, gardeners, and coastal fisher-folk: a starchy staple, sago, on the riverine coasts; sweet potatoes, yams, and taro in other regions; and mostly imported white rice and refined wheat products dominating urban diets. Fishing, agriculture, and forestry provide some protein, most vegetables, particularly greens, and some local fruits, depending on local weather and climate.

However, ubiquitous local, small, foreign-run groceries and some urban supermarkets sell increasingly more mainly imported white rice, wheat flour and refined wheat products, instant noodles, bouillon cubes, tea, sugar-sweetened beverages (SSBs), tinned fish and meat, fresh meats, particularly mutton flaps and sausages, large jugs



of oil, and confectionaries. For many, the diets lack adequate protein. Alcohol, either commercial or home-brewed, is also widely available, with 77% of those who drink identified as binge drinkers, affecting health and exacerbating gender-based and other violence.

The unhealthy food system and lack of primary health care leave many of PNG's people in poor health with little nutrition literacy and life expectancy in the 60s, which is lower and increasing more slowly than in other Pacific Islands. As a result, PNG's unsurprisingly slow development pace is characterized by only gradual economic and social transformations. PNG stunting was estimated to cost more than 2.8% of GDP annually in 2017. Greater household expenditure on sugar-sweetened beverages (SSBs) was found to be associated with under-five childhood obesity.

Despite PNG's National Nutrition Policy 2016-26 and entry to the Scaling Up Nutrition (SUN) movement should be putting nutrition on the national health agenda. However, PNG does not yet have the nutritional infrastructure with the institutional base or human resources to create common ownership of the nutrition problems to massively scale up the outreach into every household to change people's eating habits. There is no system to deliver assessment or educational services or support to most families.

While health care and the healthcare system are key to the promotion of nutrition to the public, including school students, most healthcare professionals in PNG are not trained in contemporary nutrition to play that role. There are no nutritionists or dietitians trained in-country, and only a few staff manage nutrition in the National Department of Health, which lacks a nutrition institute or department. As a result of the increasing dietary globalization without agricultural sector development or nutrition services or a safety net, diet-related chronic diseases make up an increasing share of the causes of death. However, the resulting weak to non-existent nutrition service delivery cannot control the situation.

PNG must mobilize a comprehensive, multi-sectoral, and institutionalized nutritional effort with the sustained implementation, capacity building, expansion, and monitoring needed to realize the full nutrition-development potential of the policies. The University of Papua New Guinea authors of this short piece are doing their best with colleagues to train our medical and public-health students to understand this dire PNG nutrition situation in order to build a group of nutrition-literate health professionals to establish a critical mass who will advocate for better nutrition services and become

service-oriented PNG nutrition leaders, overseeing efforts to turn around the nutrition problems and promote better nutritional health and development for all in PNG.

### References for Further Reading

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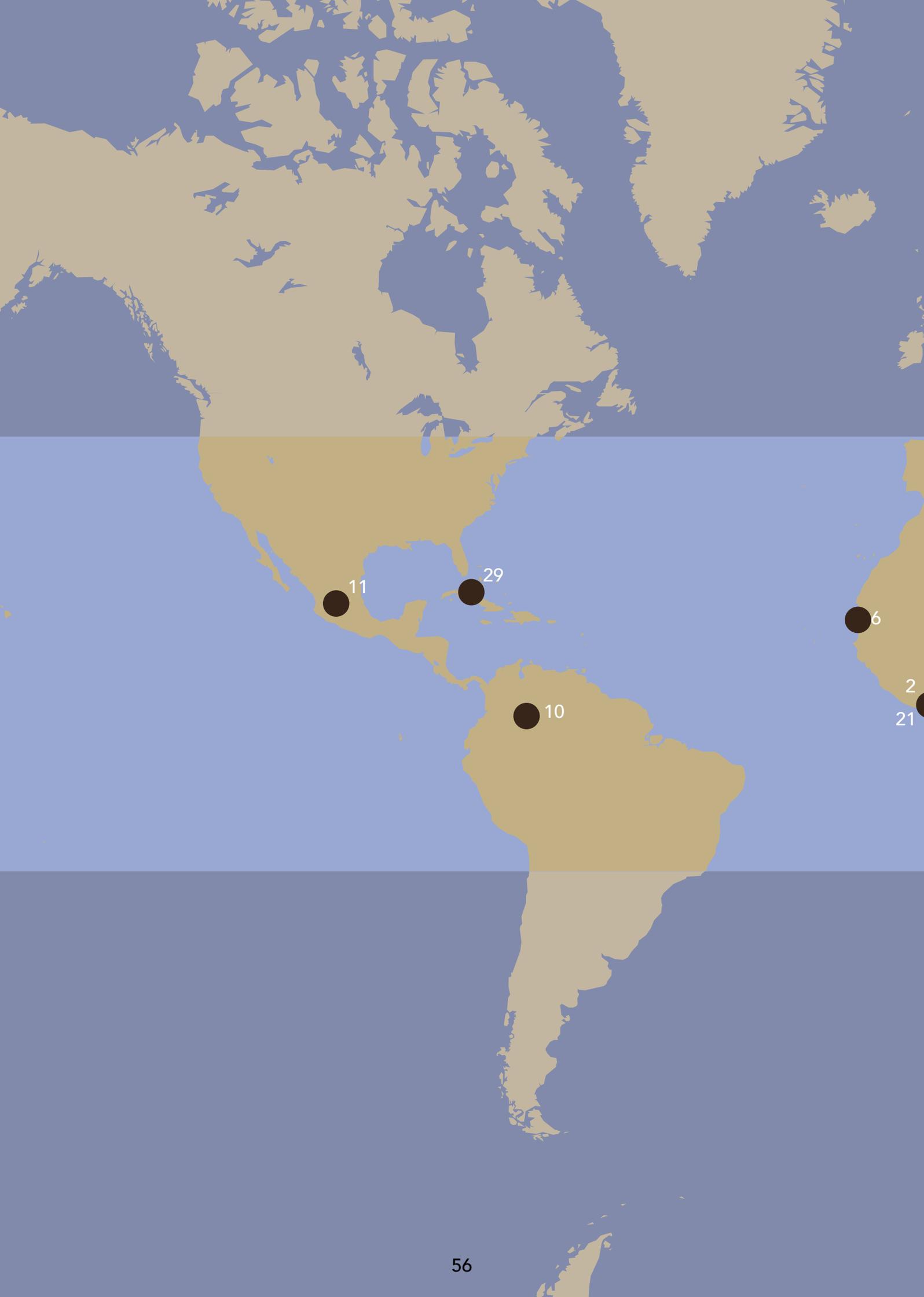
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Olita'a D, Vince J, Ripa P, Tefuarani N. Risk factors for malnutrition in children at Port Moresby General Hospital, Papua New Guinea: A case-control study. *J Trop Pediatr*. 2014 Dec;60(6):442-8. doi: 10.1093/tropej/fmu049. Epub 2014 Sep 17.



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21



# ONGOING PROJECTS



TITLE

PRINCIPAL INVESTIGATOR

MICRONUTRIENTS

- |   |  |  |
|---|--|--|
| 1 | 2019 / Iodine content in salt produced in Mozambique and the producers' knowledge about salt-iodization health benefits                          | Sergio P. Chibute / Eduardo Mondlane University Medical School, Department of Biochemistry, Maputo, Mozambique   |
| 2 | 2020 / Effect of composite foods powder intake on nutritional anaemia and growth status of young Ghanaian children                               | Egbi Godfred / University of Ghana, Noguchi Memorial Institute for Medical Research (NMIMR), College of Health Sciences, Legon, Ghana  |
| 3 | 2020 / Enhancing food literacy among Sri Lankan adolescents: Effect of school gardens in promoting healthy diets, behaviours and knowledge       | Renuka Silva / Wayamba University of Sri Lanka, Department of Applied Nutrition, Makandura, Gonawila, Sri Lanka  |
| 4 | 2022 / Improvement of iron and zinc bioavailability in complementary food of children 6-23 months in South Kivu (DR Congo)                       | Marie Amelie Nabuholo / Université Cheikh Anta Diop, Laboratoire de Recherche en Nutrition et Alimentation Humaine (LARNAH), Département de Biologie Animale, Faculté des Sciences et Techniques, Dakar, Sénégal |
| 5 | 2022 / Impact of the consumption of spirulina on the vitamin-A status of mother-newborn couples: Chadian approach to the traditional food "Dihé" | Imar Djibrine Souly / Biotechnopole Laboratory of INSTA/IRED, National Higher Institute of Sciences and Techniques of Abéché (INSTA-Chad), Njamena, Chad   |

INFANT AND CHILD NUTRITION

- |   |  |  |
|---|--|--|
| 6 | 2018 / Development of complementary foods based on local products to improve iron status of school-age children in Senegal (NFR4D) | Guillaume Antoine Baloucoune (initially awarded to Moussa Ndong) / USSEIN University of Sine Saloum El Hadj Ibrahima Niassé, Bureau de Liaison, Dakar, Senegal |
| 7 | 2019 / Does early initiation of homemade yogurt supplementation prevent stunting: A pilot randomized controlled trial              | Kaniz Khatun E. Jannat / icddr, b, Infectious Disease Division, Environmental Intervention Unit, Dhaka, Bangladesh   |
| 8 | 2020 / Positive deviance in linear growth of children aged 6-23 months in Rwanda   | Jean de Dieu Habimana / University of Rwanda, Department of Human Nutrition, Remera Campus, Kigali, Rwanda   |
| 9 | 2020 / Effect of nutrition education of village doctors on health status of children   | Li Lei / Xiamen University, Public Health School, Xiamen, PR China   |

## INFANT AND CHILD NUTRITION

- 10 2021 / Feeding patterns and growth during the first year of life in a cohort of preterm infants with Extra-uterine Growth Restriction (EUGR) at hospital discharge followed in two Kangaroo Mother Care (KMC) Programs in Bogotá, Colombia  
Nathalie Charpak / Kangaroo Foundation, Bogotá, Colombia
- 11 2021 / Vitamin A bioefficacy of high-provitamin-A carotenoid maize in Mexican schoolchildren  
Verónica López Teros / Universidad de Sonora, Hermosillo Sonora, México
- 12 2021 / Study of effectiveness of a complementary food based on the mixture of locally produced food in the malnutrition prevention of children from 6 to 23 months old in Haut Katanga Province of the Democratic Republic of Congo: Randomized controlled trial (RCT) of the MASO31 recipe in Kapolowe Health Zone  
Emmanuel Ngoy Bulaya / University of Lubumbashi, School of Public Health, Lubumbashi, Congo Republic
- 13 2022 / Formulation of nutrient-rich recipes for complementary feeding of infants and young children in Douala, Cameroon  
Marie Modestine Kana Sop / University of Douala, Department of Biochemistry, Faculty of Science, Douala, Cameroon

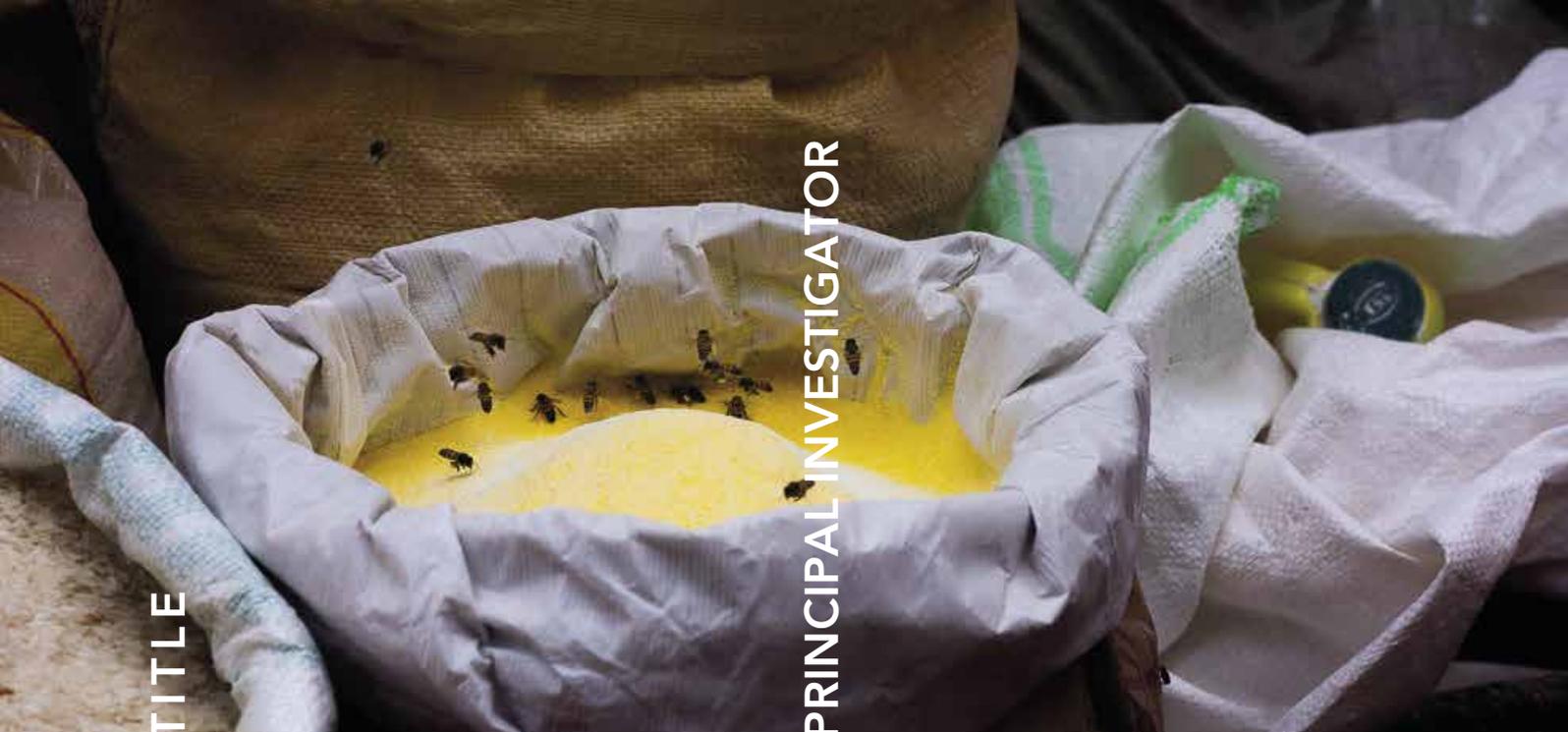
## MATERNAL NUTRITION

- 14 2017 / Underlying causes of poor dietary intake, nutritional status and birth outcomes in pregnant adolescents and adults  
Reginald Adjetey Annan / College of Science KNUST, Department of Biochemistry and Biotechnology, Kumasi, Ghana
- 15 2020 / Folate and vitamin B12 assessment among women of reproductive age in Eritrea: A population-based study 2020  
Kidane Amanuel / Xi'an Jiaotong University, Department of Epidemiology and Biostatistics, Xi'an, Shaanxi, PR China
- 16 2020 / Promotion of exclusive breast feeding and young-child feeding practices through m-Health: A randomized controlled trial  
Rozina Nuruddin / Aga Khan University, Department of Community Health Sciences, Karachi, Pakistan

TITLE

PRINCIPAL INVESTIGATOR





TITLE

PRINCIPAL INVESTIGATOR

**MATERNAL NUTRITION**

17 2020 / An urban picture of overweight, gestational weight gain and pregnancy outcomes among slum and non-slum dwellers in Pune, India

Deshpande Swapna / Hirabai Cowasji Jehangir Medical Research Institute, Pune, India

18 2022 / Effect of breastfeeding education and support provided to male partners on optimal breastfeeding practice in Ethiopia: A cluster-randomized controlled trial

Abageda Mulatu / Wachemo University, Department of Midwifery, Hosenna, Ethiopia

19 2022 / Effects of maternal preconception nutrition on offspring body composition and cognition in adolescence

Nguyen Phuong Hong / Thai Nguyen University of Pharmacy and Medicine, Luong Ngoc Quyen Road, Thai Nguyen, Vietnam

**NUTRITION EDUCATION**

20 2020 / Long-term effects of acute malnutrition on physical function: A 5-year prospective cohort study in Ethiopia

Tsinuel Girma / Jimma University, Department of Human Nutrition, Jimma, Ethiopia

21 2022 / Developing a nutrition educational program for burn survivors in Ghana: A pilot study

Jonathan Bayuo / Presbyterian University College, Agogo, Asante-Akyem, Ghana

22 2022 / Implementing a nutrition training package for rural women farmers in Tanzania

Mbwana Hadijah Ally / Sokoine University of Agriculture (SUA), Department of Human Nutrition and Consumer Sciences, Morogoro, Tanzania

**FOOD SYSTEM**

23 2020 / A methodological framework to transform monoculture to a complex rice system landscape in East Java, Indonesia

Uma Khumairoh / Brawijaya University, Malang, Indonesia

## OTHER RESEARCH AREAS

24	2008 / Causes and control of food insecurity: A pilot model in the northwest of Iran	Saeed Dastgiri / Tabriz University of Medical Sciences, Faculty of Medicine, Tabriz, Iran
25	2014 / A cohort analysis of the sustainability of food insecurity control programs in the northwest of Iran	Saeed Dastgiri / Tabriz University of Medical Sciences, Faculty of Medicine, Tabriz, Iran
26	2016 / Processing and preservation of Moringa oleifera leaves for combating micronutrient malnutrition in Tanzania	Oscar Kibazohi / University of Dar es Salaam, Department of Chemical and Mining Engineering, Dar es Salaam, Tanzania
27	2017 / Designing improved complementary feeding for infant and young children from locally available foods in rural western Ethiopia	Fekadu Gemedo Habtamu / Wollega University, Food Science, Nekemte, Ethiopia
28	2017 / Consumer attitude and perception on consumption of edible insects in western Kenya	Fanuel Kawaka / Technical University of Mombasa, Department of Pure and Applied Science, Mombasa, Kenya
29	2017 / In search of an EEG neural fingerprint of early malnutrition: A 50-year longitudinal study	Pedro Antonio Valdes-Sosa / Cuban Neuroscience Center, Havana, Cuba
30	2020 / Enhancing nutritional benefits and safety of maize to improve the health of Africans	Archileo N. Kaaya / Makerere University, Department of Food Technology and Nutrition, Kampala, Uganda
31	2019 / Factors other than food supply that affect children's nutrition in Mongolia	Sharavkhorol Erdenebileg / National University of Mongolia, The Mongolian University of Life Sciences, Ulaanbaatar, Mongolia
32	2019 / Optimizing household agricultural production for nutrition: Impacts of nutrition education on Zambian households	Kelvin Mulungu / Colorado State University, Fort Collins, Colorado, USA
33	2019 / The effects of psychosocial stimulation on the development, growth and treatment outcome of severely malnourished children age 6-59 months in southern Ethiopia: A cluster randomized control trial (EPSoSAMC Study)	Tesfalem Teshome / St. Paul's Millennium Medical College, Human Nutrition, Ethiopia

TITLE

PRINCIPAL INVESTIGATOR



- 34 2019 / Effect of a drama-based intervention program on breastfeeding self-efficacy and breastfeeding outcomes of rural pregnant women, Ibadan, Nigeria  
Yetunde Ogundairo Omotola / University of Ibadan, Department of Human Nutrition, Faculty of Public Health, College of Medicine, Ibadan, Nigeria
- 35 2019 / Peer groups to improve infant and young-child feeding in post-emergency settlements in Uganda  
Joel J. Komakech / Oklahoma State University, University of Agriculture, Stillwater, Oklahoma, USA
- 36 2021 / Towards a decision support system to control mycotoxin contamination in raw milk production in Kolokani andn Kita regions in Mali (MILKSAFE)  
Abderahim Ahmadou / Institut Polytechnique Rural de Formation et de Recherche Appliqué (IPR/IFRA), Bamako, Mali
- 37 2021 / Evidence-based nutrition intervention development to improve dietary habits of adolescents attending school in Vientiane Province, Lao PDR  
Thidatheb Kounnavong / Nagasaki University (NU-TMGH), School of Tropical Medicine and Global Health, Nagasaki, Japan
- 38 2021 / Impact of nutritional biomarkers in the pathogenesis of Buruli ulcer disease  
Aloysius Loglo / Kwame Nkrumah University of Science and Technology, Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR), Kumasi, Ghana
- 39 2022 / Empowering Weekly Iron-Folic Acid (WIFA) supplementation program for adolescent schoolgirls in high-stunting areas  
Ali Khomsan / IPB University, Department of Community Nutrition, Bogor, Indonesia
- 40 2022 / Growth and development outcomes in severe acute malnutrition (SAM) children discharged from nutrition rehabilitation centers (NRC): A community-based follow-up study  
Kumar Rohitash / King George's Medical University, Department of Community Medicine and Public Health, Lucknow, Uttar Pradesh, India
- 41 2022 / Effect of double-duty interventions on the double burden of malnutrition among children under five years in Debre Berhan City, Central Ethiopia: A cluster randomized controlled trial  
Lemma Getacher / Debre Berhan University (DBU), Asrat Woldeyes Health Science Campus, Debre Berhan, Ethiopia

## OTHER RESEARCH AREAS

42 2022 / Safety aspects of edible grasshoppers consumed in Benin: Case study of Malanville

Sika Jeanne Gwladys Gnanvi / University of Abomey-Calavi (UAC), Faculty of Agronomic Sciences (FSA), Laboratory of Valorization and Quality Management of Bio-Ingredients (LABIO), Cotonou / Abomey-Calavi, Benin

43 2022 / Impact of a bean-based soup flour containing vegetables and sweet potato on children in Rwanda

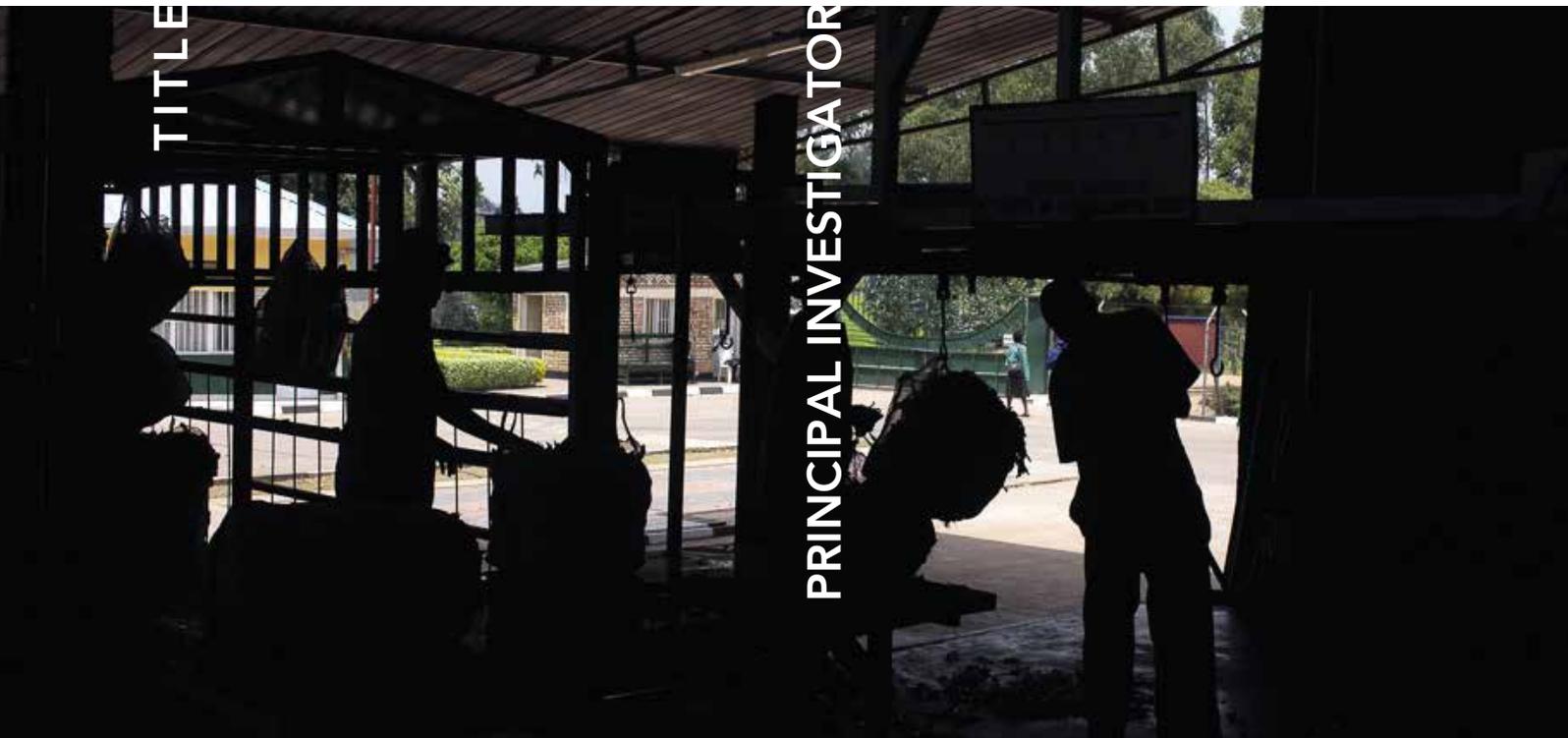
Marie-Rose Kambabazi / University of Rwanda, Department of Food Science and Technology, Musanze, Rwanda

44 2022 / Improving knowledge of prevention of non-communicable diseases among children in Morogoro, Tanzania

Safiness-Simon Msollo / Sokoine University of Agriculture, Department of Food Technology, Nutrition and Consumer Science, Morogoro, Tanzania

TITLE

PRINCIPAL INVESTIGATOR



## PUBLICATIONS

1. Sari DW, Noguchi-Watanabe M, Sasaki S et al. Dietary patterns of 479 Indonesian adults and their associations with sodium and potassium intakes estimated by two 24-h urine collections. *Nutrients* 2022; 14:2905
2. Ahomondji ES, Agoyi EE, Lokonon BE, et al. Multi-environmental evaluation of vegetable soybean for adaptation and stability in Benin. *African Crop Science Journal*, 2022;30:313-330
3. Modern G, Mpolya E, Sauli E. Causal relationship between Environmental Enteric Dysfunction (EED), poor WASH practices and growth failure in children from Rukwa-Tanzania. *Scientific African* 2022;6: e01281
4. Tang HK, Nguyen NM and Dibley MJ. Energy intakes, macronutrient intakes and the percentages of energy from macronutrients with adolescent BMI: Results from a 5-year cohort study in Ho Chi Minh City, Vietnam. *Br J Nut* 2022;1-8
5. Ahomondji SE, Agoyi EE, Agbangba CE, et al. Sensory preference criteria and willingness to adopt vegetable soybean “Edamame” in Benin (West Africa). *Journal of Sensory Studies* 2022: e12797
6. Siddiqua T, Alam MN, Ahmad SM, et al. *Helicobacter pylori* infection and vitamin B12 deficiency during early pregnancy in an urban slum in Bangladesh (P24-035-19). *Curr Dev Nut* 2019; 3: nzz044.P24-035-19
7. Habimana, JDD; Uwase A, Korukire N, et al. Prevalence and correlates of stunting among children aged 6-23 months from poor households in Rwanda. *Preprints* 2022, 2022120105.
8. Sujarwo, Putra AN, Setyawan RA, et al. Forecasting rice status for a food crisis early warning system based on satellite imagery and cellular automata in Malang, Indonesia. *Sustainability* 2022;14:8972
9. Mbwana HA, Mwinuka L. Prevalence and determinants for poor nutritional status among children in rural Dodoma Region of Tanzania. *Preprint Research Square* 2022
10. Bosch-Bayard J, Razzaq FA, Lopez-Naranjo C, et al. Early protein energy malnutrition impacts life-long developmental trajectories of the sources of EEG rhythmic activity. *Neuroimage* 2022;254:119144
11. Bringas Vega ML, Guo Y, Tang Q, et al. An age-adjusted EEG source classifier accurately detects school-aged Barbadian children that had protein energy malnutrition in the first year of life. *Front Neurosci* 2019;13:1222
12. Roger K, Vannasing P, Tremblay J, et al. Impact of early childhood malnutrition on adult brain function: An evoked-related potentials study. *Front Hum Neurosci* 2022;16:884251
13. Li M, Wang Y, Lopez-Naranjo C, Hu S, et al. Harmonized-multinational qEEG norms (HarMNqEEG). *Neuroimage* 2022;256:119190
14. Bulaya E, Mapatano A. Effectiveness of complementary food based on food recipe locally produced in malnutrition prevention of child 6–23, Katanga DRC: Randomized controlled trial of MASO31 recipe. *Current Developments in Nutrition* 2022;6: 1133
15. Ngoy Bulaya E, Mapatano Mala A, Kayembe Kitenge T, et al. Effectiveness of complementary food based on food recipe locally produced in malnutrition prevention of child 6–23, Katanga DRC: Randomized controlled trial of MASO31 recipe. *Global Journal of Food Science and Nutrition* GJFSN:128 (doi: 10.39127/2475-2368/GJFSN:1000128)

The publications are available free of charge upon request.

**Jehan-François Desjeux**  
1940 – 2022

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Scientific Advisor	1995 – 2004
Council Member	2005 – 2012



In the fall of 2022, Prof. Jehan-François Desjeux, a long-term Council Member, passed away at age 82. Jehan-François was involved in the activities of the Foundation, first as a scientific advisor (1995-2004) and then as a board member (2005-2012).

As soon as his first night calls while a resident in pediatrics in the 1970's, whether in Paris or Tunis or elsewhere, he deemed it unacceptable that infants and children would die of severe dehydration and malnutrition. He felt frustrated by the lack of adequate resources to care for sick children in low-income countries, and fought to make novel treatments (such as the oral rehydration solution) available anywhere. His research was focused on understanding the mechanisms by which water, sodium (salt), and nutrients are absorbed in the small intestine. Excited by the discovery that specific nutrients such as glucose, a simple sugar, would improve the absorption of sodium, he spent long hours watching with bright eyes Ussing chambers, an assemblage of small glass tubes where tiny fragments of tissues (e.g., a few cm<sup>2</sup> of rabbit gut) are spread between two small compartments bubbling with oxygen, and where the tiny changes in electrical currents seen on the voltage monitor reflect the passage of sodium across the intestinal lining. He built a research unit at Inserm, the French national institute of health and medical research, was elected to join the French Academy of Medicine, and was awarded the Légion d'honneur, one of the top honors in France.

Yet his scientific accomplishments are not the only reason why Jehan-François was so popular among those who knew him. This was also, and maybe most of all, because of his qualities as a human being: his ever-present humor; a kind of teasing smile that was never mean, but stimulating; and his ability to share his enthusiasm with younger colleagues and inspire them, not to admire his ideas, but to build their own, enabling them to develop their own, original projects, and grow into themselves. His openness to other cultures earned him friendships in all walks of life; he often mentioned how much he appreciated the generous hospitality of those who live in less fortunate settings. He told us about one day when, invited to dinner in a faraway land in a simple house, he expressed his admiration for a stuffed, life-sized antelope decorating the kitchen, after which the host begged him to accept the said antelope as a gift. Despite his steadfast refusal, Jehan-François found himself forced to accept that gift the following day, when he saw his host rushing through the airport with the antelope in his arms, insisting that Jehan-François take it with him on the airplane that was to bring him home ... which Jehan-François eventually did.

The Foundation will always remember this colleague and wonderful friend. His memory will inspire us to pursue the goals of supporting research on infant and maternal nutrition across the world.

Text by Prof. Dominique Darmaun





The Nestlé Foundation for the Study of Problems of Nutrition in the World was established in 1966 by a donation from the Nestlé Company on the occasion of its centenary. The Foundation is independent and self-constituting and is managed by a Council consisting of at least five internationally well-known scientists as Council Members. The Foundation has been financially and operationally independent of the Nestlé Company since its inception due to the endowment received in 1966. The offices of the Nestlé Foundation are in Lausanne, Switzerland.

# THE FOUNDATION

## **GUIDELINES FOR GRANT APPLICATIONS TO THE NESTLÉ FOUNDATION**

### **PURPOSE**

The Nestlé Foundation initiates and supports research in human nutrition with public-health relevance in low-income and lower-middle-income countries according to the World Bank classification (see <http://www.worldbank.org>). The results of the research projects should ideally provide a basis for implementation and action which will lead to sustainable effects in the studied populations as generally applicable to the population at large. They should also enable

institution strengthening and capacity building in a sustainable manner in the host country, and further cooperation and collaboration between institutions in developed and developing countries.

The Foundation expects research proposals to be primarily the initiative of local researchers from the developing countries. However, the Foundation will be inclined to consider favourably those applications made jointly by scientists from developed countries

with those from developing countries provided it is clear that the initiative will result in capacity building and human-resource development in the latter and that the bulk of the budget is spent in the developing country.

## CURRENT POLICY

Sustainable improvement in human nutrition is one of the major issues in the portfolio of the Foundation. During more than 50 years, basic and applied research in nutrition has been supported by the Foundation in over 50 developing countries. In view of the past activities of the Foundation as well as the world's situation at the turn of the millennium, it was recognized that the public-health relevance of the supported research as well as aspects of sustainability, capacity building and educational issues should have a higher priority. Thus, priority is given to projects which lead to sustainable developments with strong elements of capacity building, and the implementation of the results of a research project should be immediate and sustainable. Highly sophisticated nutrition research of mainly academic interest without public-health relevance has lower priority for support, as do solely laboratory-based studies or animal experimentation.

## RESEARCH TOPICS

At present the Foundation's work is primarily concerned with human nutrition research issues dealing with:

- (1) maternal and child nutrition, including breastfeeding and complementary feeding,
- (2) macro- and micronutrient deficiencies and imbalances,
- (3) interactions between infection and nutrition, and
- (4) nutrition education and health promotion.

The precise priorities and goals of the Foundation are modified from time to time to meet emerging public-health and nutritional needs in the developing world.

Studies in other areas of human nutrition research might also be considered, as long as they are dealing with problems of malnutrition in eligible countries (see above). Other areas of research (e.g. obesity, non-communicable diseases) may be considered for support if the applicants can offer specific and convincing evidence and justification for the choice

of the research topic, especially when an innovative approach is suggested. The Foundation prefers a food-based approach suggesting local sustainable solutions which are affordable for the whole target population. Projects with a questionable sustainability or projects with commercial, product-related solutions are not supported.

Funded projects are usually of one- to three-year duration. Projects with a high potential for effective and sustainable improvement of the nutritional status as well as a high capacity-building component will be funded preferentially. The budget of the projects must be appropriate and reasonable and has to be justified in detail.

One of the Foundation's main aims is the transfer of scientific and technological knowledge to target countries. In cases where Foundation-sponsored research projects are realized in collaboration with scientists at universities and research institutes in high-income countries, at least 75% of the budget has to be earmarked for use within the low-income country.

Research grant applications from high-income countries are only considered under rare and exceptional conditions.

The Foundation does not normally fund:

- (1) projects with low public health relevance
- (2) projects with doubtful sustainability
- (3) projects lacking transfer of scientific, technical and educational knowledge, i.e. lacking a capacity-building component
- (4) nutrition surveys or surveillance studies (except when needed as a basis for a specific intervention study)
- (5) research on food policy, food production and food technology, except when linked to an intervention with high potential for sustainable improvement of the nutritional status
- (6) non-food-based approaches (commercial drug- or product-dependent interventions lacking sustainability)
- (7) in vitro and/or animal experiments.

## ELIGIBLE INSTITUTIONS

Eligible institutions are departments or institutes from universities, hospitals, and other institutions of higher education in low- or lower-middle-income countries. Joint applications from more than one institution (especially South-South) are welcomed. Joint applications from more than one institution involving a North-South collaboration may also be considered. For project applications demonstrating North-South collaboration, it is important that the following criteria are fulfilled: (i) the Principal Investigator is from the South and the proposal has relevance to nutritional problems of the South; (ii) the majority of the budget is earmarked for the South; and (iii) demonstration upon completion of the project of institution- and capacity building in a sustainable manner in the South.

The capacity-building component represents a core issue for all applications to the Foundation. This means that every application needs to demonstrate a training and human-resource and capacity-building component for the developing world. Ideally graduate students or young investigators should play a key role and, where possible, be designated as the Principal Investigator (PI), i.e. be the primary grant applicant, or Co-PI. Established researchers can nevertheless apply but need to clearly indicate the capacity-building component and the designated beneficiaries. Established investigators alone are not usually eligible to apply for a grant, except when they address innovative and exceptionally well-justified research questions in developing countries. Such applications need to clearly state the capacity- and human-resource-building components in the host country as well as the long-term sustainability of research in the host institution. Applications from individuals who are non-affiliated researchers and not attached to research or academic institutions can be considered only in very special cases.



## TYPES OF AWARDS

The Nestlé Foundation offers different award and grant categories, some of them using a modular approach; for example, the Pilot Grant Program represents the starting grant module for a later Full Grant Research application. The eligibility criteria as well as the research objectives and topics have to be fulfilled no matter what the award category (for further details see [www.nestlefoundation.org](http://www.nestlefoundation.org)):

<b>Grant type</b>	<b>Description</b>	<b>Budget (in USD)</b>
Training Grant (TG)	The Training Grant (TG) Program supports a small research project such as a MSc or PhD thesis project or another training endeavour.	<b>up to 20,000 in total</b>
Pilot Grant (PG)	The Pilot Grant (PG) Program provides support for pilot research that has a high potential to lead to a subsequent full research project grant. Usually the Foundation does not support nutritional survey research, but often to be able to identify areas of problems for potential intervention one has to collect baseline data. If a pilot study (pre-study or baseline study) will create the needed data for a larger research project, the PG program may assist this. The pilot study and PG usually represent the starting point for a later full research grant application (i.e., a SG or LG) to the Foundation.	<b>up to 20,000 in total</b>
Small Research Grant (SG)	The Small Research Grant (SG) provides support for a small research study. This may represent a continuation of a TG or a PG.	<b>up to 50,000 in total</b>
Large Research Grant (LG)	Full grant application of a complete research proposal according to the guidelines.	<b>up to 100,000 per year to a maximum of 300,000 for 3 years</b>
Re-Entry Grants	To encourage post-graduate students to return to their own countries and to aid them in establishing their careers, the Foundation will support a research programme for eligible candidates. The host institution will need to guarantee a post for the returnee and ensure career development within the host institution. Contribution of support to the eligible candidate from the host institution is essential, while support and collaboration from the overseas institution where the candidate trained is helpful.	<b>up to 50,000 in total</b>

## **Institutional Support**

Institutional support involves the support of research or educational projects in specific institutions in low- or lower-middle-income countries which contribute to a focused development of capacity and know-how and human-resource development in the corresponding institution.

## **HOW TO APPLY**

Interested scientists should first submit a letter of intent in which they describe very briefly the kind of project they would like to undertake, including an estimated budget. Instructions for the letter of intent are available on the Foundation website at [www.nestlefoundation.org](http://www.nestlefoundation.org). For a submission of a letter of intent only the downloadable form on our website should be used. If the suggested project is compatible with the Foundation's current funding policy, applicants will receive an invitation to submit a full grant proposal. The guidelines for the submission of a full grant proposal are also available on our website. Other formats will not be accepted, neither for the letter of intent nor for the full grant applications.

In the letter of intent and in the grant application, detailed, evidence-based information about the public-health relevance of the project as well as its immediate impact and sustainability have to be reported. This part of the application is as important as the scientific section of the application.

Research grant applications are evaluated twice a year by the Foundation's Council, a group of independent international scientists. The funding of projects is primarily based on the scientific quality, public-health relevance in the short and long term, sustainability, capacity-building component and, last but not least, budget considerations.

Applications are accepted throughout the year, and the Foundation encourages applicants to submit their proposals early to allow sufficient time for internal as well as external reviews. All submissions—upon invitation after the approval of a letter of intent—should be made electronically by e-mail. Final deadlines for submission are January 10 and May 10 for the Spring and Fall Council Meetings, respectively.

**For more information consult**  
[www.nestlefoundation.org](http://www.nestlefoundation.org)



The Council of the Foundation consists of at least five Council Members and Advisors. All Council Members and Advisors are internationally well-known scientists with specific expertise in different fields of nutrition. The Council is self-constituting and operates independently. The Foundation is directed jointly by the Director and the President of the Foundation.

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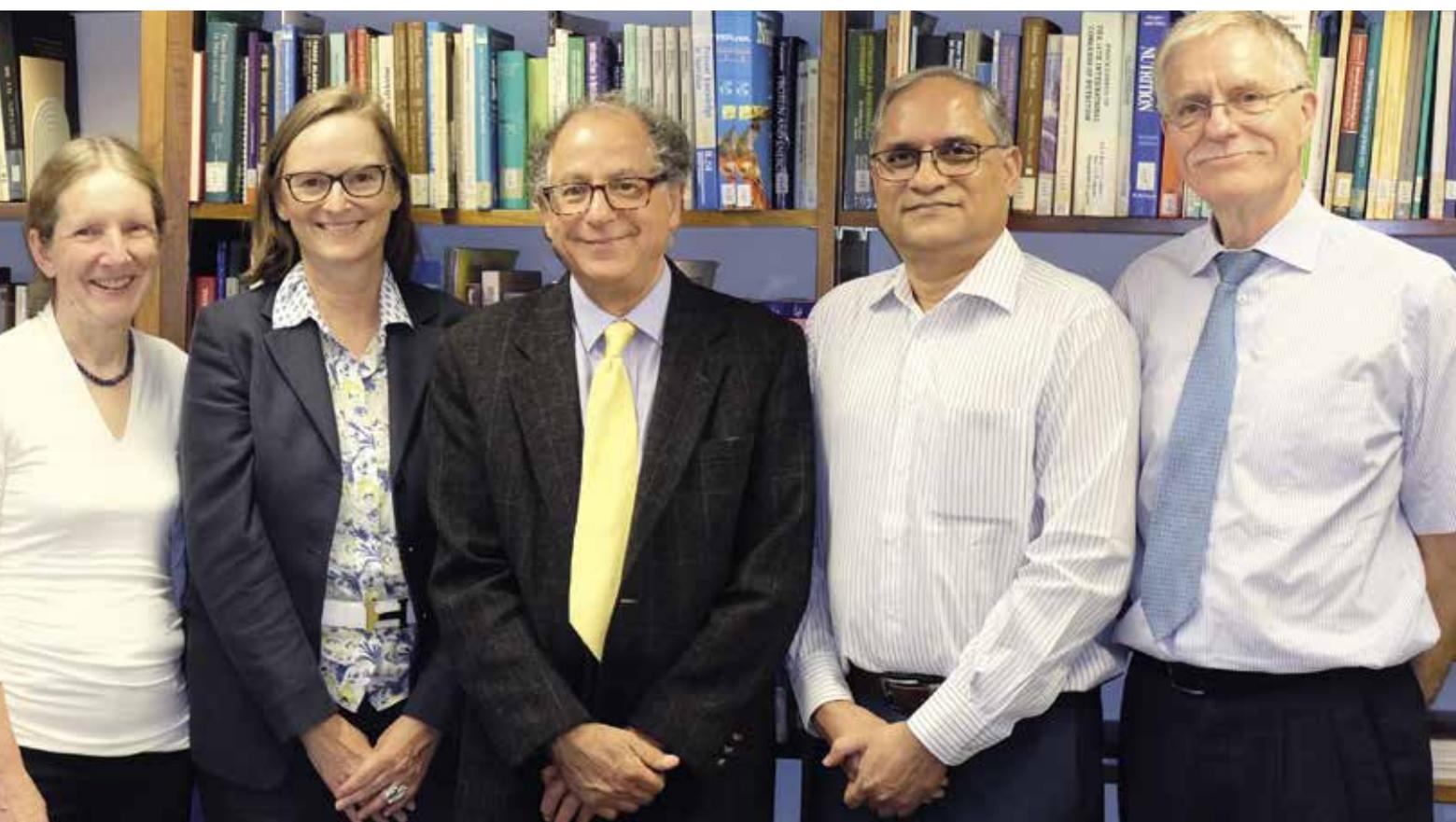
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From left to right: Ann Prentice, Petra S. Hueppi, Dominique Darmaun, Anura Kurpad, Paolo M. Suter. Anna Lartey is not on the picture, since we only had remote Council Meetings in 2022.





#### REFERENCES AND CREDITS:

**Page 51:** Country Data sources: <https://data.unicef.org/country/png/>, <https://www.cia.gov/the-world-factbook/countries/papua-new-guinea/>, <https://www.who.int/countries/png>, [https://www.nationsonline.org/oneworld/papua\\_new\\_guinea.htm](https://www.nationsonline.org/oneworld/papua_new_guinea.htm), <https://www.britannica.com/place/Papua-New-Guinea>, Der neue Kosmos Welt- Almanach & Atlas 2023, Franckh-Kosmos Verlags-GmbH & Co. KG, Stuttgart, Deutschland, 2022.

#### PHOTO:

**Page 36:** André F. van Rooyen (Engaging the community: strong community engagement and accountability in governance structures is essential), **Page 38/39:** Henning Bjornlund (Village market: the process of reducing poverty and increasing food security must start by integrating smallholders' production into the local market economy), **Page 40:** Cristiana Berti (picture from Ethiopia), **Page 42/43:** Cristiana Berti (Brazil), **Page 48/50:** Peggy Kala, **Page 52:** Francis Pulsan

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Cover: Students attending a Chemistry Class at Ahfad University (Omdurman, Sudan) - photograph by Paolo M. Suter

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Throughout The Report 2022 all gender-specific terms are to be considered to refer to both the feminine and the masculine form – except when referring to a particular person. In addition the singular denotes the plural.

## Nestlé Foundation

for the study of problems of nutrition in the world



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