The Germany-CGIAR^{++} Science and Impact Hub

Research proposal:

Title of your proposal:
Nutrient Modeling and Water Balancing of Localized Aquaponics System: Abbassa, Egypt
Summary: (give a brief summary of your research proposal, maximum 250 words)
Aquaponics, a form of Integrated Agriculture-Aquaculture (IAA) serves to bring sustainable animal and aquatic foods to people worldwide. A merged innovation in its own volition, with many technological advances along varying sectors, aquaponics systems are still being optimized due to complexities along production, nutrient cycling, and resource inputs, such as water and energy. The range of complexities are multifaceted and often vary with locality. The proposed research plan aims to address the efficiency and effectiveness of a tilapia-stocked aquaponics system using modeling and multiple-criteria Decision Making of resource use and nutrients using on-the ground experimental data from a solar-powered aquaponics system at the WorldFish center in Egypt. We envision that this research will provide information about how these optimizations can lead to better management of aquaponics systems In Egypt and thus lead to better decisions on how to interact with aquaponic systems to combat food security and limit resource use such as water and energy inputs.
Introduction: (Maximum 300 words)
Aquaponics serves as one of the breeding grounds that is combating food insecurity via an approach that is not only resource conscious and dynamic, but also offers simplicity for its users that render productive yields. Being a system that is interconnected and recirculating (e.g., coupled), resource management is essential to maintain the benefits of the system. There are interactions between fish, plant, water, environment (e.g., WEF nexus), and producer's behaviors. These interactions and exchanges, provide large variabilities and points of entry that can hamper the system, thus making the system inefficient or less productive for producers and ultimately, end-users. Managing the variabilities of an aquaponics system can allow producers to pinpoint irregularities faster, maximize optimization, and increase food yields. To assist producers with this dynamic system, modeling the nutrients used in aquaponics, can provide predictive behavior within the aquaponic system. Despite extensive research in aquaponics modeling, current literature has not fully explored all component research between specific crop type and fish, the grouping of nutrients, and specific geographic/locality conditions. Moreover, when these components are carefully selected and tangible data is received on-site, predications from aquaponics modeling can then be used in aiding producers and installers/technicians in managing the aquaponics systems for efficiency and effectiveness without the constant use of on-the-ground experimentation. The proposed research will be conducted at the solar-powered aquaponics greenhouse at WorldFish's facility in Abbassa, Egypt. Here, we will investigate key parameters that are useful for plant and fish growth, while also evaluating the water balance of the entire system, via a series of research questions and objectives.
Objective and research questions: (Maximum 200 words)
The main research objective will explore the efficiency and effectiveness of a tilapia-stocked aquaponics system that is coupled and solar in Egypt. The Research Questions are:

1. What is considered an effective and efficient aquaponic system in Egypt?
2. Define and describe the current aquaponics system with water, energy, and substance fluxes present alongside their known or unknown measurements.
2. Determine and select key parameters within each interaction stream/sub-system with the aquaponic system (fish growth/population, plant growth patterns/type, nutrient availability (including waste), circulation, and even thermal regulation).
3. What are the proper equations and existing software that can be used to model the selected parameters and perform a water balance analysis (e.g. Mass Balance Equations, Nitrification Kinetics, Fish Growth and Waste Excretion, Plant Nutrient Uptake and Growth, Evapotranspiration Penman- Monteith Equation/ or Qual2k, J-2000s, CropWat, AquaCrop, AquaNet, Matlab, Python, HydroBuddy, or open access code from literature)?
4. How effective and efficient does the constructed model predict actual on-site experimental data?
5. Using the established model as a predictor of values, how can the use of Multi-Criteria Decision- Making (MCDM) simulate scenarios that aid in the best approach for decision-makers (e.g., producers) for the selected site in Egypt? How can the transferability of results assist similar cases, regions or locations, scalability?

Methodology:

(Maximum 300 words)

1. Initially Measure and Describe Aquaponics system with characteristics of usage, maintenance, and fluxes.
2. Establish, perform, and measure one or two full cycles with selected crop (e.g. lettuce) and fish with selected parameters (e.g. nitrogen Phosphorus, mass of plants) with agreed experiential design of aquaponics system (e.g. regulation and recording of inputs, outputs, and maintenance).
3. Evaluate and keep track of on-site/experimental measurements.
4. Choose and use on-site measurements for proposed model.
5. Create, test, and evaluate model for accuracy. Then use model valves for a Multiple-criteria decision-making (MCDM) for further assessment.

Expected results and envisioned impact:

(Maximum 200 words)

<u>Expected Results:</u>

- We expect that this research will yield additional data and datasets for the newly built aquaponics system for set established parameters.
- Development of a model that is accommodated to the localized aquaponics system within climatic and input sources conditions.
- Improvements of management and design recommendations for localized system that can assist with resource use and scalability or improve standard operations procedures.

<u>Envisioned Impact:</u>

- We envisioned that productivity along the fish value chain in Egypt within aquaponics systems will improve.
- That the established model will be a launching pad for adaptation for other aquaponics systems to mold and adapt from small-scale operations to even commercial aquaponics operations
- That Sustainable Development Goals will be addressed (SDG 2, 6,7,9,12,13)
- That economic gains and jobs will be created by management practices and production.

Work plan:
(please give a monthly schedule of your activities during your research stay at the CGIAR++)

Month 1: 15 April- 14 May: Departure to research facility, WorldFish Egypt in April. Set up experimental design (roles, ethics,) and test trial parameters for accuracy in lab and retrieval of experimental locations within aquaponics system. Adjust and finalize experimental design.

Month 2: 15 May- 14 June: Start of first cycle within Aquaponics Cycle (Depending on Month 1 progress, could start in the beginning of May). Prepare Cycle and gather Data (parameters) and manage and review data. Conducted on the backend: Additional research on created/established model.

Month 3: 15 June- 14 July: Gather Data (parameters) manage data. Conducted on the backend: Additional research on created/established model. Trial and error of collected data points within modeling software and calculations. Conclusion of First cycle for plants.

Month 4: 15 July- 14 August: Start of Second cycle for plants (could occur also occur beginning of July). Gather Data (parameters) and manage and review data within model. Conducted on the backend: Additional research on created/established model. Trial and error of collected data points within modeling software and calculations.

Month 5: 15 August- 14 September: Gather Data (parameters) and manage data within model. Conducted on the backend: Additional research on created/established model. Trial and error of collected data points within modeling software and calculations.

Month 6: 15 September- 14 October: Gather Data (parameters) and manage and review data within model. Conducted on the backend: Additional research on created/established model. Trial and error of collected data points within modeling software and calculations. Conclude Second Cycle of plants and Fish.

Monitoring and calibration/updates/maintenance conducted within aquaponics would be made, progress and updates/ regular consultations, guidance on research methodology with Dr. Fink and Dr. Ahmed and team at WorldFish will also be conducted.

Thematic link to development oriented agricultural research:
(Maximum 200 words)

Conducted research will take modeled results from pure data to decision within Sustainable Development Goal 9: Industry Innovation and Infrastructure, 12: Responsible Consumption and Production, 13: Climate Action, 2: Zero Hunger, 6: Clean Water and Sanitation, and 7: Affordable and Clean Energy.

Measurements and modeled data from localized aquaponics systems would provide additional information on improvements and design options for scaling a climate-smart aquaponics systems in Egypt that could improve the local community via efficient resource management and food availability of crop and fish. These improvements should increase productivity measurements among crop and fish, while conserving water and energy.

Thematic link to the hosting CGIAR++ research program/project:
(Maximum 200 words)

Centre for Renewable Energy in Aquaculute (CeREA) is an active project at WorldFish Egypt with a main goal to “refine, test and scale innovative renewable energy solutions that

enable 5000 fish producers, processors and other fish value chain actors in Egypt to increase their productivity and incomes." In 2024 and funded via the CeREA project, a Solar Powered Aquaponics was built in Abbassa, Abu-Hammad, Sharqia, Egypt with the intentions to scale and distribute similar tailored aquaponics models to surrounding areas.

Proposed research aligns with CeREA project in that assessing the water balance and modeling key water parameters for fish and plants within the allied and pilot-built aquaponics system; will support in refining and testing a known solution that integrates renewable energy and is combating food insecurity. We hope that throughout this research additional information is known on how to improve productivity along the fish value chain in Egypt.

References:

Baganz, G. F. M., Junge, R., Portella, M. C., Goddek, S., Keesman, K. J., Baganz, D., Staaks, G., Shaw, C., Lohrberg, F., & Kloas, W. (2022). The aquaponic principle—It is all about coupling. Reviews in Aquaculture, 14(1), 252–264. https://doi.org/10.1111/raq.12596

Goddek, S., Joyce, A., Kotzen, B., & Burnell, G. M. (Eds.). (2019). Aquaponics Food Production Systems: Combined Aquaculture and Hydroponic Production Technologies for the Future. Springer International Publishing. https://doi.org/10.1007/978-3-030-15943-6

Mosbah, M. (2024, June 5). WorldFish and Norway spearhead cutting-edge solar-powered aquaponics solution. WorldFish. https://worldfishcenter.org/blog/worldfish-and-norway-spearhead-cutting-edge-solar-powered-aquaponics-solution.

Sadek S, Elewa A, Ahmed N, Munir S, Mahfouz AR and Nasr-Allah A. 2023. An assessment and analytical report for integrated agriculture-aquaculture (IAA) systems in Egypt.Penang, Malaysia: WorldFish. Program report: 2023-38.

WorldFish. (n.d.). Center for Renewable Energy in Aquaculture (CeREA). https://worldfishcenter.org/project/center-renewable-energy-aquaculture-cerea

I hereby confirm to the best of my knowledge and belief that the information provided above is correct. Furthermore, I hereby confirm that no artificial intelligence was used to write the above proposal, and I am aware that any kind of deception may lead to immediate rejection of the application.

Köln, 14. February 2026

Place and date | Signature