A2E

ACCESS TO ENERGY INSTITUTE

PRODUCTIVE USE MACHINERY IN AGRICULTURE

FROM DEVELOPMENT TO MARKET MATURITY

A summary of learnings from A2EI's Entrepreneur in Residence (EiR) scheme from Jan 2019 to Jun 2021 and a proposal for a systematic approach for successful product development

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PREAMBLE

Productive use appliances in agriculture have been the "next big thing" in the energy access sector for the best part of the last decade. However, only a few successful examples can be showcased and learned from. With Imara Tech as our first Entrepreneur in Residence at A2EI, we were lucky enough to be part of one of the successful ventures in the agricultural productive use appliance sector and want to share our learnings and propose a way forward that we believe could increase the likelihood for successful product development.

We found that the combination of thorough research on plausible business models for users/customers on the one hand and on the other hand R&D, testing, piloting and feedback loops with customers to validate the economic value of the product to them are key ingredients for a successful product development. In particular, combining the crucial local knowledge of what exact product is needed combined with access to international resources e.g. R&D and supply chains are important.

A2EI and Imara Tech teams testing a solar-powered peanut sheller (left) and solar-powered oil press (right).

Productive use appliances research: The analytical basis

As a starting point, an extensive and systematic research around plausible business models from a user perspective was necessary. We commissioned an extensive research piece for 10 productive use appliances ranging from maize shelling to oil pressing.

The objective of this research was to use a business modeling approach to identify opportunities for solar energy to be used productively in agricultural contexts. Quite explicitly, we also wanted to find out which factors were responsible for the lack of scaling we had been observing in the sector.

A methodology for constructing and evaluating solar-powered, productive-use business models was developed. This methodology was then applied to ten agricultural processes in order to evaluate the market potential for different productive-use technologies in Tanzania.

For each agricultural process, a productive-use technology enabled business model was constructed using data collected from interviews conducted in Tanzania with operators of similar technologies and end-users such as farmers.

The business models were then evaluated based on criteria that revealed the attractiveness of the investing in the productive-use business, such as unit economics and other financial metrics. Businesses were further evaluated through criteria that assessed the desirability of products and services for end-users and the viability of the product to scale.

Insights on the factors influencing productive-use potential were drawn from the ten use-case analyses and summarized so that other productive-use cases can be quickly assessed at a high level.

The effectiveness of the modeling approach was explored and recommendations were made for adapting the methodology to other contexts for other purposes. Suggestions were given for how the methodology may be used by stakeholders in the off-grid energy and agricultural sectors.

Spreadsheets containing all assumptions and calculations used in this research are available on the A2EI website so that readers can adapt the models.

The publication is recognized as a systematic and practically usable methodology in the sector and has guided most of the subsequent R&D focus at Imara Tech. (https://a2ei.org/resources/uploads/2020/09/A2EI_Productive_Use_Report_Agricultural_Technologies.pdf)

The main finding of the research is that technology is not everything and that just having a brilliantly engineered product and cheap electricity is not enough. We found that more often than not, economic factors that do negatively impact the ability of a customer to make additional revenue with the machinery are the main cause for lack of scaling. For example, the assumptions as to the daily/monthly/yearly use of machines is often overestimated, seasonality effects underestimated and it was found that demand for the product is often lacking. The best product but without a market is not a recipe for success.

The research identified several appliances had the best chances of success, in the sense that the likelihood of generating incremental income with appropriate appliances would be highest. Building off of the research results, we have begun development of solar powered oil pressing, shelling and milling appliances in collaboration with Imara Tech, a local company that was A2EI's first entrepreneur in residence (EIR). With support from EIR, Imara Tech was able to scale one its multi-crop thresher product, and we intend to replicate that approach with these new products and with other identified products such as chaff cutting machines and walking tractors.

Imara Tech co-founders Alfred (center) and Elliot (right) testing the MCT with users in the field.

The concept of the Entrepreneur in Residence (EiR): Access to Resources

The cooperation between Imara Tech and A2EI has started in January 2019 within the framework of the "Entrepreneur in Residence (EiR)" concept. In a nutshell the idea is to put resources of the A2EI (R&D lab, engineering experience, field testing capacity, focus group research and financial support) at the disposal of local companies in order for them to speed up innovation and market entry of their products to ultimately scale and achieve impact.

A2EI and Imara Tech decided to partner around the development and testing of productive use appliances (PUA) in agriculture, including research, R&D, field testing and market entry.

Imara Tech had been active in the field of developing PUA since 2016 but lacked access to financial and R&D resources to succeed. With hindsight, the EiR with A2EI was the stepping stone for scaling and measurable impact.

Following the publication of the PUA report and methodology, the focus was on 3 different productive use appliances (flour mill, oil pressing, shelling) that are being developed, field tested and brought to market.

The financial support of A2EI for Imara Tech was leveraged in 2020 with co-financing from Carbon Trust's Transforming Energy Access programme (TEA).

This was followed by the offer for Imara Tech to apply for the Sprint Programme of the World Food Program (WFP) to help scale the Multi-Crop Thresher technology.

The main learning of the EiR is that it was crucial for the local company to have uncomplicated access to financial resources from A2EI to pay for the necessary infrastructure to develop the right technology AND attract further funding. Additional access to resources such as R&D Labs, experienced engineers, supply chains and networks complement the needed endowment to be successful.

The process always includes detailed research of customer needs, a plausibility for business models, R&D, field testing and ultimately, scale and impact.

The first example of a successful partnership leading to the development of a successful product is detailed below.

Customers operate the MCT for threshing crops such as maize (left).
The threshers are made locally at the Imara Tech workshop (right).

Productive use appliance 1:

MULTI CROP THRESHER SCALING

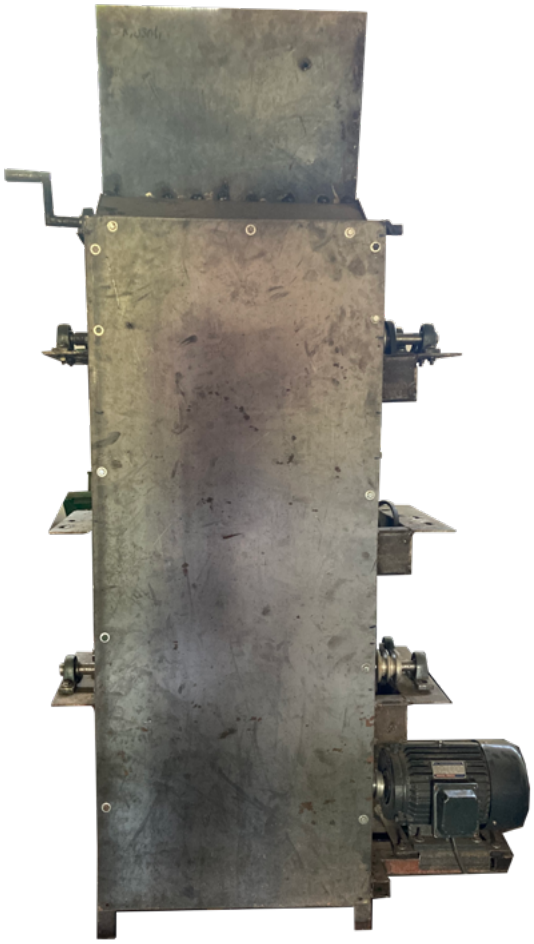
- Imara Tech's Multi-crop Thresher (MCT) is an appliance that removes the grain from staple crops after harvest, which reduces post-harvest losses and leads to improved grain quality
- The MCT saves time and labor and is up to 75x faster than traditional manual methods
- Customers use the MCT as a business. It is carried around on a motorcycle and used to thresh farmers' crops. The MCT earns its owners an estimated $10/hour net profit or a seasonal earn of $750 while approximately 50 farms are being served.
- The product costs $750, which means the payback period is approximately one year.
- Before 2018, Imara Tech had designed a first product and organized multiple small-scale market pilots, but challenges to scaling could not be overcome: only 10 machines sold per year between 2016-2018, clearly not a viable way forward.
- EiR approach 2019 with A2EI: A2EI's financial and infrastructure support (e.g. shared office space) helps Imara Tech to open its first workshop and hire a local team. Imara Tech sells 23 threshers.
- 2020: Imara Tech makes and sells 244 threshers, estimated to have created 180 jobs and reached 9.000 farms.
- Importance of A2EI funding and access to R&D resources on MCT thresher helped move Imara Tech out of pilot stage towards market traction and scale.
- Market traction and proof of concept helps boost confidence: Imara Tech is now working on new products to target the same customers, such as walking tractors, chaff cutting machines etc.
- 2021: Imara Tech invited to participate in World Food Programme (WFP) accelerator and beginning geographic expansion. Imara Tech now employs 27 young people below 35 and works with 35 external sub-contractors.
- Imara Tech is now specifically targeting smallholder farms and young people in order to create jobs for the 48m people below 35 in Tanzania

Following on the demonstrated impact of the MCT, we are replicating the approach with other technologies, described below.

Users carry the MCT on motorcycles to transport the equipment from farm to farm, enabling the service business.

Productive use appliance 2:
AVOCADO OIL PRESS

- Hydraulic Oil Presses were one of products identified as viable in the PUA in agriculture report.
- A more detailed analysis started with mapping the customer journey. Avocado growers have huge quantities of local avocados which exceed the local demand for fresh avocados. So most of the harvest goes to waste. Oil pressing is a way to conserve the fresh avocado into long lasting avocado oil. This refining is adding value and allows to enter into a much more affluent market (cosmetics). With the availability of the avocado press, *all* avocados can be converted into revenue.
    - There are two types of avocados: local varieties and modern varieties. The modern ones are grown for export, but most farmers don't have these strains. Instead, the majority of avocados grown are local varieties, which spoil easily and fetch a very low price on the market (if they can even be sold). Avocado trees are mostly just grown for shading coffee, not for the benefit of the fruit. So most of the farmers earn extremely little income from local avocados: although a small farm may have 6 trees and produce 5000 avocados in a year, they will typically sell only a fraction (5-20% of their harvest) and earn less than 40 USD from that sale.
    - The oil press Imara Tech built as a second product of the EiR scheme does two things: 1) it increases the value and price that can be captured from each avocado by turning it into a valuable product with stable shelf life (OIL); 2) it allows farmers to make use of their entire harvest. Previous estimates suggest that on a small farm, a technology like this could turn a previously low-value, waste crop into one of the main economic activities for a small farm. Assuming 50 avocados per liter avocado oil, 5.000 avocados per farm/household, and 10,000 TZS (4 USD) per liter sales price, each household is expected to increase their income by 1M TZS per year (400 USD per year). This is almost entirely a net benefit, allowing farmers to increase the value of their crop by 10x.
    - In Northern Tanzania, there are an estimated 20,000 small farms growing avocados and 100 million avocados that go to waste each year.



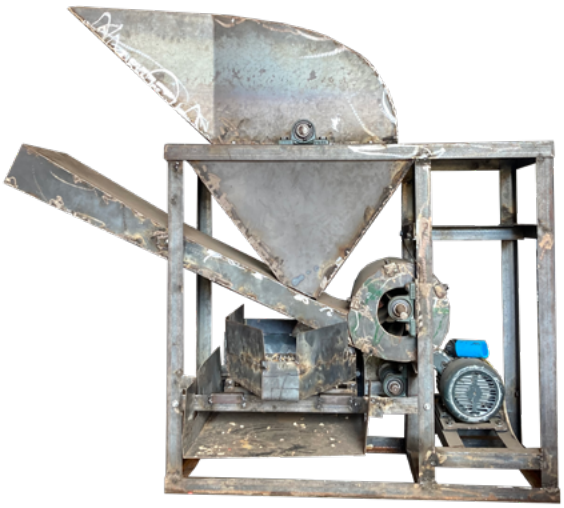
An early-stage small-scale flour milling prototype.

    - After two weeks of testing in the field, Imara Tech surveyed 10 farmers who had used the pressing machine. The farmers each pressed an average of 12L of avocado oil, which can be sold locally for over $50 to SMEs that process the oil for cosmetics.
    - This initial press prototype processes up to 28L of oil per hour using 1kWh of energy. Based on user feedback from the user trials, Imara Tech will now refine the design of the press so that it can be piloted with different oil-crops and evaluated for its income generating potential.
- First prototypes have gone to the field. Farmer cooperatives are managing them and using them to press avocado oil
    - Currently farmers pay nothing for services. Presses are managed by a third party organization (Avomeru: avocado oil start-up that is purchasing all of the oil). Imara takes a cut of the income earned through the press to recover the cost of the machines.
    - Future operational model: Imara provides products and solar to partners or cooperatives, receive revenue share from the oil pressing businesses
- Huge market potential: at one site, 173 farmers are using the press. Each farmer produces an average of 6.000 avocados per year, totaling 1M avocados produced annually in this area. At 50 avocados/L and 10,000 TZS/L, this area is producing an estimated $86,000 of oil each year.

A2EI and Imara Tech teams install a solar-powered oil press near Mt. Meru, Tanzania.

Productive use appliance 3:
PEANUT SHELLER

- Shelling was also identified as a promising technology in the joint Imara Tech/A2EI agricultural report.
- User interviews found people are spending months shelling peanuts by hand, a tough work with low throughput of 0.5 to 1 kg/hour. Peanut shellers with relatively low power (<1kW) are capable of shelling up to 100 kg/hr. The willingness to pay for shelling services has been identified at around 1 USD/40kg
- Based on this, Imara has started prototyping peanut shellers for use with solar that are expected to enter in a pilot phase in August 2021.



An early-stage peanut shelling prototype

Productive use appliance 4:
SOLAR MILLING

- Solar mill is one of those products that has garnered lots of interest but faced significant challenges in scaling in East Africa
- Favored milling technology for small-scale mills today is hammer mills: blades spin really fast and shatter grain, breaking it into powder.
    - Favored because it is very easy to make and simple technology.
- Hammer mills however are not very efficient, which we believe is because of the air resistance on the hammer blades: air resistance squares with speed, so the faster the blades go the less efficient the mill becomes.
    - Hence most solar mills are small-scale and have low throughput, as this is where they are most efficient
    - Diesel and AC mills are often much bigger and have through 2-5x higher than typical small-scale solar mills
- Instead of trying to perfect hammer mills, A2EI/Imara took a different route and are investigating a new technology based on roller mills

  - Roller mills look like multi-stage pasta rolling machines: tubes spin and crush and shear grain between them, broken grain passes through to pairs of rolls with increasingly smaller gaps
  - Favored technology by industrial millers. Store-bought flour is made in roller mills, which are favored for their efficiency
- The challenge with roller mills is their cost: rolls need to be precisely made, typically use special steel and have precision manufacturing. All of the above is not typical of local production in small shops. Hence SMEs are not able to buy this industrial scale technology
  - Imara/A2E strategy: instead of trying to improve the efficiency of a hammer mill, we are trying to bring down the cost of an efficient roller mill.
  - In a first step, roller mill components are manufactured locally, bringing down costs by changing roll material (using off-the-shelf steel instead of specialty steel) and changing size (using hollow pipe rolls with small diameter instead of large, heavy rolls)
- A2EI/Imara Tech are currently finishing the prototyping phase. Initial tests were promising, but we have been facing steep challenges in getting the prototypes ready. The prototype fabrication required importation of specialty equipment (slow!) but we are hopeful for this product.
- Imara Tech expected to be able to commercialize the next series of prototypes B2B (selling to mini-grids) and by setting up stand-alone mills that are locally operated and financed by Imara in exchange for a revenue share.

Productive use appliance 5:
PIPELINE OF FURTHER PRODUCTS

- The direct exchange with an existing customer base allows Imara Tech to provide a wider portfolio of products that are desired/required, including e.g. chaff cutters and walking tractors that existing tresher customers can use to earn additional income in different seasons thereby diversifying their incomes and reducing their dependency on one source of income e.g. threshing business, planting business, animal fodder business reduces overall risk
- Imara Tech has recently made first analyses of locally manufactured wind turbines that could be a way to bring down costs of energy generation throughout rural areas, in particular by pairing these turbines with PUA machines designed for use with solar

Overall learnings of the EiR

FROM PRODUCT DESIGN TO PRODUCT MARKET MATURITY?

- Local companies cannot overcome the barriers to scale alone. The combination of research, R&D resources and local pilot projects within an Entrepreneur in residence scheme seems promising for the series of technologies described above.
- R&D is difficult in Tanzania and cooperation with an international partner, in particular though co-usage of their labs, access to their engineering and supply chain capabilities help alleviate the R&D challenges
- Financial resources help not only hire staff and build infrastructure but also attracts further donors (leverage)
- Sufficient time for field testing and piloting help develop the right product and avoid commercial sales pressure too early on
- The development of the successful MCT shows that 24 to 30 months were necessary to bring the right product to market
- Importance of research (e.g. Evaluations report): Given the long timelines and high resource investment needed for R&D and market validation, it's important to de-risk new products with research.
- Energy: MCT achieved a positive impact on livelihoods and farm labor but did not use solar. Some of the solar powered machines were in high demand in on-grid areas. Separating and distinguishing the topics of PUE and renewable energy would accelerate the impact PUE technologies can have on livelihoods.

Imara Tech staff demonstrate and promote the MCT to raise awareness around mechanization.