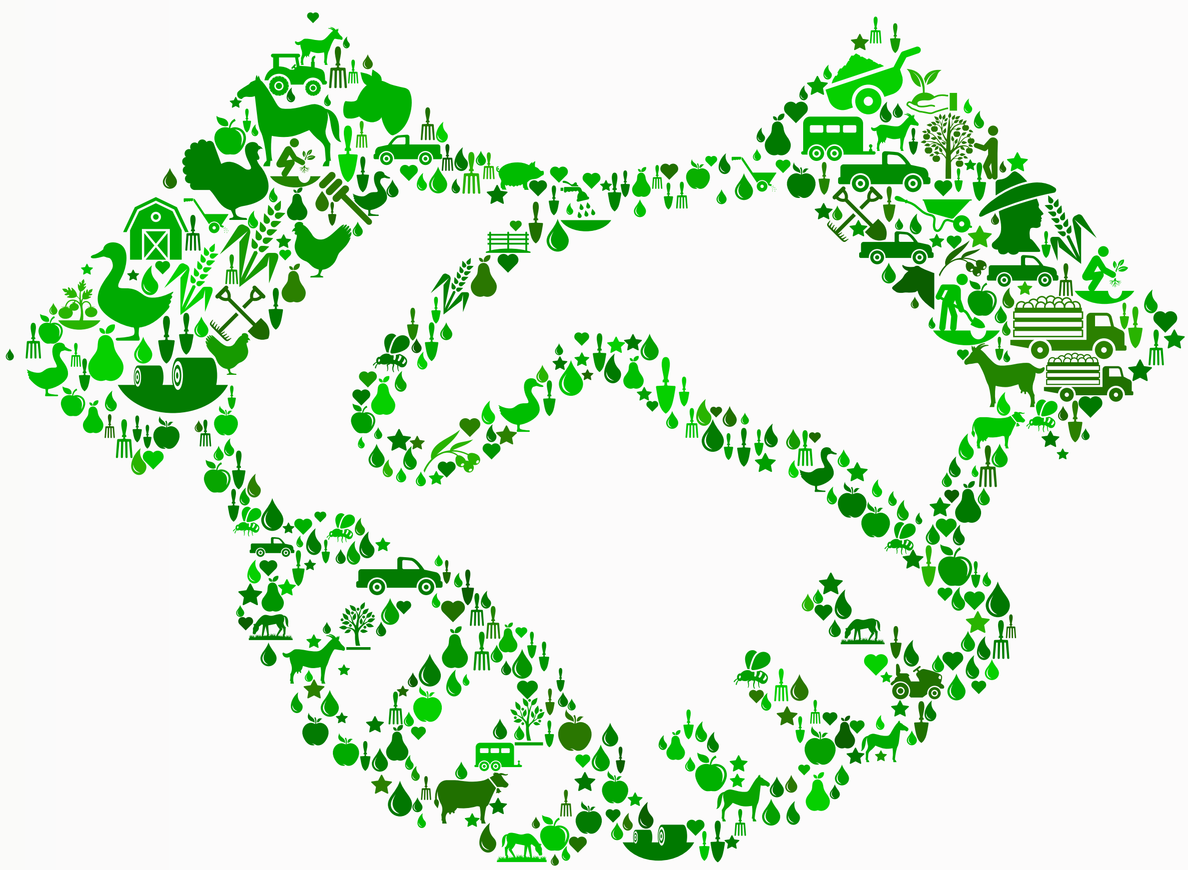
The Benefits of Collaborative Front-Line Research

Jonathan T. Scott and **Chenghai Yang**
explain a front-line research project bringing together an eclectic group of professionals to innovate and streamline key production segments in agriculture and other industries



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After three years of effort, the Circular Economy Alliance (CEA), the Circular Economy Research Center (CERC) at the Ecole des Ponts Business School, and the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) came together following the lifting of COVID restrictions.

EFMD Global's award-winning publication, 'The Sustainable Business', played a key role.

In its design phase, the 'Green Front Line' project was envisioned to investigate the introduction and application of sustainability and circular economy practices in agriculture and land management. The objective was to gain insight as to if and how eliminating and reducing resource use in various production stages can boost productivity, generate revenue increases, and reduce costs without decreasing quality (i.e., enabling the transition to a circular economy).

Planning began with a basic process map (see Figures 1 and 2, pages 22 and 23) that helped locate inefficient equipment and work stages in food production. After identifying a problem area, less wasteful and more economical alternatives were proposed and recommended for feasibility testing (proof of concept). Crucially, every improvement suggestion (e.g., tools, equipment, process changes, etc) had to meet three criteria:

(1) **affordability** (tools, equipment, and costs associated with making changes must be within the financial reach of intended users in terms of purchase price and operational costs);
(2) **availability** (equipment, tools, replacements, and parts must be easy to find and obtain); and
(3) **accessibility** (includes: ease of access to instruction or training, ease of use, and ease of maintenance and repair).

Remote sensing was chosen as a starting point because, as a problem prevention asset in early production stages, aerial-imaging equipment has the ability to detect oncoming devastation before it's too late – often before it's seen on the ground – which is a valuable attribute in an industry that's feeling the profound effects of global weather pattern shifts (climate change). These shifts result not just in loss of life and property, but can also be a trigger for disease, moulds, pests and fires, all of which can wipe out crops or forests in 48 hours or less. Unfortunately, large-scale aerial-imaging is expensive, costing anywhere between 500 USD and 3,000 USD per hour, says Chenghai Yang, a research agricultural engineer at the United States Department of Agriculture Agricultural Research Service (USDA-ARS). Indeed, one of the most frequent complaints Yang hears from aerial applicators is the high cost of using their agricultural aircraft for imaging.

The Road to Job Creation

The cost savings that aerial images can provide for land managers are significant. For example, if a grower only has to spray 30% of a 300-acre plot, and the spray product costs 50 USD an acre, it would take 15,000 USD of product to spray the entire field, versus 4,500 USD to spray 90 acres, or 30% of the field.

In Costa Rica, a farm owner increased his harvest by 33% and his profits by 200 USD per hectare, by using aerial-imaging to decrease chemical use. The results were so successful that he converted 300-hectares of his land into a pesticide-free operation and now only adds nutrients (such as phosphorous) when they're needed.

Meanwhile, Homeland Security officials in the United States have discovered that the cause of a puzzling increase in the number of Latin American families showing up at the U.S. border seeking asylum is not due to a spike in violence within their home regions, but a growing hunger crisis. According to the U.S. Customs and Border Protection agency, 'food insecurity' issues are being reported by the United States Agency for International Development (USAID) as well as the agency's own intelligence assessments. Years of meager harvests, drought and the devastating effects of "coffee rust" fungus in an industry that employs large numbers of rural farmers, is speeding up the exodus of families from villages bereft of jobs and food. And analysis of current regional migration surges indicates that 'the root causes of emigration could be alleviated by reducing hunger and creating jobs'.

Process Map: Collects and displays measurements from every stage of a production process to help visualize inputs and outputs for the purpose of eliminating waste, lowering costs, and reducing resources use.

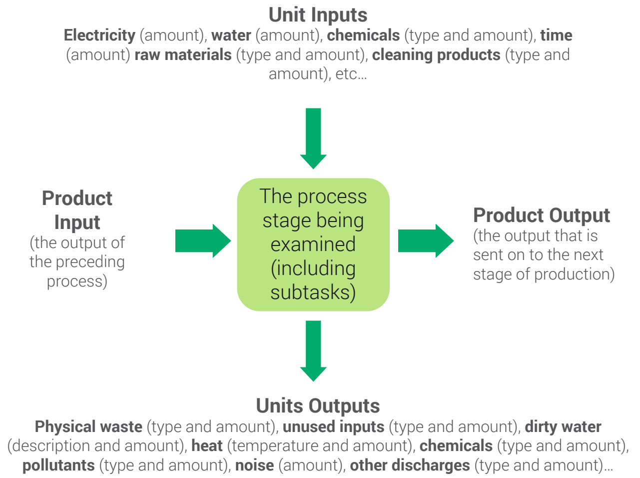
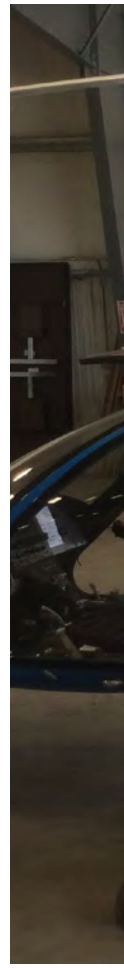
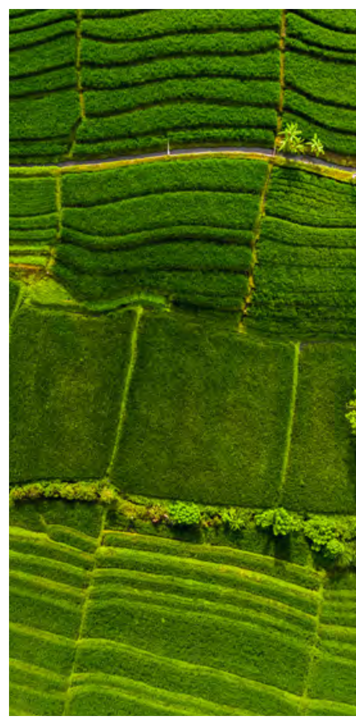


Figure 1

To date, remote sensing uses three types of camera platform: satellites, unmanned aircraft systems (UAS), and manned aircraft. Each has its strengths and weaknesses. Satellites are suitable for imaging large geographic areas, but they are limited by cloud cover and availability (every 1-16 days due to their orbits) and booking time can be expensive. UAS are great at covering small areas and producing high spatial resolution, but height and weight restrictions limit their range and abilities. Manned aircraft can do just about everything associated with imaging, but four-seat and six-seat aircraft are pricey to operate, particularly when they're used solely to carry cameras that only weigh 4-5 kilos. Indeed, it was this observation in 2019 that prompted Scott to contact Yang and ask why aircraft that consume 68 or more liters of leaded aviation fuel per hour (approximately $125 an hour) are used for aerial-imaging. And the reply he received to that question is commonly heard in many businesses – the equipment being used is the only equipment available and employees use what they have.





ATTACHING CAMERAS TO THE MAGNI GYROPLANE M24 (PHOTO COURTESY JONATHAN SCOTT)

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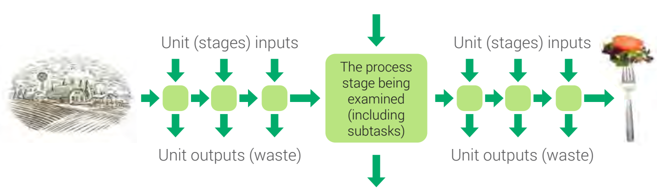
Yang and his team had previously concluded that manned aircraft, when flown at higher altitudes, can economically cover more area in a given time frame than UAE (drones), and are more reliable than satellites. So the first step Scott took was to investigate the purchase price and operating costs of manned aircraft. After conducting extensive secondary research and speaking with numerous aircraft manufacturers, it became apparent that lower-cost alternatives are widely available and a unique category called 'Light Sport Aircraft' (LSA) could be purchased at a price on par with that of a mid-sized tractor (50,000 USD or less) if the proposed aircraft was pre-owned. Fuel expenses would also be reduced by as much as 80%, because small aircraft use small motors powered by unleaded automobile petrol (not leaded aviation fuel, which costs twice as much). The combined cost savings could therefore make aerial-imaging more affordable to farming communities (co-ops), governments, and businesses. But no one had verified proof that LSA could do imaging work. Anecdotal evidence suggested that light sport aircraft can perform basic photography work at heights of around 900 meters, but no studies could be found that examined LSA carrying specialised aerial-imaging cameras while flying at heights of around 1.5 kilometres.

Process Map

Every work stage in every production process produces waste

Example: From the Farm to the Fork...



Approximately 30% to 50% of the world's food is lost due to multiple wasteful practices and inefficiencies at various stages of production and storage. If this waste is eliminated, total food output could *increase* (perhaps even double) with little to no need for additional land, water, and other resource inputs.

The world does not have a food *shortage* problem, it has a food *waste* problem.

Figure 2

Field tests took place from 21 to 24 June at the USDA-ARS Southern Plains Agricultural Research Center in College Station, Texas and involved attaching a two-camera normal color and near-infrared system to three different LSA models; a gyroplane (rotorcraft), an all-metal fixed wing airplane, and a motor-glider constructed of carbon fibre composites. Each aircraft then flew a 30,000-acre imaging pattern with flight times averaging one hour (it's important to note that a drone would need several weeks to cover the same amount of surface area). The general fuel consumption rate averaged between 17 and 21 litres (roughly 15 USD per hour).

Preliminary results showed that all three aircraft carried the imaging system successfully, flew over the predetermined flight line without incident, and efficiently collected the required images. Despite cloudy weather conditions, the images were mosaicked and provided seamless coverage of the designated crop fields.

Economic and material input/output analysis (including GHG emissions) of the aircraft are now being analysed to paint a more detailed picture of the implications that are possible and identify derivative uses and outcomes. For example, fuel calculation and basic emission comparisons show that if the state of Florida replaced its present-day wildfire-detection fleet (17 planes) with the aircraft tested at USDA-ARS, the fuel savings alone would amount to over 1,000 USD per hour and GHG emissions could be cut by more than two-thirds. Engine maintenance and aircraft storage requirements also decrease because the smaller engines that power LSA are less complex and use less oil. Additionally, LSA take up markedly less hangar space and are therefore less costly to store.

Unsurprisingly, the project showed that waste elimination and prevention techniques that succeed in other industries are equally as applicable in agriculture. Moreover, by introducing waste elimination before the introduction of waste prevention measures associated with the circular economy, expenses associated with overall process changes are reduced. Put another way, sustainable/circular resources (i.e., materials and molecules designed for reuse/repair/remanufacture) presently being developed to prevent waste in business and industry will not achieve their full potential if they're incorporated back into unchanged, inefficient work and production systems (see Chapter 9 of *The Sustainable Business*).

PIPISTREL SINUS (MOTOR GLIDER) BEING OUTFITTED WITH USDA'S CAMERAS (PHOTO COURTESY JONATHAN SCOTT)

Just as important, by bringing together different disciplines, by replacing/updating inefficient equipment with less wasteful alternatives it's possible to achieve dramatic cost reductions without a decrease in quality. In this case, equipment (aircraft) costs of 200,000 to 1-million USD can be reduced to 50,000 USD and fuel costs were lowered from 125 USD per hour to 15 USD per hour (with a commensurate decrease in GHG emissions). And once again, the methods used to achieve these results are applicable in most businesses, industries and workplaces. The bottom line: as the effects of

15 USD

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"...waste elimination and waste prevention techniques that succeed in other industries are equally as applicable in agriculture."

PROJECT DIRECTOR JONATHAN SCOTT WITH THE MAGNI GYROPLANE M24 (PHOTO COURTESY JONATHAN SCOTT)

Doing More with Less: Transitioning to a More Sustainable and Circular Economy (Adding Up the Waste Elimination, Efficiency Increases and Resource/Cost Reductions)

- Leaded aviation fuel replaced with less-polluting unleaded autogas (mogas)
- Fuel consumption lowered from 57 litres per hour to 11-23 litres per hour
- Hourly fuel costs cut from approx. US$125 to US$15 (based on June 2021 fuel prices)
- Maintenance cost reductions (e.g.: no 50-hour oil changes or spark plug cleaning)
- Purchase price decreases (smaller aircraft can cost 20% to 90% less than traditional larger aircraft)
- Flying time greatly reduced - at a height of 1.5 kilometres, 30,000 acres can be photographed in one hour (a drone needs several weeks to cover the same area)
- Fewer square meters of hangar space required (up to 50% less storage space with some small aircraft)

climate change continue to worsen, there will be an ever greater need for decision makers and front-line workers across the globe to access more efficient tools and work systems so they can reliably and affordably make their own informed decisions, produce better results, and contribute toward the transition to a more sustainable and circular economy.

The goal now is to apply the teamwork and knowledge derived from the first stage to improve the process of wildfire detection

It can't be overstated – impactful, collaborative research generates more than a limited set of empirical experiences. Everyone involved in the above project mentioned that they walked away enlightened. The aircraft manufacturers greatly appreciated the opportunity to demonstrate their aircraft and learn about a new potential market. The pilots learned to fly rudimentary aerial-imaging patterns. The USDA-ARS team realised that LSA have the potential to significantly reduce aerial imaging costs and that all aspects of agriculture can play a significant role in the circular economy (there is growing anticipation that LSA will be authorised for commercial use in the United States sometime in 2023). And everyone developed a more pronounced interest in the application of sustainability and the circular economy.

The second stage of the project will commence in 2022. The goal now is to apply the teamwork and knowledge derived from the first stage (above) to improve the process of wildfire detection – with implications for search and rescue, water detection, archeology, security, and so on. If all goes well, and funding can be obtained, the third and final stage is envisioned as a three to five-year learning-by-doing field initiative in a part of the world where aerial-imaging is needed and subsequent results can be measured. The idea is to bring together local experience, regional infrastructure, and the findings of the first two stages to act as a catalyst for change. All of which helps set the stage for a smoother transition to the burgeoning field of manned electric aviation.

Prof. Alon Rozen, Dean of the Ecole des Ponts Business School, and Christos Papakyriakou Director of the Circular Economy

LEFT TO RIGHT, CHANGHAI YANG, FRED GOMEZ, JONATHAN SCOTT (PHOTO COURTESY JONATHAN SCOTT)

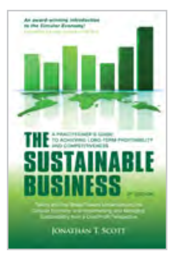
Typical benefits of collaborative research include:

- Valuable feedback
- Improved problem solving resulting from discussions and trial-by-error implementation
- Motivation
- The building of personal professional ties
- Increased skill development
- Knowledge and innovation development
- The satisfying of social needs (especially after COVID)
- An increased feeling of openness, sharing, and in-depth investigation
- Appreciation and interest in what other researchers and contributors have to offer

THE TEXAS AIRCRAFT COLT-100 WITH CAMERA (PHOTO COURTESY JONATHAN SCOTT)

Alliance, say that their team's commitment to produce measurable results, combined with front-line projects like 'Sustainable Aerial-Imaging', can offer similar waste and cost outcomes in related crossover projects including damage assessment, aerial surveys, forestry, policing & security, search & rescue, archeology mapping and more. 'One of the goals we've set,' says Rozen, 'is for CEA, Ecole des Ponts Business School, and our partners to use this project as an on-going template to educate and empower business so they too can eliminate and prevent waste in their work and production processes, with accompanying increases in profits and job creation. 'Of course, we're setting the bar high, but as long as we continue to break barriers and set new standards in the air and across the globe, we believe it's possible.'

EFMD Global is proud to be a part of this on-going research project.



EFMD Global's award-winning publication, ***The Sustainable Business***

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About the Authors

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Note: *The Circular Economy Alliance (CEA) was established with the support of the Circular Economy Research Center at Ecole des Ponts Business School. Its purpose is to enable a successful transition to a circular economy by building an alliance of eclectic and experienced stakeholders that will work in unison to: (1) identify front-line problems and development gaps, (2) propose workable solutions, (3) define action requirements, (4) share measurable results and best practices, and, (5) provide the training needed to upskill and reskill current and future labour forces.*