UK SPACE AGENCY

UK Space Agency International Partnership Programme

Space for Finance in Developing Countries

January 2020

https://www.gov.uk/government/organisations/uk-space-agency

The UK Space Agency leads the UK's efforts to explore and benefit from space. It works to ensure that our investments in science and technology bring about real benefit to the UK and to our everyday lives. The Agency is responsible for all strategic decisions on the UK civil space programme. As part of the Department for Business, Energy and Industrial Strategy, the UK Space Agency helps realise the government's ambition to grow UK industry's share of the global space market to 10% by 2030. The UK Space Agency:

- Supports the work of the UK space sector, raising the profile of space activities at home and abroad
- Helps increase understanding of our place in the universe, through science and exploration and its practical benefits
- Inspires the next generation of UK scientists and engineers
- Regulates and licenses the launch and operation of UK spacecraft, launch operators and spaceports
- Promotes cooperation and participation in the European Space Agency and with our international partners

International Partnership Programme

https://www.gov.uk/government/collections/international-partnership-programme

The International Partnership Programme (IPP) is a five-year, £30 million-per-year initiative run by the UK Space Agency. It focuses on using the UK space sector's research and innovation strengths to deliver sustainable economic or societal benefit to developing economies around the world. IPP is part of, and is funded from, the Department for Business, Energy and Industrial Strategy's Global Challenges Research Fund (GCRF). GCRF is a £1.5 billion fund announced by the UK Government which supports cutting-edge research and innovation on global issues affecting developing countries.

Caribou Space

www.caribou.space

Caribou Space supports organisations to bridge the worlds of space and development by working with governments, space agencies, development agencies and private sector space companies. Caribou Space provides:

- **ODA fund and programme strategy:** Strategic recommendations for the design and delivery of ODA programmes.
- **Fund management:** Large scale ODA funds (£100M+), and seed stage funds (£4M+).
- **Monitoring and evaluation (M&E):** Design of M&E systems, delivery of process and impact evaluations and M&E training.
- **Research, communications and knowledge sharing:** Conducting research on market opportunities, user needs, use cases and the impact of space solutions. Sharing knowledge publicly of what works, doesn't work and why, through diverse communications channels including press and media, publications, social media, conferences and workshops.
- **Programme management:** Delivery of complex, multi-country, multi-million-pound programmes in developing countries.
- **Product strategy:** Supporting strategy for the sustainability and commercialisation of space solutions for developing countries.
- **Economic evaluation:** Quantification of the economic case and impacts of space technology.

Caribou Space has also published these additional reports for UK Space Agency:

- Space Solutions for Development
- Space for Forestry in Developing Countries
- Space for Disaster Resilience in Developing Countries
- Space for Agriculture in Developing Countries

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Acknowledgements

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The UK Space Agency and Caribou Space would like to acknowledge the following people for their valuable contributions to this report. This publication would not have been possible without their insights and stories.

- Hermen Westerbeeke – RHEA Group
- Moslehuddin Ahmed – Micro-Insurance Research Centre UK (MIRCUK)
- Nick Walker – eOsphere
- Saravana Gurusamy – Rezatec
- Ruchit Garg – Harvesting
- Victor Wang – Pula Advisors
- Eli Pollak – Apollo Agriculture
- Charles K. Huyck – ImageCat
- Shubharoop Ghosh – ImageCat
- Janet Wilson – Airbus Defence and Space

Background

This report was commissioned by the International Partnership Programme (IPP), a five-year, £30 million per year initiative of the UK Space Agency. IPP uses the UK space sector's research and innovation strengths to deliver sustainable, economic and societal benefit to developing countries. Projects within IPP span a range of themes including: building disaster resilience; improving agriculture; reducing deforestation; preventing and reducing maritime pollution and illegal fishing; optimising renewable energy production; and improving access to appropriate and affordable financial services.

IPP is part of the Department for Business, Energy and Industrial Strategy's (BEIS) Global Challenges Research Fund (GCRF), a £1.5 billion Official Development Assistance (ODA) fund which supports cutting-edge research and innovation on global issues affecting developing countries. ODA-funded activity focuses on outcomes that promote long-term sustainable development and growth in countries on the OECD Development Assistance Committee (DAC) list. IPP is ODA compliant, being delivered in alignment with UK aid strategy and the United Nations' (UN) Sustainable Development Goals (SDGs).

This report outlines why and how the space industry has a role to play in addressing challenges within the finance sector in developing countries. It is part of a series of five sector-focused reports, also including disaster resilience, agriculture and forestry.[1,2,3]

The report draws on examples of space solutions for finance supported by IPP and organisations outside of IPP. Finance products include payments, savings, credit and insurance. All the IPP projects in this report examine solutions for the insurance sector, and the report also highlights space solutions from beyond IPP for credit and payments. Some of these solutions are operational, while others are in the research and testing stage.

The primary audience for this report is the space, development and finance sectors, and it is written as an introductory primer on the role of space in the finance sector. It outlines why and how the space industry has a critical role to play in addressing challenges confronting the finance sector in developing countries.

Report structure

The report is structured as follows:

- **Executive summary**
- **The case for space technology:**
  - Outline of the major challenges for finance providers and customers
  - The role of space technology in finance
  - Main use cases of space technology in the finance sector
  - Potential impact of using space technology on finance providers and customers
- **Conclusions:**
  - Analysis of emerging themes from the use cases
- **Additional resources** on space technology and finance
- **Annex one** – Profiles of organisations using space technology for the finance sector
- **Annex two** – Glossary

1 UK Space Agency International Partnership programme. 2018. 'Space for Agriculture in Developing Countries'. https://www.spacefordevelopment.org/library/space-for-agriculture-in-developing-countries/

2 UK Space Agency International Partnership programme. 2018. 'Space for Forestry in Developing Countries'. https://www.spacefordevelopment.org/library/space-for-forestry-in-developing-countries/

3 UK Space Agency International Partnership programme. 2018. 'Space for Disaster Resilience in Developing Countries'. https://www.spacefordevelopment.org/library/space-for-disaster-resilience/

Who is this report for?

This report is an introductory primer on the role of space technology in finance in developing countries. It is intended for a range of audiences, and contains various insights applicable to each.

Audience	Learning objectives
Downstream space sector Organisations that use space technology to design solutions for public and private sector users	– Understand challenges to the finance sector of developing countries from the perspective of customers and providers, and the subsequent market opportunity for space technology – Learn about existing collaboration between the UK space sector and partners in developing countries, and how space technology is tackling finance challenges through IPP – Gain insights on how technology and finance organisations have used space technology to solve different challenges – **Relevant report sections:** *Customer and financial provider challenges; Use cases of space technology in finance; Key themes from use cases; Product and business model considerations; Profiles of organisations addressing these challenges*
Financial technology (fintech) sector Organisations that use digital solutions to provide financial services	– Understand challenges to the finance sector of developing countries from the perspective of customers and providers, and the subsequent market opportunity for space technology – Gain insights on how technology and finance organisations have used space technology to solve different challenges – Review profiles of organisations that are applying space technology to the credit and insurance sector, and understand the opportunities in the payments sector – **Relevant report sections:** *Types of space technology; attributes and advantages of space-derived data; Use cases of space technology in finance; Key themes from use cases; Product and business model considerations; Profiles of organisations addressing these challenges*
Finance sector Banks, Microfinance institutions, insurance, reinsurance and micro-insurance companies	– Learn about the opportunity for space technology to benefit the finance sector through increasing customers, incorporating new customer segments, reducing costs and improving portfolio risk management – Review profiles of organisations that are applying space technology to the credit and insurance sector and understand the opportunities in the payments sector – **Relevant report sections:** *Types of space technology; Attributes and advantages of space-derived data; Key themes from use cases; Product and business model considerations; Profiles of organisations addressing these challenges*
Development sector Development organisations, donors, investors, NGOs	– Understand challenges to the finance sector of developing countries from the perspective of customers and providers, and the subsequent market opportunity for space technology – Learn about the expected impact of using space technology in the finance sector – Review profiles of organisations that are applying space technology to the credit and insurance sector, and understand the opportunities in the payments sector – **Relevant report sections:** *Types of space technology; Attributes and advantages of space-derived data; Use cases of space technology in finance; Key themes from use cases; Product and business model considerations; Profiles of organisations addressing these challenges*
Government agencies	– Understand the opportunity for space technology to add value to national insurance schemes – Review case studies of organisations that are applying space technology to national insurance schemes – **Relevant report sections:** *Types of space technology; Attributes and advantages of space derived data; Use cases of space technology in finance; Key themes from use cases; Product and business model considerations; Profiles of organisations addressing these challenges*

Executive summary

Globally, 1.7 billion adults remain unbanked – without an account at a financial institution or a mobile money provider – virtually all live in the developing world.[4] Only about 5.4%[5] of the adult population of Africa has insurance, and only 9%[6] of people in developing countries have borrowed from a formal financial institution. Without access to financial services, the ability to smooth consumption and access opportunities to improve welfare is reduced. Financial services can help drive development. Yet there are many challenges to delivering accessible, affordable and appropriate financial products to customers in developing countries. These challenges include:

For finance providers:

- Limited data on potential customers, to assess credit and insurance risk profiles
- Low income customers are outside financial providers' reach due to high operational cost of serving remote areas
- Constrained business models to operate in remote areas serving low income customers
- Customers inexperienced with formal financial services

For customers:

- Limited financial histories or documentation to supply to the finance providers
- Low access to appropriate financial services
- Limited excess income, coupled with variable income flows
- Lack of trust in formal financial services, compounded by poor digital and financial literacy

The space sector is poised to contribute new types of information to form part of the solution to many of these challenges. The unique benefit that space solutions offer is global, repeatable, scalable data that can deliver high-value insights about the Earth, especially on developing countries where existing data and insight are limited. There are several organisations using space technology, in particular Earth Observation (EO) and Global Navigation Satellite System (GNSS), to enable greater access to financial services.

For this report Caribou Space interviewed eight organisations (five from IPP and three external to IPP) and conducted a literature review on the applications of space technology in the finance sector today.

Use cases of space technology in the finance sector

While they remain nascent, several use cases for space technology in the finance sector are being tested, while others are already deployed. Use cases for space technology can be currently found in insurance, credit and payments and transactions.

4 Demirgüç-Kunt Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. 'The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution'. World Bank. www.openknowledge.worldbank.org/handle/10986/29510. Accessed January 2019.

5 Biese, K., McCord, M. J. and Sarpong, M. 2016. 'The Landscape of Microinsurance in Africa 2015'. Microinsurance Centre. http://www.microinsurancecentre.org/resources/documents/unknown/the-landscape-of-microinsurance-in-africa-2015.html. Accessed January 2019.

6 The Global Findex definition of formal financial institution includes all types of financial institutions that offer deposit, checking, and savings accounts–including banks, credit unions, microfinance institutions, and post offices–and that fall under prudential regulation.

Box 1: Use cases for space technology in the finance sector

Insurance	Credit	Payment and transactions
1. EO and GNSS support risk modelling to inform insurance policies 2. EO and GNSS support portfolio monitoring and risk mitigation 3. EO and GNSS facilitate the design of efficient index-based insurance products 4. EO and GNSS supports remote decision-making on verification of insurance claims	1. EO and GNSS support loan portfolio monitoring 2. EO and GNSS support remote decision-making on credit risk profile	1. Satellite communication enables payments and transactions in remote areas

Emerging themes from use cases

The use of space technology for financial services is beginning to gain ground, and themes that illustrate how space technology is used in financial services are emerging:

Strong case for insurance: All five IPP projects considered in this review focused on the insurance market. There is a clear use case for EO and GNSS providing insurance companies with data on assets, input for index insurance products, portfolio monitoring and the management of claims assessments. The lack of dependable, frequent data for insurance companies is frequently cited, pointing to a clear opportunity for EO data.

Emerging cases for credit: A scan of space technology for finance solutions highlights that there are more insurance-focused solutions than there are for credit. However, there is a clear business case for credit solutions, as evidenced by the two companies profiled in this report providing access to credit using EO and GNSS.

Potential case for payments: While only one use case for improving payments and transactions is noted in this report, it is a fundamental one. There is an opportunity for satellite communications to enable payments and transactions to exist in areas with limited mobile or fixed network coverage.

Opportunities in the agricultural sector: Seven of the eight organisations interviewed have focused on the agricultural sector. They are addressing crop and livestock insurance, products that need nuanced, hard-to-source data that is difficult to verify. This is where space technology can be invaluable.

Opportunities in other sectors: While not explored to the same extent in this report as the agricultural sector, there are cases for using space technology for finance beyond agriculture. For example, assessing risk and verifying loss for natural disasters, infrastructure exposure and transport insurance.

EO and GNSS are the dominant space technology in use: Space services to the finance industry come under three applications; EO data; GNSS data; and Satellite Communications (SatComms). All applications discussed in this report are using EO for both insurance and credit solutions. Integrated within these solutions is the use of GNSS to enable finance providers to designate the boundaries of a farm for portfolio monitoring. SatComms was highlighted for enabling payments when terrestrial networks are limited or non-existent.

Most solutions are using a business to business (B2B) model: Most space solutions are focused on solving challenges to the financial provider, to enable them to serve a greater number of customers efficiently and at a lower cost. However, successful cases for direct to customer service provision are also highlighted within this report.

Satellite data enhances other data sources: No organisation interviewed used satellite data in isolation. They are using an array of EO datasets and coupling them with non-space datasets, such as data from microfinance institutions, crop growth models, and livestock mortality surveys. Emerging evidence has indicated that satellite data in combination with other sources of data is more powerful than either alone.[7,8]

A number of product and business model considerations when using space technology also emerged from the research. Some examples include:

- Requirement for training data
- Building trust in space technology
- Reviewing the capabilities and skills needed for finance service providers to use space technology
- Considering scalability when using space technology

Impact of space technology

Ultimately the effects of integrating space technology into a product accrue to the provider of the financial service, who in turn can pass on these gains to customers in terms of access to appropriate and affordable financial services and products.

Space technology's impact on finance providers is primarily through:

Increasing the customer base: Improving the accuracy of index-based insurance products so that they will reliably pay out following an insured event can lead to an increase in trust and so in insurance uptake. Space technology also helps expand the customer reach of finance providers through freeing up capital, by decreasing the need for on-the-ground assessments of all customers. Satellite data also provides finance providers with information on customers who previously lacked sufficient data to access credit and insurance products.

Reducing operational costs: By accessing quality satellite data on potential customers and potential risks, the requirement for finance providers to do on-the-ground assessments and portfolio monitoring can be reduced, resulting in cost savings for finance providers.

Improving risk management: By incorporating an array of EO data into customer risk assessment models, and through the ability to access live data, financial providers can improve their risk management strategies. This can happen by providing finance organisations with detailed information before the insurance policy or loan decision is taken. In other cases, insurance companies have access to information post-insurance and can provide 'nudges' to customers to mitigate risk.

Reduction in index-based insurance basis risk: Index insurance can be affected by basis risk, which arises when the index measurements do not match an individual's actual losses. High-quality index insurance requires significant data at a more granular level, which EO data can support.

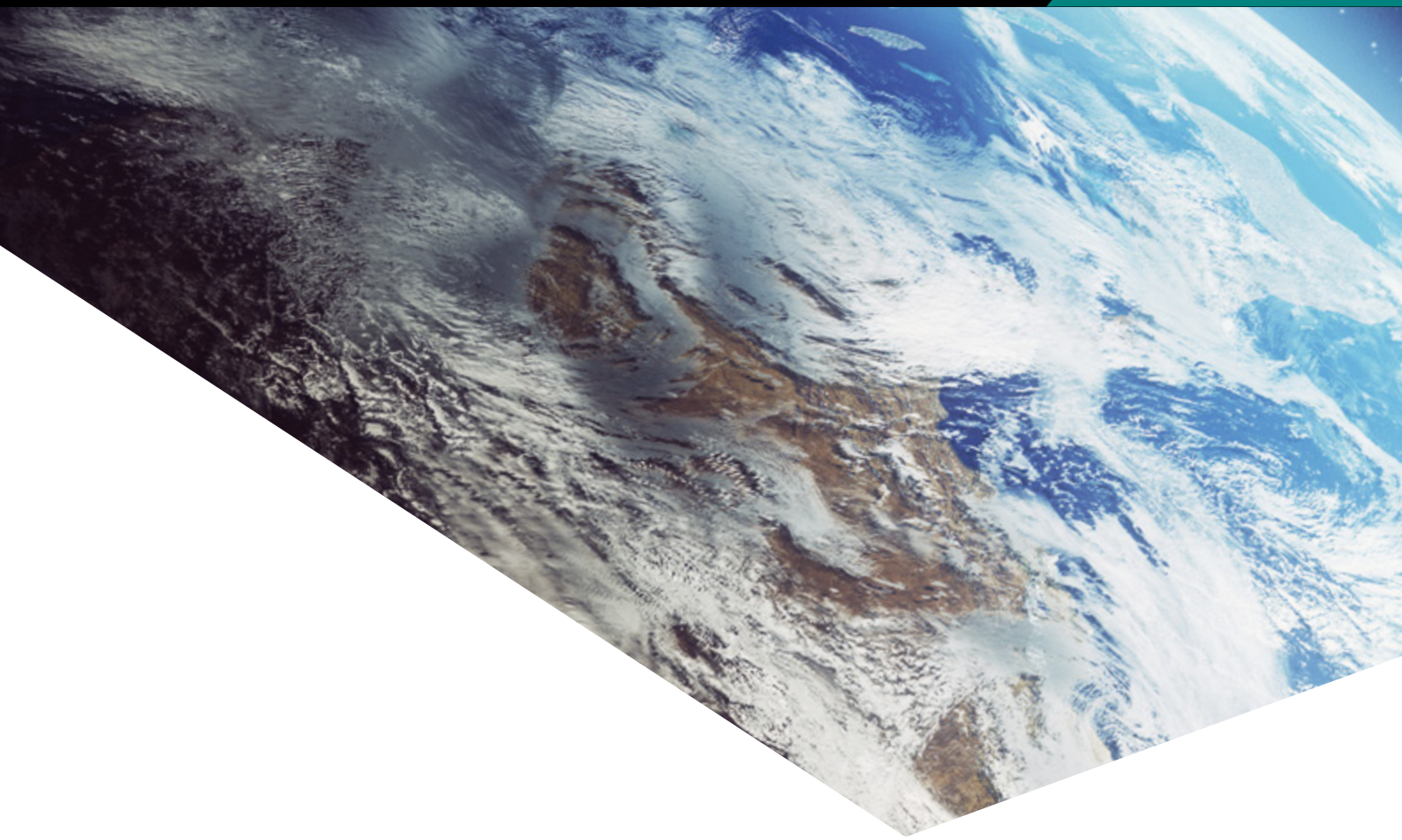
Impact at the finance provider level is passed on to customers in terms of:

Improved access to affordable finance products: Incorporating satellite data into finance providers' business models can lead to a reduction in operational costs. It is feasible that this cost saving could be passed on to the customer via lower interest rates or premium rates. Additionally, space technology can improve the availability of certain products, for example SatComms enabling payment and transaction services in remote areas with limited access.

Increasing trust: It is important for customers to trust that if they invest in an insurance product they will receive a payout should they suffer any losses. If through the integration of satellite data, index-based insurance becomes more accurate and more likely to pay out in the event of a loss, this will build trust in the product, which increases the likelihood of new customers purchasing insurance.

7 World Bank. 2015. 'Agricultural data and insurance, Innovations in agricultural data development for insurance.' https://blogs.worldbank.org/psd/files/agricultural-insurance-data-15sept2015.pdf. Accessed March 2019.

8 Jon Einar Flatnes, Michael R. Carter and Ryan Mercovich. 2019. 'Improving the quality of index insurance with a satellite-based conditional audit contract'. University of California Davis. https://basis.ucdavis.edu/publication/paper-improving-quality-index-insurance-satellite-based-conditional-audit-contract. Accessed April 2019.



Customers who use credit and insurance may benefit from a number of changes. Credit can smooth consumption during financial shocks, providing capital to businesses and for household expenses, effectively helping customers better manage financial choices.[9] Insurance improves resilience to shocks by providing customers with an efficient means to manage risk and avoid negative coping strategies such as selling productive assets or depleting savings. There is also emerging evidence on the productivity enhancing effects of insurance.[10]

Conclusion

While satellites capable of imaging the Earth have been in orbit for decades, the space sector is now undergoing a revolution. Due to advances in manufacturing techniques and innovation in space technology, there is an abundance of satellites imaging the Earth's surface, providing an increase in EO data. Crucially, some of this new data is being provided to users free of charge. This improves the cost-effectiveness of space solutions in the finance sector compared to existing alternatives, such as on-the-ground assessments and monitoring.

Furthermore, the parallel revolution in computer processing power and data science has allowed software to handle and automatically process EO data to extract insights. As costs fall and analytical products and platforms mature, space solutions will increasingly provide the opportunity to tackle some of the finance sector's challenges.

Space technology for financial services is comparatively new. Its full potential is being explored and tested, but it is clear that space technology offers advantages in areas where other sources of information are limited. While many concepts are still being tested, others are deployed. The examples presented by IPP and other organisations in this report provide a perspective and a path forward to leveraging space technology in financial services. The future is bright for space technology in the finance sector, and now is the time to seize this opportunity.

9 J-Pal and IPA Policy Bulletin. 2015. 'Where credit is due.' https://www.povertyactionlab.org/sites/default/files/publications/where-credit-is-due.pdf. Accessed March 2019.

10 Dercon Stefan and Christiaensen Luc. 2007. Consumption Risk, Technology Adoption, and Poverty Traps : Evidence from Ethiopia. Policy Research Working Paper; No. 4257. World Bank, https://openknowledge.worldbank.org/handle/10986/7417. Accessed March 2019.

The case for space

The role of finance in development

Financial services can help drive development. Savings, credit, insurance and payments enable people to smooth consumption and take opportunities to improve their welfare. Different finance products serve different purposes:

- **Saving** helps people accumulate capital for planned and unplanned expenses. Those who save may be rewarded with interest or as they build a financial history, with access to credit.
- **Credit** is a powerful tool in providing liquidity. Credit can smooth consumption during financial shocks, and provide capital for businesses and for various household investments.
- **Insurance** improves resilience to shocks by providing people with a tool to manage risk and avoid selling productive assets, e.g. livestock, to cope with shocks.
- **Payments and transactions** enable the movement of cash in economies, from remittances, bill payments, salaries, or accessing government financial support.

Globally, 1.7 billion adults remain unbanked – without an account at a financial institution or a mobile money provider – virtually all live in the developing world.[11] Only about 5.4%[12] of the adult population in Africa has insurance and only 9% of people from developing countries have borrowed from a formal financial institution.[13] Without access to financial services, the ability to smooth consumption and access opportunities to improve welfare is reduced.

A pathway to development impact

There are numerous challenges to the delivery of financial products to remote populations in developing countries. These range from limited customer data to constrained business models, the accessibility and affordability of products, and low consumer trust in formal financial services.

The space sector is well placed to contribute new types of information which can form part of the solution to a number of these challenges. In particular, it can help address data limitations and enable financial service providers to assess risk, monitor their portfolio and verify claims. The direct impact of using space technology will be via the finance providers, through increasing their customer base, reducing operational costs, improving risk management and in the case of index insurance, reducing basis risk. These effects at the financial provider level can be passed on to impact the customer, by increasing access to affordable financial products and improving trust in financial services.

Through literature reviews and expert interviews, Caribou Space has developed an impact pathway diagram that describes how space technology can address some of the finance sector's challenges, and which describes the potential impact of these solutions, as per Figure 1.

11 Demirgüç-Kunt Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. 'The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution'. World Bank. www.openknowledge.worldbank.org/handle/10986/29510. Accessed January 2019

12 Biese, K., McCord, M. J. and Sarpong, M. 2016. 'The Landscape of Microinsurance in Africa 2015'. Microinsurance Centre. www.microinsurancecentre.org/landscape-studies/2015-landscape-of-microinsurance-in-africa.html. Accessed January 2019.

13 The Global Findex definition of formal financial institution includes all types of financial institutions that offer deposit, checking, and savings accounts–including banks, credit unions, microfinance institutions, and post offices–and that fall under prudential regulation.

Figure 1: Space technology for the finance sector – an impact pathway

Impact-Customer	Increased resilience | Improved welfare			
Outcomes-Customer	Access to, and use of affordable financial service products			
Outcomes-Providers	Increase client base and incorporation of new clients segments | Reduction of costs relating to serving clients | Improve risk management			
Space technology solutions for finance	**Insurance:** 1. Earth observation (EO) and Global Navigation Satellite System (GNSS) supports risk modelling to inform insurance policies 2. EO and GNSS supports portfolio monitoring and risk mitigation 3. EO and GNSS facilitates the design of efficient index-based insurance products 4. EO supports remote decision making on verification of insurance claims	**Credit:** 1. EO and GNSS supports loan portfolio monitoring 2. EO and GNSS supports remote decision making on credit risk profile	**Payments:** 1. Satellite communications enable payments and transactions in remote areas	
Finance provider challenges	Lack of information on customers to assess credit or insurance risk	Customers beyond current reach	Constrained business models	Customers inexperienced with formal financial services
Customer challenges	Limited financial histories or documentation to assess risk	Low access to appropriate insurance or credit service providers and products	Limited excess income coupled with seasonal/ variable income flows	Limited trust of insurance coupled with low financial and digital literacy
Macro challenge	Climate change – Increase in the frequency and severity of extreme weather events			

The following section is an analysis grounded in the impact pathway in Figure 1, and it will:

- Elaborate on the finance provider and customer challenges
- Describe the use cases for space technology to advance finance solutions, with examples from IPP and other organisations
- Highlight the impact that finance providers and customers may experience using evidence from the research and literature

Customer and financial provider challenges

Finance provider and customer challenges are discussed in tandem, as they compound each other. For example, low customer engagement with the formal sector,[14] and resultant limited data about their financial behaviour, constrain the business case for serving customers because of an inability to assess risk.

Not all challenges described here can be solved by space technology. However, it is critical to understand the issues in order to design and deliver solutions that can positively impact the finance sector and customers in developing countries.

14 Sector which encompasses all jobs with normal hours and regular wages, and are recognised as income sources on which income taxes must be paid.

Limited information for verification of customer risk profiles

"The problem is the availability of information. Dependable information, frequent information, information that you can change into knowledge."

RHEA Group – IPP DFMS project

Low-income customers engage less often with the formal sector. 93% of the world's informal employment is in developing countries.[15] This lack of engagement means there is insufficient documentation to prove identity, asset ownership or financial history. For example, 26% of people from low-income countries cited that they do not have a formal financial account because of a lack of identification documentation.[16]

These information gaps compound to affect the volume and quality of customer data that finance service providers can obtain. This data is traditionally required to develop risk profiles, contribute to product design, inform marketing efforts and verify claims. Without suitable documentation, many potential customers cannot access traditional financial services.

Access to appropriate financial services

"Most of the lenders today have this unsaid rule wherein you only serve within 20 kilometers from the last mile branch. Because after that, it's hard to get information about the farmer."

Harvesting

Traditional finance providers rely on branches, agent networks and aggregators for product distribution. These physical touch points are largely concentrated in urban areas. However, a high proportion of the market is unbanked, informally employed and live in rural areas. This makes it difficult to serve this market and results in fewer financial services being available to these populations.[17, 18]

"One of the problems is, it tends to be the wealthiest households who are taking it (insurance) up, leaving the poorest still in a vulnerable position, exposed to risks."

eOsphere – IPP SIBELIUs project

By reducing the requirement for staffed offices in remote locations, digital financial services – financial services accessed and delivered through digital channels – may be part of the solution to providing access. However, difficulties exist in accessing digital financial services, albeit to a lesser extent than for traditional services. Not everyone has a phone, even fewer have a smartphone, and not everyone has unrestrained access to the internet. The choice of the delivery model needs careful consideration to avoid deepening the exclusion of populations that do not have access to these technologies.

However, access to financial services is only the first step. The products also need to be appropriate to the needs of low-income customers. Designing products to meet their needs requires a tailored approach. This includes considering the risk events, such as farming risks or natural disasters, that are most appropriate to cover by insurance, the manner and timing of payment and the types of documentation needed to develop risk profiles and verify claims.[19] Tailoring products requires investment in different approaches to accessing data on customers and in alternative channels and business models for delivering the products, as well as an appetite to serve low-income segments.

15 ILO. 2018. 'Women and men in the informal economy: A statistical picture'. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf. Accessed February 2019.

16 Demirgüç-Kunt Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. 'The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution'. World Bank. www.openknowledge.worldbank.org/handle/10986/29510. Accessed January 2019

17 Same as above

18 Premasis Mukherjee et al. 2014. 'The landscape of microinsurance in Asia and Oceania 2013'. https://microinsurancenetwork.org/sites/default/files/The_landscape_of_microinsurance_in_Asia_and_Oceania_2013__full_report.pdf. Accessed February 2019.

19 Hermen Smit et al. 2017. 'Role of insurtech in microinsurance: How is insurtech addressing 5 challenges in microinsurance'. https://cenfri.org/wp-content/uploads/2017/11/InsurTech-Research-Study_March-2017.pdf. Accessed February 2019.

Affordability of financial products and need for low-cost business models

"Insurance is a relatively new concept for many in the Mongolian herding community and there is a tendency for herders to only insure a small proportion of their livestock in order to minimise their premiums, but often they are then disappointed only to receive a relatively small payout after losing many animals."

eOsphere – IPP SIBELIUs project

Low-income customers struggle to afford expensive insurance premiums or high-interest loans. 26% of lower income populations said that one reason they do not have a financial account was that the products were too expensive.[20] Research has shown that demand for insurance falls dramatically as the price increases and vice versa, suggesting that cost is an important consideration.[21] Furthermore, it is not only the cost of the product that needs to be considered, but the cost of accessing it in terms of travel and time taken from productive activities.

"It's very hard for microfinance institutions to scale after 10,000 or 15,000 farmers, because after that, it's really hard to manage. At that point, it's important for microfinance institutions to start adopting technology."

Harvesting

At the same time, if financial service providers provide cheaper products, they then need a low-cost business model with high volumes to make a profit. The traditional approach to insurance and credit delivery involves costly infrastructure. Digitisation provides a way for providers to reach scale and serve new customer segments, while remaining affordable due to savings on staff and infrastructure.

Trust in financial services

"We've got quite a bit of feedback from herders who say "We have the insurance, we lost many animals and we didn't get paid". This is often an example of basis risk, where the index currently used in their livestock insurance (IBLI) is quite crude and not very regionally sensitive."

eOsphere – IPP SIBELIUs project

Positive experiences build trust, negative experiences erode it. In the insurance sector, basis risk can damage trust. Basis risk in index insurance arises when the index measurements do not match a customer's actual losses. There are two main sources of basis risk. One source stems from poorly designed products, and the other from geographical elements. Basis risk is minimised through robust product design and back-testing of the index parameters.

Research has shown that demand for insurance increases over time as people become more familiar with it.[22] In the absence of unbounded trust or sufficient social proof, it will take time to scale insurance, and to a lesser extent credit, to low income customers. To maximise success, financial service providers need to design for trust.[23]

Digital and financial literacy requirements

"The real challenge is education. For example, not all farmers are digitally literate. You will see farmers in the north that are quite adapted to technology and using iPhones. Whereas in the south, education is questionable, access to mobile phones is another issue. And hardly any farmers have used smartphones at all."

Rezatec – IPP COMPASS project

20 Demirgüç-Kunt Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. 'The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution'. World Bank. www.openknowledge.worldbank.org/handle/10986/29510. Accessed January 2019

21 De Bock, O. and W. Gelade. 2012. 'The demand for microinsurance: A literature review'. Research Paper No. 26, ILO, Geneva. www.ideas.repec.org/a/eee/wdevel/v94y2017icp139-156.html. Accessed January 2019.

22 Ulrich Hess and Peter Hazell, 2016. 'Innovations and emerging trends in agricultural insurance'. GIZ. https://www.spacefordevelopment.org/wp-content/uploads/2018/06/Innovations-and-Emerging-Trends.pdf. Accessed February 2019.

23 Jane Del Ser and Maelis Carraro. 2017. 'In Digital Financial Services We Trust'. BFA. https://medium.com/f4life/in-digital-financial-services-we-trust-850352dea2e9 Accessed February 2019.

While space technology cannot directly address the challenge of low digital and financial literacy, literacy is an important challenge to understand when designing solutions for the finance sector.

Digital literacy – the ability to find and evaluate information on various digital platforms – is a barrier to accessing financial services. CGAPs research found that only 68% of Tanzanian farmers, 25% of Mozambican farmers, and 24% of Pakistani farmers had the ability to send an SMS.[24] Introducing smartphones to a product design brings another level of technical exclusion. Providers need to think critically about the digital channel used to provide services, and evaluate who is included and who excluded when using a particular channel.

Financial literacy – skills and knowledge to make informed financial decisions – is required both to adopt and to effectively use financial services. The recent proliferation of Kenyans blacklisted by the central credit bureau due to small outstanding loans is evidence of low financial literacy among certain customers.[25] An understanding of the levels of financial literacy among customers should be incorporated into product design. Not addressing digital and financial literacy is a lose-lose situation, for customers and for finance providers.

Climate change – a macro challenge

"Increasingly, and this is being exacerbated by climate change, they have weather events which they refer to as dzuds, where typically, a dry summer leads to lack of pasture. So, the animals go into the cold winter months weakened. Then if there is a particularly cold winter with deep snow this can be devastating. In 2009/2010 about 20% of the entire national livestock was lost." (9.7 million animals)

eOsphere – IPP SIBELIUs project

Climate change may increase the need for insurance as a risk management strategy. While people may feel increasingly vulnerable and more likely to include insurance in their risk management practices,[26] it is also a challenge for the insurance industry, as it is expected to increase both the frequency and severity of extreme weather events.[27]

Under these circumstances, insurance should be more appealing as a risk management strategy in the face of increasing vulnerability. However, affordability is a concern, as insurers are equally likely to raise premium rates to reflect higher payout levels and hedge against uncertainties.[28] This may require risk pools that are too much for one insurer to bear. Governments used to deal with these risks in their disaster management programmes, but they are increasingly partnering with the private sector to make costs more predictable. Now more than ever, dependable data about our dynamic planet is required.

24 Anderson and Ahmed. 2016. 'Smallholder Diaries: Building the Evidence Base with Farming Families in Mozambique, Tanzania, and Pakistan'. CGAP. https://www.cgap.org/sites/default/files/research_documents/perspectives_2_executivesummary.pdf. Accessed February 2019.

25 Wright, Graham et al. 2017. "Where Credit Is Due - Customer Experience of Digital Credit in Kenya." MicroSave. http://www.microsave.net/resource/where_credit_is_due_customer_experience_of_digital_credit_in_kenya. Accessed February 2019.

26 ILO. 2018. 'Ten years of impact insurance – The future of Impact Insurance'. http://www.impactinsurance.org/publications/cb13. Accessed February 2019.

27 Moody's Investors Service. 2016. 'Understanding the Impact of Natural Disasters: Exposure to Direct Damages Across Countries', https://www.eenews.net/assets/2016/11/30/document_cw_01.pdf. Accessed February 2019.

28 Ulrich Hess and Peter Hazell. 2016. 2016.'Innovations and emerging trends in agricultural insurance' GIZ. https://www.spacefordevelopment.org/wp-content/uploads/2018/06/Innovations-and-Emerging-Trends.pdf. Accessed February 2019.

Space technology as part of the solution

Many of the actions to address these challenges faced by customers and providers can be advanced by the inclusion of space technology in finance product design and delivery mechanisms. Space technology can help address these challenges by using the unique capabilities of satellites for earth observation, communications and navigation. In this section the types of space technology are highlighted, the factors that led to a growth in space-derived data are reviewed, and the advantageous attributes that space technology can bring to the finance sector are discussed.

Types of space technology

- **Earth observation (EO) satellites** gather information about the physical, chemical, and biological systems of the planet via remote-sensing technologies, supplemented by earth-surveying techniques which encompass the collection, analysis and presentation of data. EO is used to monitor and assess the status of, and changes in, natural and built environments.
- **Satellite communications (SatComms)** have ubiquitous coverage, and provide critical communications services for voice and data if terrestrial networks are partially or fully unavailable.
- **Global Navigation Satellite Systems (GNSS)** send positioning and timing data from space to a wide variety of devices with receivers that determine accurate location and time.

Why now?

"With the advent of technology, we can now do things which are so big that only governments could do before, such as going to the moon. Now, we have private companies who can go to the moon. So similarly, I could see that we could build a technology company which can help billions of lives in rural agriculture communities to connect to finance as a starting point."

Harvesting

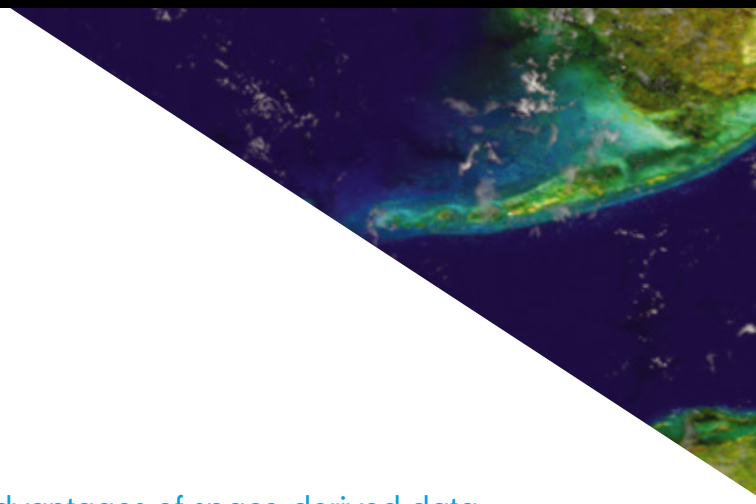
Space technology is not new. In August 1959, Explorer 6 took the first pictures of Earth.[29] Nearly 60 years later there are approximately 5,000 objects in orbit, of which 2,000 are operational.[30] As of 2016 there were over 400 EO satellites in orbit, and at least 400 more are expected to be launched by 2025.[31]

Space technology was previously under the remit of governments, but with the advancement of technology, commercial organisations are also now involved in the development and use of space technology. Factors that contributed to the increase are, among others, the availability of **free satellite data**, for example from ESA's Sentinels, the increasing **accuracy** (spatially and temporally) of the data, and **improved algorithms** and models for data processing (see Box 2). As a result, products have been developed using space technology that can support solutions for numerous local and global challenges.

29 ESA. '50 Years of Earth Observation' https://www.esa.int/About_Us/Welcome_to_ESA/ESA_history/50_years_of_Earth_Observation. Accessed February 2019.

30 Pixalytics. 2019. 'How many satellites orbiting the earth in 2019?' https://www.pixalytics.com/satellites-orbiting-earth-2019/. Accessed February 2019.

31 Source: The Parliamentary Office of Science and Technology, Westminster, London. 2017. www.parliament.uk/post Number 566. Accessed March 2019.



Box 2: Factors that contributed to the advancement of space technology and uptake in the commercial and sustainable development sectors[32]

Free and open access to EO data:
Government and international space agencies are increasingly making a wider range of EO data available at no cost for anyone who wishes to access it. This now includes data with a spatial resolution down to approximately 10 metres.

Advanced manufacturing:
Technological advances in manufacturing techniques are gaining ground in the space sector, for example 3D printing.

Small satellites:
In recent years small satellites (those weighing less than 500kg) have been developed and deployed. Small satellites make space technology more affordable, and accessible to new types of user.

Space technologies:
Developments in space technology have accelerated in recent years. For example, electronic propulsion for satellites allows the use of cheaper launch vehicles.

Advances in computer processing power and analytics:
It has become possible to develop hundreds of applications for satellite imagery, due to faster computer processing, cloud computing, and machine learning techniques.

Advantages of space-derived data

There are many attributes of space derived data that make it complementary to the goal of providing financial services to customers in developing countries:

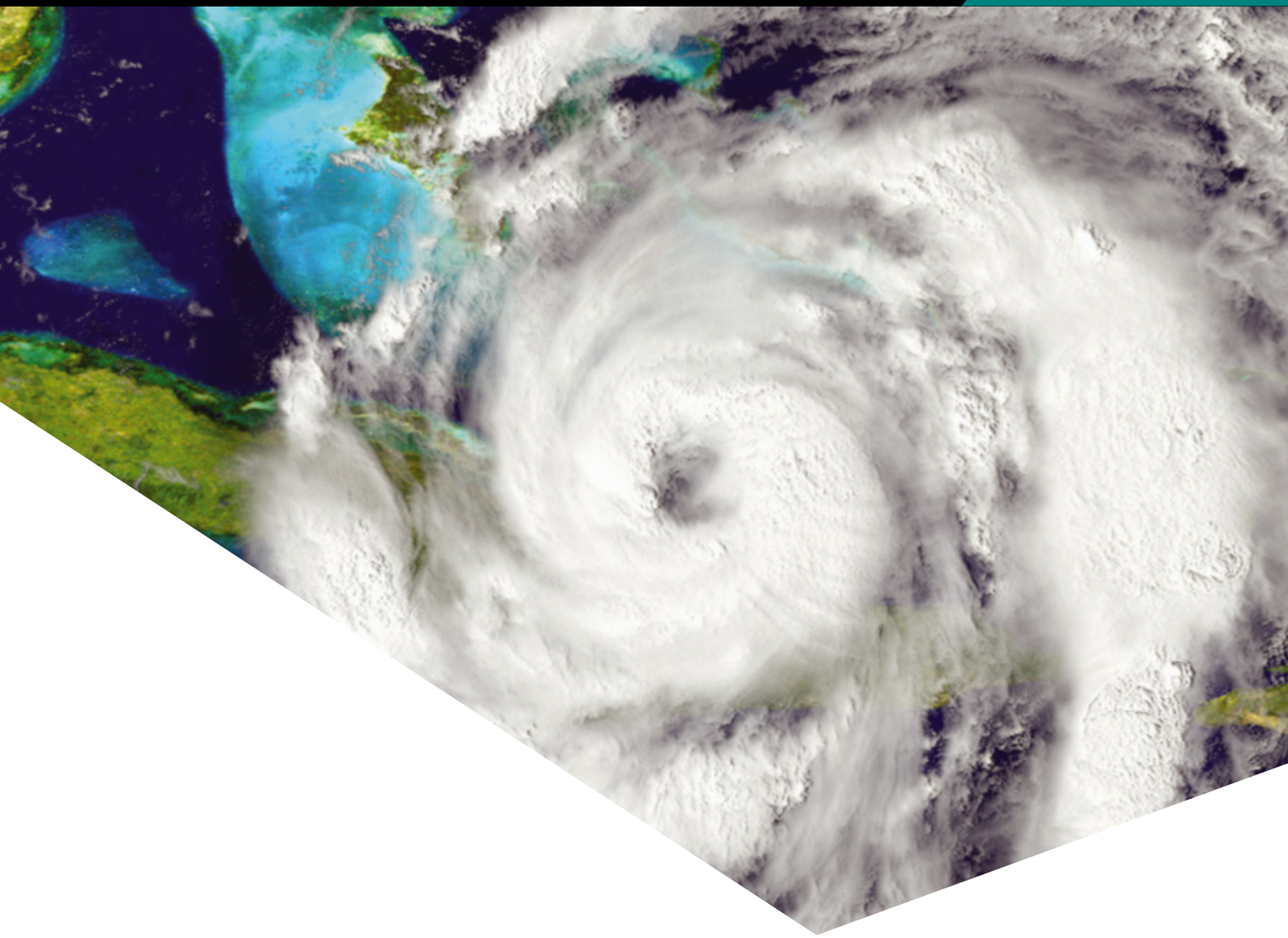
1. **Coverage:** Satellites often provide global coverage, allowing consistent observations of land features, and making it possible to monitor and scale up from field to country to continent in an accurate and repeatable way.

2. **Historical data:** Satellites have regular revisit times, and these consistent and regular observations mean that there is a historical cache of data on which to identify trends. How far back they go depends on the date when the individual satellite became operational. However, many satellites are designed to provide measurements consistent with those of earlier missions.

3. **Resolution:** Over the years improvements have been made in the resolution of EO data, which is increasingly being made freely available. The higher the spatial resolution, the more detail in an image.

4. **Range of data:** Satellites collect data via a number of sensor types. This allows for the identification and monitoring of many different weather and environmental conditions including cloud systems, wind, ocean surface features, water height, water extent, snow depth, moisture, temperature (of land and ocean), soil condition and vitality of leaf vegetation.

32 OECD. 2016. 'Space and Innovation'. OECD publishing, Paris. https://www.oecd.org/publications/space-and-innovation-9789264264014-en.htm. Accessed February 2019.



5. **Analysis-ready data:** Satellite data can be processed to defined industry standards, and organised in a form that allows immediate value addition and analysis. For example, it can be used as an input to models, such as those being developed in IPP. Field, village or country scale measures can be derived automatically using satellite imagery and presented as simple outputs in the form of maps, dashboards and graphs compatible for use with credit and insurance portfolio management systems.

6. **Remoteness and safety:** Data collection using satellites is significantly faster than on-ground data collection and is a safe and cost-effective way to obtain data in remote or conflict areas.

7. **Speed of delivery:** Increasingly, analysis-ready EO data is available for use soon after it is acquired, which is important for insurance portfolio monitoring or in disaster situations where rapid claim assessment is required.

8. **Cost:** EO data can be obtained both for free and for a commercial fee. The majority of the organisations that were interviewed in this research use free EO data, particularly from ESA Sentinels.

Use cases of space technology in the finance sector

Although the information provided focuses on EO, and to a lesser extent SatComms, most of the use cases presented in this section make use of the Global Navigation Satellite System (GNSS) to capture boundaries of fields. As GNSS technologies are more mature and integrated in standard practice, their role is not separately highlighted. It is also important to note that space derived data is rarely used in isolation. Typically, it is integrated into models that use additional data assets.

This section uses case studies as detailed in **Annex one**. A short description of each organisation and their services is provided here:

1. **SIBELIUs (IPP portfolio)**: The consortium is working on greater dzud-resilience (against severe summer and winter weather conditions) for herders in Mongolia. The consortium is developing a product that will allow a time series of satellite data to be queried by Mongolia's National Agency for Meteorology and Environmental Monitoring (NAMEM) and shared with the Mongolian Index Based Livestock Insurance scheme, to supplement and improve the spatial resolution and accuracy of their current insurance index.

2. **Crop Observation, Management and Production Analysis Services System (COMPASS) (IPP portfolio):** The consortium is working to help smallholder farmers growing sugar cane and wheat to improve crop management in Mexico. The technology will use EO data, and in-situ data captured by the farmers, to help them identify and mitigate factors that cause the yield gap. As part of the project the consortium is developing tailored insurance products for COMPASS farmers through the satellite data-driven 'Life Platform' application.

3. **Drought and Flood Mitigation Service (DFMS) (IPP portfolio):** DFMS is a suite of meteorological, hydrological and other EO data and information products that will allow decision-makers in Uganda to mitigate the impacts of drought and floods and make better-informed environmental and agricultural management decisions. DFMS is using this product to develop customised decision support tools for insurance companies to improve their risk management.

4. **Modelling Exposure Through Earth Observation Routines (METEOR) (IPP portfolio):** The consortium is working to help governments in Nepal and Tanzania to increase their resilience to natural hazards through the integration of robust and open building exposure data derived from satellite data. They are facilitating governments to reduce the human and financial costs of disasters through risk management activities and insurance products, using their national building exposure databases.

5. **Airbus Defence and Space (IPP portfolio):** The consortium is working on alleviating risk for farmers who currently have little or no access to insurance by demonstrating the efficacy of EO data for the micro-insurance market in Kenya. The information provided will support decision making and the development of improved insurance products, and ease the claims verification process, using indices that more accurately reflect the incidence of drought than current measures.

6. **Pula Advisors (Non IPP):** Pula works with various aggregators to provide appropriate and affordable insurance products. Products include weather index and yield index insurance. Pula also provides farmers with targeted agronomic advice via SMS messaging, helping them grow more from their existing landholdings. Pula uses satellite data and farm yield measurements to understand how weather patterns affect yields for smallholder farmers.

7. **Apollo Agriculture (Non IPP):** Apollo Agriculture helps small-scale farmers maximise their profits, starting in Kenya. Apollo uses machine learning, satellite data, and mobile phones to deliver financing, farm products, and customised advice to farmers with efficiency and scalability.

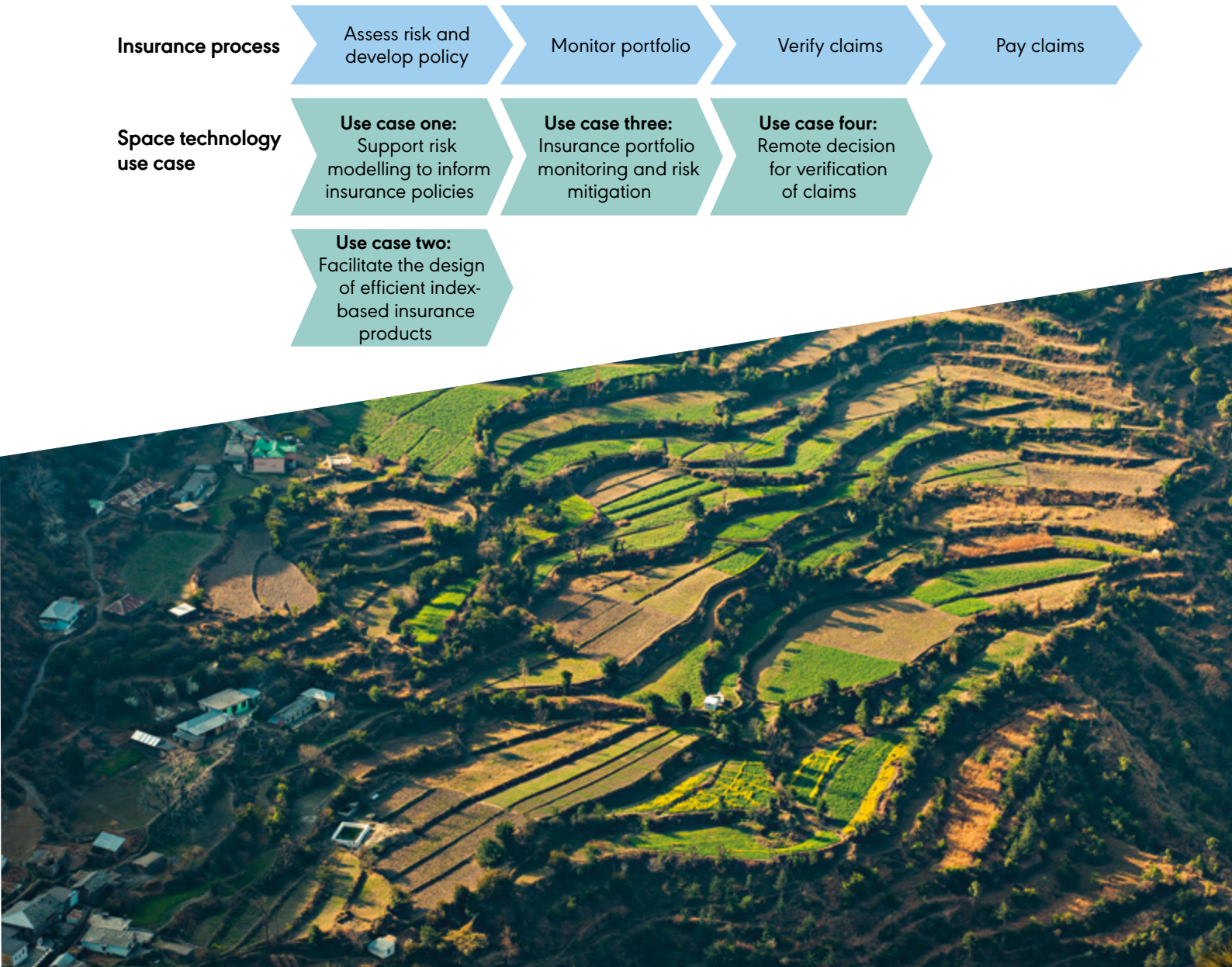
8. **Harvesting (Non IPP):** Harvesting has developed an agri-lending suite using alternative datasets (including satellite data) and artificial intelligence. It will improve the reach and risk management of organisations lending to smallholder farmers. The goal is to drive financial inclusion by providing actionable data to credit institutions in developing countries.

The use cases for space technology within the finance sector are derived from expert interviews and a review of literature. Use cases for insurance, credit and payments are highlighted.

Insurance product use cases

Space technology can support solutions in the majority of an insurance product's process. A simplified mapping of insurance processes and the supportive role of space technology is shown in Figure 2. Each use case is discussed below, with examples from IPP and other organisations implementing these solutions.

Figure 2: Space technology use cases in the insurance process



Use case one: Support risk modelling to inform insurance policies

"The most applicable use of what we are doing for METEOR is for understanding risk, risk assessment and, establishing a risk profile through an average annual loss indicator, that helps countries. And finally, the structuring of risk products provided by the insurance industry."

ImageCat – IPP METEOR project

To develop an insurance product and price the risk, insurance companies need data. Without sufficient data, risk models are generalised and premium prices are higher, to mitigate the lack of data and the resulting higher risk. Satellites collect large volumes of data that can be used for risk modelling. Indices such as soil moisture content, precipitation, vegetation health and others can be monitored. Additionally, GNSS enables the capture of asset boundaries to validate an applicant's stated assets. When collected over time, the data can be used in models to forecast various risks or the likelihood of events.

The IPP-supported **COMPASS** project in Mexico noted that currently, the premium for crop insurance is standard for all farmers in a region. To anticipate claims, these insurance companies monitor crop performance through in-situ visits, resulting in high operational costs. The technology developed by the COMPASS project will use EO data along with in-situ farm data captured by the farmers. This is then modelled and shared on a dashboard with an insurance company, with the farmers' permission. This is expected to result in more accurately priced premiums unique to each farmer.

In Kenya, the IPP-supported **Airbus Drought and Flood Resilience** project is developing a Vegetation Health Index (VHI) to support claims verification. The VHI uses satellite imagery to monitor crop status on a 10-day and 20-metre basis. The data will be used in a drought indexing mechanism and the outcomes, which are expected to include present weather conditions and forecasts, will be presented to micro insurance users via an online dashboard to enable them to develop risk profiles and price their insurance policies accordingly.

Space technology can provide insurance companies and governments with greater levels of detail on risks. In Tanzania and Nepal, the IPP-supported **METEOR** project is developing remote sensing based solutions for quantifying exposed populations and building infrastructure using EO data. METEOR will provide a framework to implement measurable risk reduction strategies to governments, by providing better data on risk exposure using EO data. This can strengthen the government's capacity to plan for disasters, allow it to make informed decisions on natural hazard risk reduction, and aid insurance market development.

Use case two: Facilitate the design of efficient index-based insurance products

"Reliable pasture and snow information derived from satellite EO, combined with existing temperature data, is enabling us to work with the in-country insurance sector to introduce a more regionally sensitive element to their index-based livestock insurance. The whole aim here is to reduce basis risk, that is a well-known current problem, that was very much confirmed by our project's fieldwork surveys."

eOsphere – IPP SIBELIUs project

Index-based insurance is an approach that measures deviations from the normal level of parameters such as rainfall, temperature, crop yield, or livestock mortality rates. Index insurance schemes are generally much cheaper to run than normal insurance, which is much more liable to false claims unless extensive verification checks are conducted. These checks are expensive to administer. If a deviation from a threshold is reached for a given index (e.g. based on rainfall or vegetation level) compensation is automatically paid, regardless of the individual's' actual losses.

However, index insurance can be affected by basis risk, which arises when the index measurements do not match an individual's actual losses. There may be individual situations where there was no loss above the threshold, and insurance was paid, or there was loss above the threshold but insurance was not paid. High-quality index insurance requires significant data at a more granular level.

In Mongolia, the Index Based Livestock Insurance scheme (IBLI) is available to herders to cope with livestock loss. However, the index relies on biannual livestock mortality surveys. The basis risk within this index has negatively impacted trust in the system and led to less uptake of insurance. The IPP-supported **SIBELIUs** project will supplement the IBLI scheme's livestock mortality surveys with satellite-derived data. In a scenario where a region has not reached the mortality threshold that triggers automatic payment, herders will still be compensated if the environmental conditions (as measured by EO data) exceed a predefined level that indicates this region had particularly harsh conditions compared to normal.

IPP is supporting the **Drought and Flood Mitigation Service (DFMS)** project in Uganda. DFMS aims to add features to its platform for insurance companies, including notifications if a threshold is reached. Examples include water extent and height for flooding, or Normalised Difference Vegetation Index (NDVI) to indicate crop health.

Pula provides a weather index insurance product that uses satellite data, to compensate for the lack of weather stations in the countries in which it works. When a weather index insurance product is deployed, Pula will monitor weather performance using EO data to reduce basis risk.

Use case three: Insurance portfolio monitoring and risk mitigation

"Insurance companies can have live information on the farmers' activities in the field. Because the farmer has to update the application in order to get the accurate results like yield predictions. At the same time that information is used by the crop insurance company to see whether the farmer has done the [proper] crop management. If they haven't, then they can communicate with the farmers and say that you haven't irrigated, as recommended."

Rezatec – IPP COMPASS project

Satellite data can enhance monitoring of an insurance company's portfolio. In a traditional insurance setting, insurance companies are limited by access to data on risk until a claim is made. Satellite data can provide insurance companies with live information throughout a season and in some innovations, they may be able to nudge a customer to corrective action, for example to prevent crop failure. This results in a win-win situation for the insurance provider and the customer.

The IPP-supported **COMPASS** project is developing a live dashboard that requires farmers to submit information on various crop management practices, in order to receive advice and yield predictions. If the farmer has insurance, the insurance company can view a map of the field to view crop health, while also accessing information on whether the farmer has carried out the appropriate crop management protocols. **Pula**, an organisation that develops insurance products, provides farmers with targeted, satellite-derived agronomic advice via SMS messaging.

Example of Pula SMS

Hi Immaculate! How have you been?

It has been about 30 days since you planted and Eldoret has had more than 15mm rainfall over the past 3 days.

This is the optimum time to apply top dressing fertiliser to increase the chances of double cobbing.

Use case four: Remote decision-making for verification of claims

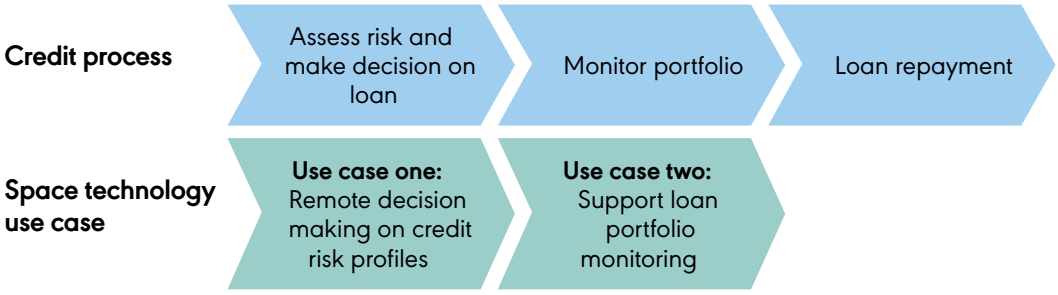
For many insurance companies, it does not make business sense to offer insurance products to lower income and remote customers, due to the costs of assessing individual losses. With access to a range of EO data, insurance companies can develop products that could reduce the need to verify all insurance claims. With EO data, insurance companies can track vegetation coverage across a region and check whether a particular area was negatively affected by a weather event. When on-ground verification is required, EO data also helps companies to efficiently target where they need to send staff to make assessments before making a payout.

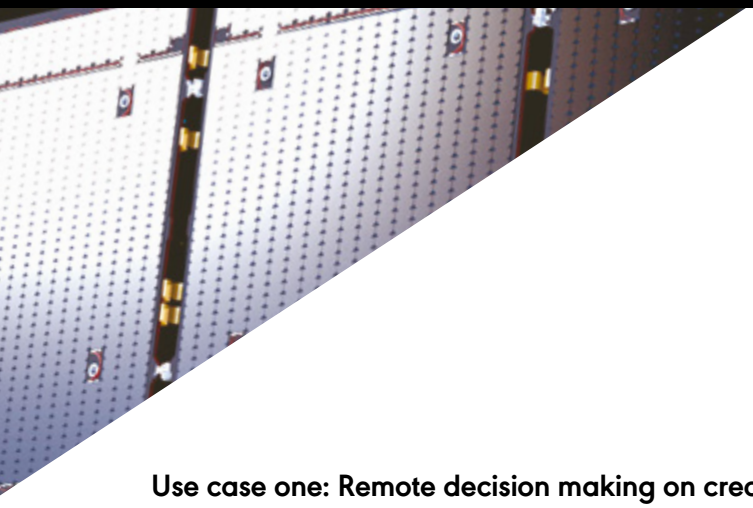
Several IPP projects (**SIBELIUs, DFMS, COMPASS** and **Airbus Drought and Flood Resilience**) are developing satellite data products that can support the claims process for insurance companies, with a potential to significantly reduce the need for feet on the ground.

Credit product use cases

Space technology can support solutions in the credit product process. A simplified mapping of credit processes and the supportive role of space technology is shown in Figure 3. Each of the two use cases are discussed, with examples from organisations implementing these solutions.

Figure 3: Space technology use cases in the credit process





Use case one: Remote decision making on credit risk profiles

"A typical credit score requires you to work with digital assets, like what's happening on the phone, how much time somebody's spending talking on the phone, how much their topping up and things like that, which is good to a certain extent. But if you look at the farm, the ability to pay is directly related to the farm."

Harvesting

Satellite imagery – in combination with demographics, financial, agronomic, geospatial, and psychometric data – can provide sufficient detail on 'thin file' customers (those without traceable financial histories) to make lending decisions. Providers are generating credit scores using algorithms that rely on mobile phone data, alternative data and machine learning. Space-derived data is now being used to create a credit score. Taking the example of a farmer, the farm boundaries can be captured using GNSS and based on that data, historical farm performance information can be reviewed using a diverse set of space data such as Normalized Difference Vegetation Index (NDVI), soil moisture, water extents and height, etc.

The fintech company **Harvesting** has developed a credit risk assessment using EO and other data points that provides lenders with a data-rich, easy to use interface. It has the flexibility of customising multiple variables to determine the creditworthiness of an applicant quickly and cheaply. Another fintech company, **Apollo Agriculture**, provides credit directly to farmers and highlighted that satellite imagery has significant potential to generate features relevant to credit models.

Use case two: Support loan portfolio monitoring

"If you are a lender and you have 100 loan agents, remote sensing technologies can help further fine tune the places where you need to send your agent. You would still have to send agents to do certain work, but instead of going through all the 10,000 farmers you are working with, remote sensing can help guide, "go to these 50 farms, because that's where things don't look great." And then it will be a combination of high touch and high tech."

Harvesting

EO data can be a powerful tool in helping lenders monitor their portfolio, and also to adapt to customers' needs. In an example scenario, a farmer has taken out a loan that is due by a date selected to correspond to crop harvesting. However, due to weather circumstances the farmer cannot harvest in time for the repayment and requests an extension until after the harvest. Traditionally granting an extension would require agents to ground-truth the claims. However, EO data can show if a claim is valid without anyone leaving the office.

Harvesting has developed a loan monitoring dashboard that empowers lenders to use satellite data to view the progress of the farm throughout the loan cycle. This helps them track if funds are being used for their intended purposes. It also creates a two-way communication and alert system that assesses any potential risks, be it lack of irrigation, or soil or crop damage. Lenders can alert farmers to take corrective actions, and recognise the possibility of repayment issues due to these obstacles.

Payment product use cases

Figure 4: Space technology use cases in the payments process[33]

Simplified payment/ transaction process	Transmission of transaction request	Transaction processing	Transaction settlement
Space technology use case	**Use case one:** Enabling transactions in remote areas with Satellite communications		

Payment products transfer money between people and businesses. The flow of a digital payment transaction differs depending on the product used, for example debit cards, mobile money, or bank transfers. However, what is essential is a data connection to ensure the flow continues. Without a data connection, digital payments are not possible. One emerging use case of space technology in payments was observed in using satellite communication technology to enable transactions in areas without a communication infrastructure.

Use case one: Enabling transactions in remote areas with Satellite communications (SatComms)

SatComms have ubiquitous coverage and provide critical communications services if terrestrial networks are partially or fully unavailable. Mobile and fixed network communications may be absent in remote or rural regions and are regularly damaged by natural disasters. SatComms can enhance or even pioneer payments systems in areas that do not have mobile or fixed network coverage.

For example, Inmarsat piloted SatComms services for banks to extend their branch network into rural areas, set up ATM and Point of Sale services.[34] Previously, Inmarsat worked in partnership with the Equity Bank Group on a pilot, to deliver financial services to unbanked communities at 200 merchant sites across Kenya.[35] Similarly SatFinAfrica is piloting a project to demonstrate the suitability of the Sat3Play platform, to provide reliable and secure financial services to money transfer companies, microfinance institutions, banks and ATMs, in remote and underserved areas in Africa.[36]

33 This is a generalised and simplified diagram. Transaction processes vary depending on the product used.

34 Inmarsat website. https://www.inmarsat.com/enterprise/banking-and-finance/. Accessed March 2019

35 Inmarsat website. https://www.inmarsat.com/about-us/what-we-do/digital-frontiers/. Accessed May 2019

36 ESA website. https://business.esa.int/projects/satfinafrica. Accessed March 2019

Impact of space technology within the finance sector

Figure 1 outlined the potential impact for customers and financial service providers who have integrated space technology within their product or service. However, it is important to note that two challenges arise when thinking about the impact of space technology on the finance sector.

The first challenge is that this is a nascent sector. Use cases of space technology in forestry, disaster resilience and agriculture are widely tested. It is only recently that organisations have begun to explore the application of space technology for the finance sector. This limits the evidence available for development impact.

The second challenge is that the use of space technology is typically integrated into a financial product and business model, making it difficult to isolate the precise effects of the use of space technology. Studies, when conducted, are rarely engineered to provide detail of whether the space technology component of the design or delivery mechanism contributed to an identified impact. There are a thousand choices that go into designing financial services and products, of which space technology is only a part.

Ultimately the effects of integrating space technology into a product accrue to the provider of the financial service, who in turn can pass on these gains to customers in terms of access to appropriate and affordable financial services and products.

The information in this section is derived from existing literature, and from interviews with organisations which are developing financial services using space technology.

Financial service provider impact

Increase in customers

"Technology is what you use if you don't have manpower."

Harvesting

There are a number of mechanisms through which products using space technology can expect to catalyse growth in customer numbers. For example, **SIBELIUs** anticipates that by improving the accuracy of the Mongolian index-based livestock insurance scheme, more herders will see value in purchasing insurance. **COMPASS** expects that through consensual data sharing between COMPASS farmers and selected insurance companies, farmers will be attracted to tailored premium prices over time as the farmer's unique risk profile is developed. Both **Harvesting** and **Pula** aim to expand the reach of current insurance and credit providers. Pula provides access to insurance, typically where none previously existed, through working with aggregators. On the other hand, Harvesting partners with credit providers that have a rural footprint, and uses space technology to extend their reach.

Reduction of operational costs

"Remote sensing, allows us to make decisions remotely. If I can tell what's growing on the farm without actually going to the farm, which otherwise would have taken one full day, it's a huge step up in the process."

Harvesting

The mechanism through which the cost of serving customers is reduced is similar across the IPP **DFMS**, **COMPASS** and **Airbus** projects. By providing insurance companies with quality satellite data on potential customers and potential risks, the insurance companies' requirement to do on-the-ground assessments is reduced. Access to historical EO also assists insurance companies to price premiums, by reviewing past farm performance. This in turn assists the crop insurance companies to take measurable risk on setting new premiums. This is similar for **Harvesting**, whose various services in their agri-lending suite, such as credit risk assessment and loan monitoring dashboard, enable targeted and less frequent use of loan officers to assess risk and monitor the loan portfolio. **Apollo Agriculture** has developed a network of contractors across Kenya who use an app to complete assigned tasks, for example to collect the GPS boundaries of a farmer's field, which allows Apollo Agriculture to observe fields using satellite imagery. This enables Apollo to operate without the conventional and costly agent infrastructure typical of smallholder input finance models.

Improve portfolio risk management

"You have to justify the premium. Insurers need these risk databases, or they will charge a higher price for the uncertainty. And then it's less likely to be sold. So it's about having that data available there for them to price the risk to enable this type of insurance product."

ImageCat – IPP METEOR project

By incorporating an array of EO data into customer risk assessment models, and through the ability to access live data, financial providers can improve their risk management strategies. This can happen by providing finance organisations with detailed information before the insurance policy or loan decision is taken. In other cases, such as the IPP **COMPASS** project, insurance companies have access to information post-insurance and can provide 'nudges' to farmers to mitigate risks, such as on the timing of irrigation. **Pula** provides satellite-derived agronomic advice via SMS direct to farmers to decrease the likelihood of crop failure, and thus of insurance claims, while **Harvesting's** loan monitoring dashboard equips lenders with live data on their loan portfolio at risk.

Reduction in basis risk

"There are currently a lot of herders who are disgruntled about the existing index-based insurance scheme. If we can make the insurance products more regionally sensitive and get those disgruntlement levels down, we believe the uptake of these products will increase."

eOsphere – IPP SIBELIUs project

A reduction in basis risk can increase trust in insurance products, which would lead to a greater number of customers purchasing insurance. A World Bank study in India found that satellite data combined with crop cutting experiments (CCE)[37] increases index accuracy. Using satellite data to target CCEs can reduce the cost of conducting the CCEs by a factor of four, or improve the accuracy by a factor of two.[38] Central to IPP project **SIBELIUs** is a reduction in basis risk and an increase in the number of insured herders.

37 A crop cutting experiment involves a trained individual visiting a designated farm, harvesting a small area for a designated crop, waiting for the produce to dry, and then weighing it. Sample-based area yield indices are typically calculated as the average yield from a series of randomly selected CCEs in the area the index is designed to cover.

38 World Bank. 2015. 'Agricultural data and insurance, Innovations in agricultural data development for insurance.' https://blogs.worldbank.org/psd/files/agricultural-insurance-data-15sept2015.pdf. Accessed March 2019.

Customer impact

Increased trust in insurance products

"The worst thing you can have is a market that doesn't trust insurance, then you're out of play; you can't operate effectively there anymore."

Pula Advisors

It is important for customers to trust that if they invest in an insurance product they will receive a payout should they suffer any losses. If through the integration of satellite data, index-based insurance becomes more accurate and more likely to pay out in the event of a loss, this will build trust in the product. Through social network or peer effects, positive experiences are shared, which increases the likelihood of customers repeating insurance purchases, and greater numbers of new customers purchasing insurance. A recent study in Tanzania found that when a satellite-derived index insurance product contained a clause allowing for an in-situ assessment when the index threshold was not triggered, demand for insurance rose from 22% to 36%.[39] This shows, the authors say, that in data-scarce environments, a satellite-based conditional audit contract may be superior to standard index insurance contracts.

Access to and use of affordable financial services and products

"Satellite data affords not just decreasing the premium rates but allowing this product to exist at all. One of the functions at Pula is to be able to create products that aren't currently on the market."

Pula Advisors

Incorporating satellite data into finance providers' business models can lead to a reduction in operational costs. It is feasible that this saving could be passed on to the customer via lower interest rates or premium rates. Furthermore, while satellite data can help make financial services more affordable, it can also enable products to exist at all. **Pula** is providing access to insurance products to customer segments that did not previously have such access. Harvesting is enabling lending organisations to reach further into remote areas, and a 2018 Lean Data survey of **Apollo Agriculture** customers found that 90% reported no better credit alternative to Apollo Agriculture.

End impact on customers

Customers who use credit and insurance may benefit from a number of changes derived from the use of space technology. Credit can smooth consumption during financial shocks and provide capital to businesses and for household expenses, effectively helping customers better manage financial choices.[40] **Apollo Agriculture's** Lean Data survey results found that 84% of customers said their quality of life has improved, while 89% say their productivity has increased since working with Apollo Agriculture.

Insurance improves resilience to shocks by providing customers with an efficient means to manage risk and avoid negative coping strategies such as selling productive assets or depleting savings. There is also emerging evidence on the productivity-enhancing effects of insurance. Some agricultural insurance schemes have been enabling those with insurance coverage to take more risky but higher return investment decisions. In this case, insurance can enhance and not just safeguard the economic development of the households it protects.[41]

39 Jon Einar Flatnes, Michael R. Carter and Ryan Mercovich. 2019. 'Improving the quality of index insurance with a satellite-based conditional audit contract'. University of California Davis. https://basis.ucdavis.edu/publication/paper-improving-quality-index-insurance-satellite-based-conditional-audit-contract. Accessed April 2019.

40 J-Pal and IPA Policy Bulletin. 2015. 'Where credit is due.'https://www.povertyactionlab.org/sites/default/files/publications/where-credit-is-due.pdf. Accessed March 2019.

41 Dercon Stefan and Christiaensen Luc. 2007. 'Consumption Risk, Technology Adoption, and Poverty Traps : Evidence from Ethiopia'. Policy Research Working Paper; No. 4257. World Bank, https://openknowledge.worldbank.org/handle/10986/7417. Accessed March 2019.

Conclusions

There is a clear role and opportunity for space technology to contribute to addressing some of the challenges facing the finance sector today. In order to take advantage of this opportunity, it is useful to review some of the different solutions already available and their associated business models. Profiles of the organisations cited in this report can be found in **Annex one**. Some applications and the associated business models are completely operational, while others are in the research and testing stage.

Key themes

The use of space technology for financial services is beginning to gain ground. Themes for how space technology is applied to various customers for various challenges, using various business models, are emerging and are shared below.

Strong case for insurance

All five IPP projects have focused on the insurance market. There is a clear case for using space technology to provide insurance companies with data on assets, portfolio monitoring and the management of claims assessments. The lack of dependable, frequent data for insurance companies is frequently cited, pointing to a clear opportunity for EO data.

Emerging case for credit

Harvesting and **Apollo Agriculture** are the only organisations interviewed which are working on increasing credit access. A scan of space technology for finance solutions highlights that there are more products for insurance than for credit. However, as evidenced by Apollo Agriculture and by Harvesting, there is a business case for using space technology for credit services.

Potential case for payments and transactions

While there was only one use case for improving payments and transactions, it is a fundamental one. There is a clear opportunity for SatComms to enable payments and transactions to exist in areas with limited mobile or fixed network coverage.

Opportunities in the agricultural sector

Seven of the eight organisations interviewed have focused on the agricultural sector. They are addressing challenging products – crop and livestock insurance – that need nuanced, hard-to-get data that is difficult to verify. There are an estimated 500 million smallholder farms in the world, a significant underserved market.[42]

Opportunities in other sectors

However, there are other cases for using space technology for finance for other customer segments or sectors. There is a case for using space technology to assess risk and verify loss for natural disasters such as drought, flooding and earthquakes. For example, the **DFMS** platform will also incorporate data on flooding, which can be insured against. **Airbus** is focused on providing information for drought insurance in Kenya. **METEOR** is providing data on building exposure and multi-hazard risk products. There are also developments in space technology for the insurance sector in other developed country markets that have relevance for developing countries (Box 3).

42 IFAD. 2013. 'Food prices: Smallholder farmer can be part of the solution'. https://web.archive.org/web/20130528223144/ http://www.ifad.org/operations/food/farmer.htm. Archived from the original on 05.05.2013.

Box 3: Other space technology and insurance use cases

Transport insurance

InsurTRAX[43]

The project is studying how information from satellites can be utilised for the monitoring of cargo transport, in order to decrease the risk of damage. InsurTRAX will look at how insurance products for transport might be made more profitable through the use of space technology.

Home fire insurance

Lumkani[44]

Lumkani is addressing the challenge of fires in urban informal settlements in South Africa. It uses an early-warning system coupled with low-cost insurance to provide safety and financial security to customers. The device is a small box that measures the rate of temperature rise. The network of Lumkani devices in a specific settlement uses radio frequency to send SMS messages to notify people in an emergency. An alarm is activated in all houses within a 60-metre radius if the initial alarm is not disarmed within 30 seconds. The central device of the network locates the GPS coordinates of the fire, to coordinate with the fire department for intervention.

Infrastructure insurance

CountFloors[45]

The exposure data currently used by insurance companies is limited by resolution and accuracy. CountFloors (CF) is a service designed to automatically retrieve ground-level and satellite images on urban areas of interest, and uses a machine learning approach to extract risk-relevant characteristics of buildings in the images.

Natural disaster insurance

InsureMe[46]

InsureMe is conducting a feasibility study to assess the validity of the InsureApp service to support the insurance industry with a novel approach to interaction between insurers and their customers before, during and after natural hazards. The provision of warnings and feedback collection from policyholders forms an integral part of the service.

43 ESA. 'InsurTrax - Preparing Polish Insurance Industry for the South-North Transportation Axis (Heavy Duty Vehicles)' https://business.esa.int/projects/insutrax. Accessed February 2019.

44 Lumkani. https://lumkani.com/ Accessed May 2019.

45 ESA. 'CountFloors'. https://business.esa.int/projects/countfloors. Accessed February 2019.

46 ESA. 'InsureApp Services'. https://business.esa.int/projects/insureapp-service-fs. Accessed February 2019.

EO and GNSS are the dominant space technology in use in the finance sector

Space services to the finance industry come under three applications; EO data, GNSS data and SatComms. All applications discussed in this report are using EO for both insurance and credit solutions. Integrated within these solutions is the use of GNSS to enable finance providers to designate the boundaries of a farm for portfolio monitoring. SatComms usage was highlighted as enabling payments when terrestrial networks are limited or non-existent.

Most solutions are using a business to business (B2B) model

The majority of solutions developed using space technology are supplied to the financial provider rather than directly to the customer. From **Harvesting's** perspective, providing solutions directly to the financial service provider creates more opportunities to scale and reach more customers than a business-to-customer model.

However, there are organisations that do utilise space technology to directly serve customers. **Apollo Agriculture** has automated its supply chain using space and other technology to acquire customers, disburse products and loans, provide advice, and collect payments with limited field staff. Along its journey, Apollo Agriculture has solved the challenge of providing services direct to rural customers in a low-cost and scalable way.

Satellite data enhances other data sources

"I expect the industry to move towards increasing reliance on satellite data, but at the end of the day, you do need ground truths. As time goes on and your models get better, you need less ground truthing".

Apollo Agriculture

No organisation interviewed used satellite data in isolation to develop solutions. In the **SIBELIUs** project, EO data is used to supplement livestock mortality surveys. For crop insurance products, projects such as **COMPASS** have made significant research investments in developing specific crop growth models. These combine satellite data with data on the farmers' agronomic practices, that feed into their insurance decision support tools. The **DFMS** platform is using data on weather, hydrology, crop and livestock conditions, along with various EO products, e.g. soil moisture, evapotranspiration, water height, water extent, land cover and vegetation indices.[47] There is evidence that satellite data in combination with other sources of data is more powerful than either alone.[48,49]

Differences between providing information versus advice and recommendations

"So how do we translate all these scientific data, and provide insights to the lender to help him do what he does.

Now that can be presented in the dashboard, if a farmer calls and says 'I cannot pay you tomorrow because I have not harvested', our technology can then give a green light to extend the loan. The point is we are not saying the field is green, we are saying it's okay to extend the loan."

Harvesting

There is a spectrum of how the solutions support users from the provision of data, to information, to recommendations, as shown in Figure 5:

47 It is also important to note that these IPP projects are developing both for and beyond the finance sector

48 World Bank. 2015. 'Agricultural data and insurance, Innovations in agricultural data development for insurance.' https://blogs.worldbank.org/psd/files/agricultural-insurance-data-15sept2015.pdf. Accessed March 2019.

49 Jon Einar Flatnes, Michael R. Carter and Ryan Mercovich. 2019. 'Improving the quality of index insurance with a satellite-based conditional audit contract'. University of California Davis. https://basis.ucdavis.edu/publication/paper-improving-quality-index-insurance-satellite-based-conditional-audit-contract. Accessed April 2019.

Figure 5: Data to recommendation spectrum

Data

- **Definition:** Unstructured raw facts
- **Example:** *Image of a landscape [all organisations]*

Information

- **Definition:** Data that is organised and contextualised for consumption
- **Example:** *Dashboard of customers farms distinguishing healthy and unhealthy vegetation [COMPASS]*
- **Example:** *List of locations where a rainfall threshold has been reached [DFMS]*

Recommendations

- **Definition:** Clear insights for action
- **Example:** *Dashboard of customers indicating a list of permissible loan extensions [Harvesting]*
- **Example:** *List of clients who have not followed crop management protocols to follow up [COMPASS]*

At a minimum, all of the organisations turn satellite data into information. For example, **COMPASS** is not providing the insurance company with EO imagery. Instead the data is translated into an interface that allows insurance companies to select locations of interest. Additionally, COMPASS will highlight, using a colour code, if there is an issue with the crops in that area. **DFMS** plans to use 'notifications' to indicate if a threshold has been reached, and also transforms data into information. **Harvesting** goes further and provides decision recommendations. For example, rather than provide a colour coded map, it would indicate a potential decision, for example a loan extension.

How far an organisation goes on the 'data to decision' spectrum is dependent on both the need and the risk it is willing to take. **DFMS** is focused on providing better information, as that is the core issue for its customers. DFMS noted a risk-related control over how information is used, saying: *"If you're selling something and people are using it in the wrong way, that may kill your business altogether, because people who are using it in the right way, may start to believe that your product is not dependable."* Thus, for DFMS, a combination of user training and qualifying what the product can and cannot do and user training, is important.

Product and business model considerations

While it is evident that space technology is part of the solution in providing access to appropriate and affordable financial services, there are also challenges in developing, deploying and monetising models. A few of these are discussed below.

Training data

Testing the effectiveness of EO data requires time to capture data to train the models and to iterate on predictive models. This can present a challenge to organisations that may only get new data to validate their model after a crop cycle or in the event of a natural disaster. Furthermore, machine learning models need to be trained using ground observations (ground truthing) to ensure that the observations from satellite data are accurate and calibrated to reality on the ground. These longer cycles can slow the pace of model development and so it is important to build in this time up front in planning.

Building trust in space technology

The difficulty in developing a product that end users will trust was highlighted by many of the organisations. Limited trust in the current IBLI scheme in Mongolia was **SIBELIUs'** main driver for using space technology to increase accuracy and credibility amongst the herding community. **COMPASS** ensured that it designed its smartphone application with the farmers to build trust and that *"For every feature you see on the screen, we consulted with the farmers."* However, organisations acknowledge that it takes cycles to build trust, *"We're building trust in the product. We've made payouts. So, farmers know that these insurance products are legitimately backed."* – **Pula**

Capability to use space technology

In some cases, limited training is required for finance providers to use the product. This happens when a product provides clear actionable insights rather than information that needs to be translated before it is actioned. However, the IPP projects noted that there are cases where training is required to enable finance organisations to utilise a product, to ensure that information is turned accurately into insights for action. IPP projects **DFMS** and **METEOR** highlighted that while some potential customers will have that capability, others will not. So capacity-building and knowledge-sharing are required to ensure the correct creation of products from the information provided by the space technology.

Ability to scale for crop insurance

One of the benefits of using free satellite imagery is that it is a fixed cost that will not increase as the business scales its operations. However, in crop insurance, the accuracy with which the insurer quantifies the risk is dependent on the availability of real yield data. This is done through developing crop models on expected yields when no historical records are available. Significant research and development is invested in developing crop models and testing the accuracy of their predictions for a specific crop, before this can be marketed to insurance companies. **COMPASS** has invested in crop growth models for two crops. While this is a valuable contribution to scientific knowledge on these crop varieties and can provide insurers with crop specific yield predictions, insurance is limited to the specific crop that was modelled. The trade-off is to integrate the traditional Crop Cutting Experiment with EO data, which is more labour intensive and costly, but less likely to limit the number of crops under insurance.

Conclusion

While satellites capable of imaging the Earth have been in orbit for decades, the space sector is now undergoing a revolution. Due to advances in manufacturing techniques and innovation in space technology, there is an abundance of satellites imaging the Earth's surface, providing an increase in EO data. Crucially, some of the new data is being provided free of charge. This improves the cost effectiveness of space solutions in the finance sector compared to existing alternatives such as on-the-ground assessment and monitoring.

Furthermore, the parallel revolution in computer processing power and data science has produced software to handle and automatically process EO data to extract insights. As costs fall and analytical products and platforms mature, space solutions will increasingly provide an opportunity to tackle some of the finance sectors challenges.

Space technology for financial services is comparatively new. The full potential for financial services is being explored and tested. But it is clear that space technology offers advantages in areas where other sources of information are limited. The examples presented by the IPP projects and other organisations in this report provide a perspective and path forward to leverage space technology in financial services. The future is bright for space technology in the finance sector. Now is the time to seize this opportunity.

Additional information and guidance

The preceding sections of this report highlight the opportunity for space solutions to bring benefits to the finance sector. This section provides further detail for those seeking to adopt space solutions. Note that this part of the report is focused on EO, as it is the dominant technology within the use cases identified.

This chapter provides guidance on:

– Characteristics of EO data

– Sourcing EO data

– Processing and analysing EO data

– Sourcing EO expertise

– Additional reading and resources

Characteristics of EO data

Data from EO satellites comes from a variety of sensors. Satellite sensors are commonly divided into active and passive, each offering different benefits and constraints. A sensor can often be referred to by other names including camera, instrument and payload. The exact terminology depends on the sensor type.

Passive sensors receive emitted or reflected energy from external sources such as sunlight. Examples of passive sensors include instruments and cameras that can detect visible wavelengths, infra-red and thermal (for surface temperatures), and microwave wavelengths (for surface roughness, soil moisture and salinity).

Active sensors both emit and receive signals. These include radars such as synthetic aperture radar (SAR), scatterometers, radar altimeters and sonar. Another active sensor, Light Detection and Ranging (LIDAR), is also commonly used from aerial platforms and complements satellite observations.

EO solutions are dependent on the satellite input data used, the other data they are combined with, and the analytics applied to it all. The satellite input data vary in terms of spectral, spatial and temporal resolution and it is important when choosing a source of satellite data to consider the characteristics of the features which are to be examined.

Spectral resolution

EO sensors use the electromagnetic spectrum (Figure 6) to see the Earth. Spectral resolution refers to the number of colours or discrete spectral samples that are recorded for each image pixel. Typically, the presence of more spectral wavebands increases the ability of the imagery to discriminate between different features – for example, types of land cover – as there is more information and therefore more discriminating power in the image.

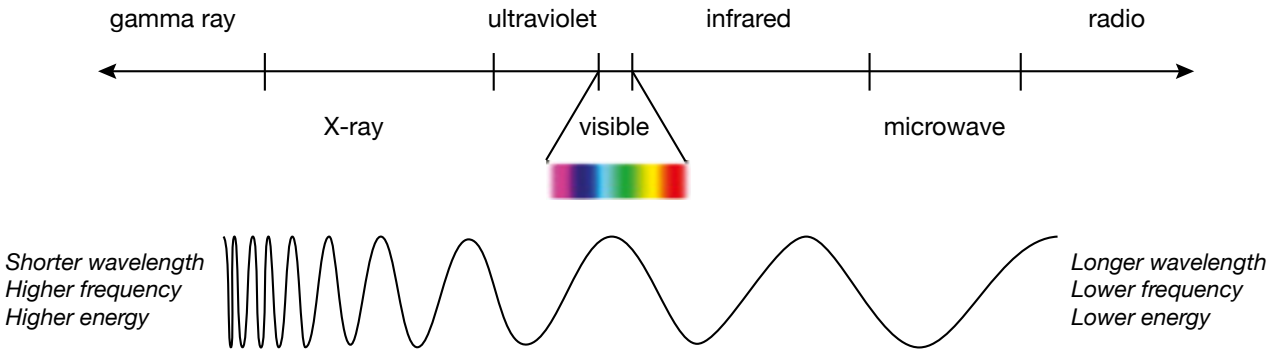
Optical sensors

Multi-spectral satellites (often referred to as optical satellites) are common in EO, providing images of the Earth's surface and atmosphere captured in the visible and infrared portion of the electromagnetic spectrum. They have a broad set of applications including agriculture, land-cover mapping, damage assessment associated with natural hazards, and urban planning, but are limited to cloud-free conditions and daytime operation.[50] Optical data are easier to process and understand and are therefore a more easily transferable technology.

50 ESA. 'Optical Missions'. Posted at http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Optical_missions. Accessed June 2019.

Multi-spectral sensors generally capture information from around 3-16 bands. Hyperspectral sensors can capture hundreds or thousands of bands, each representing a much narrower wavelength of the electromagnetic spectrum. Having a higher level of spectral detail in hyperspectral images improves the ability to see the unseen; the many characteristics of the land surface that the human eye cannot see. However, having so many bands increases the complexity of data quality management and handling. In addition, the cost of acquiring hyperspectral images (from airborne platforms) is relatively high and is therefore better suited to smaller scale, targeted surveys.

Figure 6: The electromagnetic spectrum

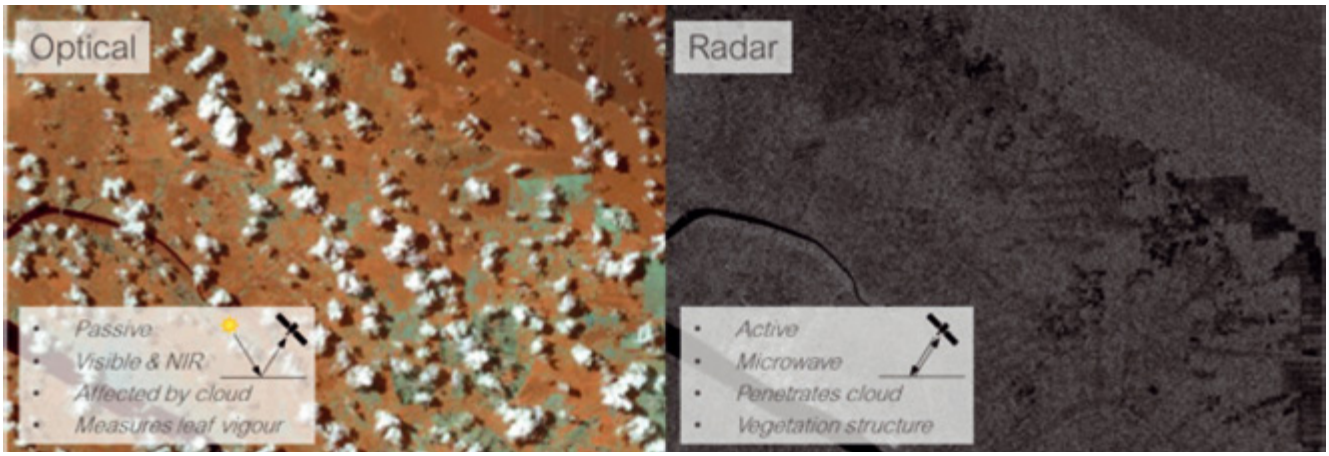


Credit: eOsphere SIBELIUS

Synthetic Aperture Radar (SAR)

SAR is an active system that transmits a beam of radiation in the microwave region of the electromagnetic spectrum. The data captured reveals information about the Earth's surface. This data has many applications including monitoring growth and change in crop and vegetation cover. Radar complements optical data because it can provide additional information about the timing of agricultural operations, for example cultivation and harvesting, when data from optical sensors is interpreted alongside it to deduce the likely crop present.

Figure 7: The differences between optical and radar satellites



Light Detection and Ranging (LIDAR)

LIDAR is a surveying method that measures distance to a target by illuminating it with a pulsed laser light and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3D representations of the target. LIDAR overcomes issues such as low cloud cover and rough terrain, and can penetrate forest canopies. However, at present, LIDAR does not have sufficient range to be mounted on satellites. It is used instead with airborne platforms such as planes and unmanned aerial vehicles (UAVs), which limit the geographic coverage.

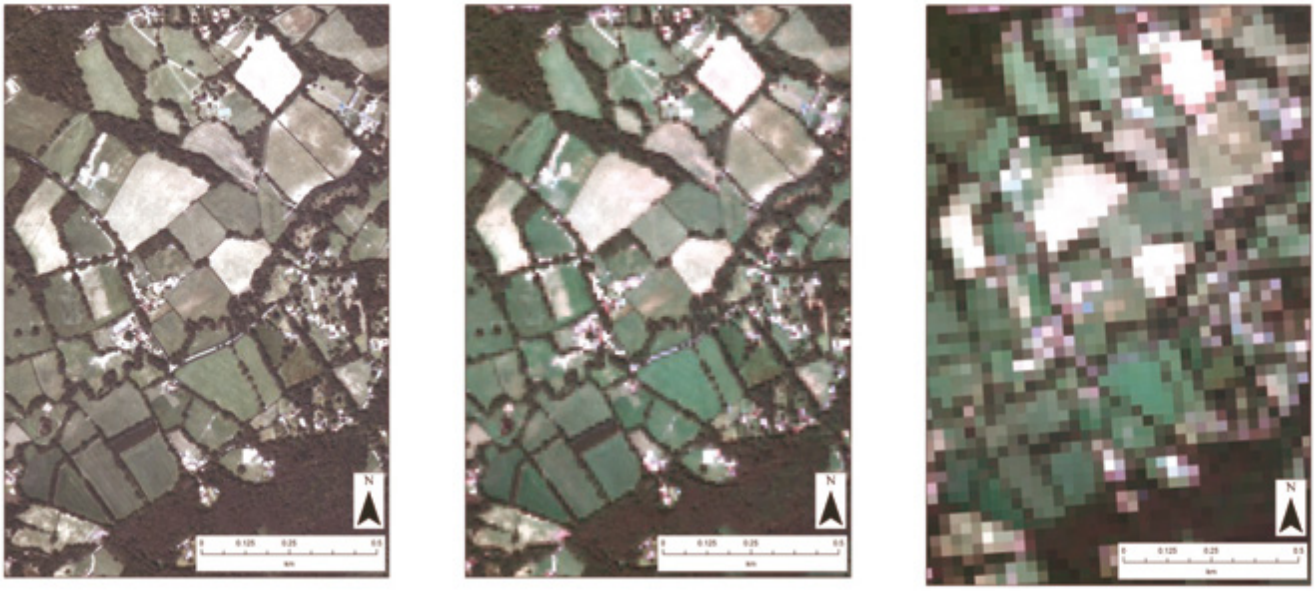
Spatial resolution

Spatial resolution refers to the pixel size of an image. The higher the spatial resolution, the greater the ability to identify and see more detail in an image (Figure 8). Typically, a higher spatial resolution means a smaller image extent (the area covered by a single image). When discussing the resolution of imagery in this report the following terminology is used:

Table 1: Spatial resolution terminology

Abbreviation	Image resolution (metres)
LR (low resolution)	*20+*
MR (medium resolution)	10-20
HR (high resolution)	5-10
VHR (very high resolution)	1-5
AP (aerial photography)	0.3-0.5

Figure 8: Representation of a WorldView-2 image (VHR, 1.84m^2 pixels), Sentinel-2 image (HR, 10 m^2 pixels) and a Landsat 8 image (LR, 30m^2 pixels) for the same area



Temporal resolution

Temporal resolution is related to the repeat frequency with which a system can acquire images of the same location. However, with optical satellites, environmental factors such as cloud cover have an overriding impact on the availability of suitable images. One of the current trends in EO is to maximise the use of the time series that new EO constellations provide to give ultra-high tempo data as the basis for analytics. Examples include the weather-independent availability of Sentinel-1 SAR.

Sourcing Earth observation data

Satellites are one of the most extensive forms of remote sensing; as of 2016 there were over 400 EO satellites in orbit, and at least 400 more are expected to be launched by 2025.[51] There are numerous sources of EO data that can be accessed for use in the finance sector, and many of these provide free access to data.

For a list of freely available and commercial remote sensing portals, tools data and products please see the 'Additional Information and Guidance' section in Space for Agriculture in Developing Countries.[52]

Processing and analysing Earth observation data

There are two main approaches to extracting useful information from satellite imagery. The first is a statistical analysis of the image values of pixels in the image, or groups of pixels that are identified as objects (e.g. within a field). This type of analysis can in many cases be performed using software that is not specifically designed for remote sensing purposes. Applying artificial intelligence to analyse images (e.g. machine learning algorithms) is an increasingly common approach. Another form of statistical analysis involves using a rules-based approach.

Alternatively, visual interpretation can be used. This can work well for a small number of images over a limited area, but the scaling value of satellite analytics is lost. The software tools for processing and analysing satellite data include GIS and image processing software. This software includes specialised tools that correct and adjust images to improve location accuracy, and which provide the ability to identify features on the map. To automate these processes, these systems use algorithms and functions to extract information from the image.

For details on specific steps for processing and analysing EO data, please see the 'Additional Information and Guidance' section in Space for Agriculture in Developing Countries.[53]

Sourcing Earth observation expertise

Currently, the use of space technology and data in finance is complex and requires advanced skill, capability and computing infrastructure. Skills and capabilities are required in the fields of software engineering, GIS, machine learning and user interface design to convert the EO data into a decision support system. Computing infrastructure is required, including significant data storage capacity, internet bandwidth and processing power.

This means that organisations active in the finance sector, such as private sector companies, government bodies, donors and NGOs, may need to source specialist expertise to support them in applying EO data. The IPP organisations featured in the case studies in Annex one are good candidates for support, but that list is not intended to be exhaustive.

51 Source: The Parliamentary Office of Science and Technology, Westminster, London. www.parliament.uk/post Number 566 November 2017.

52 Caribou Space. 2018. 'Space for Agriculture in Developing Countries'. https://www.spacefordevelopment.org/wp-content/uploads/2018/10/6.4502_UKSA_SPACEUK_Solutions-for-Agriculture_web.pdf

53 Caribou Space. 2018. 'Space for Agriculture in Developing Countries'. https://www.spacefordevelopment.org/wp-content/uploads/2018/10/6.4502_UKSA_SPACEUK_Solutions-for-Agriculture_web.pdf

Additional reading and resources

Caribou Space reports

1. Caribou Space. 2018. 'Space for Agriculture in Developing Countries'.
https://www.spacefordevelopment.org/wp-content/uploads/2018/10/6.4502_UKSA_SPACEUK_Solutions-for-Agriculture_web.pdf

This report has an 'additional guidance' section which provides detail on accessing, processing and analysing satellite data, organisations to work with, and a list of free and fee-based satellite data resources.

Space technology resources

2. European Space Agency (ESA). 2019. 'Newcomers Earth Observation Guide'.
https://business.esa.int/newcomers-earth-observation-guide

The aim of this guide is to help non-experts in providing a starting point in the decision process for selecting an appropriate Earth Observation solution. It provides an overview of the various types of EO imagery, parameters relating to EO imagery, lists of remote sensing satellites, guidance on pricing policies, and how to access EO data.

3. National Aeronautics and Space Administration's (NASA) Fundamentals of Remote Sensing webinars
https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

Four free webinars on the 'Fundamentals of Remote Sensing,' which are available for viewing at any time. The learning objectives are to familiarise the viewer with satellite orbits, types, resolutions, sensors and processing levels. In addition to a conceptual understanding of remote sensing, attendees will also be able to articulate its advantages and disadvantages. Participants will also gain a basic understanding of NASA satellites, sensors, data, tools, portals and applications to environmental monitoring and management.

Finance resources

4. CENFRI. 2017. 'Role of insurtech in microinsurance: How is insurtech addressing five challenges in microinsurance'.
https://cenfri.org/wp-content/uploads/2017/11/InsurTech-Research-Study_March-2017.pdf

A review of insurance technologies and applications in Africa, Asia and Latin America. Highlights various microinsurance delivery challenges and the role of various technologies in solving them.

5. Demirgüç-Kunt Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. 'The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution'. World Bank.
http://documents.worldbank.org/curated/en/332881525873182837/The-Global-Findex-Database-2017-Measuring-Financial-Inclusion-and-the-Fintech-Revolution

Leading annual report providing detailed insight into how adults in more than 140 economies access accounts, make payments, save, borrow, and manage risk.

Finance and space technology resources

6. Satellite Applications Catapult. 2018.'Routes to Market Report 18 – Satellite Technologies for Insurance Services'.
https://sa.catapult.org.uk/wp-content/uploads/2018/12/18-Insurance-Services1.pdf

A market overview of the opportunities to use space technology in the insurance sector, mainly focused on developed markets. Highlights the value proposition, market competition analysis, revenue projections and a review of the opportunity blockers.

7. The Partnership for Finance in a Digital Africa (FiDA). 2018. 'Launching into Space: Using satellite imagery in Financial services'.
https://www.spacefordevelopment.org/library/launching-into-space-using-satellite-imagery-in-financial-services/

A case study that explores the use of satellite imagery in financial services through the work of two FinTech organisations: Apollo Agriculture and Harvesting Inc. This case study investigates how these organisations implemented Earth observation technology and the journeys on which each organisation embarked as they integrated satellite imagery into their business models and product offerings.

8. NpM. 2018. 'Inventory of geodata and ICT related initiatives relevant to finance'.
http://www.inclusivefinanceplatform.nl/geodata

The NpM database, with an inventory of geodata and ICT-related initiatives that are relevant to inclusive finance. An interactive map gives an overview of Geodata and ICT technologies that are currently being supported to boost production, market access and access to finance for smallholder farmers.

9. The Geodata for Agriculture and Water (G4AW). 2018. 'Geodata for inclusive finance and food [G4IFF] inventory of technology'.
http://www.inclusivefinanceplatform.nl/documents/20180517geodata%20for%20inclusive%20finance%20and%20food%20-%20inventory%20of%20technology%20-.pdf

The Geodata for Agriculture and Water (G4AW) Facility of the Netherlands Ministry of Foreign Affairs, administered by the Netherlands Space Office (NSO). The Facility supports 23 projects that apply satellite information for smallholder farmers and pastoralists. The paper explores the added value of geodata to promote access to finance for agricultural activities.

10 Veck, Nick. 2015. 'Earth Observation markets and applications'. Ofcom.
https://www.ofcom.org.uk/__data/assets/pdf_file/0021/82047/introduction_eo_for_ofcom_june_2015_no_video.pdf

Overview of trends and opportunities for EO data in various sectors, including finance. Provides a good background on the EO data revolution.

11. Global Index Insurance Facility (GIFF). 2016. 'Achievements Report (Phase 1: 2010-2015)'.
https://www.indexinsuranceforum.org/publication/global-index-insurance-facility-achievements-report-phase-1-2010-2015

Profiles of various organisations working in developing countries and supported by the GIIF. A number of these companies are integrating EO data into their insurance products.

12. GIIF. 2015.' Using Satellite Data for Index Insurance'.
https://www.indexinsuranceforum.org/publication/using-satellite-data-index-insurance

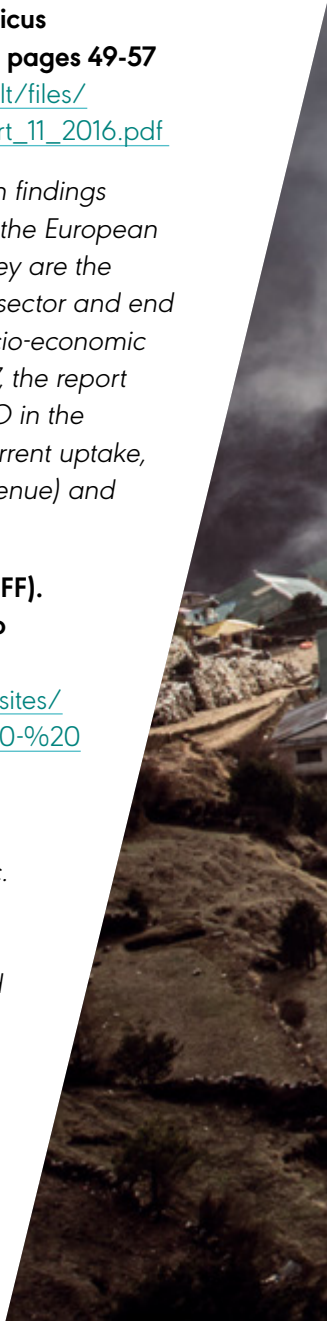
This short briefing highlights how satellite technology and its continued advancement are critical to the relevance and accuracy of index insurance products as a counter against weather-related risks. The briefing highlights the various EO data sources used, case studies, and challenges.

13. PwC, November 2016, 'The Copernicus Downstream Sector and User Benefits'. pages 49-57
https://www.copernicus.eu/sites/default/files/documents/Copernicus_Market_Report_11_2016.pdf

This market report summarises the main findings from two studies, prepared by PwC for the European Commission and published in 2016. They are the report on the Copernicus downstream sector and end user benefits, and the report on the socio-economic impact of Copernicus. On pages 49-57, the report highlights the market opportunity for EO in the insurance sector, sharing insights on current uptake, potential impact (social, economic, revenue) and a case study from the Spanish market.

14. Global Index Insurance Facility (GIFF). 2012. 'Earth Observation Responses to Geo-information Market Drivers.'
https://www.indexinsuranceforum.org/sites/default/files/Earth%20Observation%20-%20Index%20Insurance%20Products.pdf

This interim summary report has been produced by Aon Limited and ESYS plc. It identifies and focuses on aspects of the insurance industry which have a demand for geo-information and could potentially use EO data. It also reviews the current level of space technology use in the insurance industry and identifies blockages to wider use of space technology.



Annex one: Profiles of space and finance organisations

IPP has five projects with use cases for the finance sector which began between 2016 and 2018. As they are still implementing it is too soon to identify results and lessons. These case studies will be updated in the later stages of IPP to capture and communicate results and lessons. Here we also include profiles of organisations from outside IPP to highlight additional use cases on credit and payment projects and to provide examples of services that are already deployed.

Profile one: SIBELIUs – Improving the accuracy of the Mongolian Index Based Livestock Insurance scheme (IBLI)

SIBELIUs is an IPP supported project. The consortium is working in partnership with Mongolia's National Agency for Meteorology and Environmental Monitoring (NAMEM) to develop a range of new and improved environmental products which will be used by several different stakeholders (e.g. the Ministry for Agriculture and the Land Management Agency), and to develop a new product that will supplement the existing Mongolian Index Based Livestock Insurance (IBLI) scheme. This will improve the accuracy and regional sensitivity of the index with the aim of reducing basis risk.

Year project began: **2018**

Country: **Mongolia**

Partners

Project lead:

- **eOsphere Limited**

Project consortium:

- **Deimos Space UK**
- **The University of Leicester**
- **Micro-insurance Research Centre UK (MIRCUK)**

International partners:

- **National Agency for Meteorology and Environmental Monitoring of Mongolia (NAMEM)**
- **Agricultural Reinsurance (AgRe)**
- **Ministry for Agriculture and Light Industry – Administration for Inter-Aimag Otor Pastureland Use and Coordination**
- **Center for Nomadic Pastoralism Studies (CNPS)**
- **Mercy Corp**

Product

Development of a range of satellite-derived environmental products to help improve resilience for the Mongolian herding community. The routes to impact for the project include the development of a new satellite-derived index, based on pasture anomaly, snow anomaly and temperature anomaly, that will be used to supplement and improve the Mongolian Index Based Livestock Insurance (IBLI) scheme.[54]

54 Here we focus on insurance. This description does not represent the full suite of products under this project

Target customers

The Mongolian herding population, through developing products to improve the Mongolian IBLI scheme.

Challenge being solved

Mongolia is a large, rural country with 30% of the population dependent on livestock herding. Herders are exposed to extreme weather events, known as dzuds, which are highly damaging to herder and the economy. The Mongolian Index Based Linked Livestock Insurance (IBLI) scheme is available to herders to cope with livestock loss. However, the index relies solely on biannual livestock mortality surveys. When a certain threshold of mortality is triggered in a region, those insured will automatically receive compensation regardless of actual loss. At the same time, others may have suffered losses above the threshold found in the region, but would not receive compensation. The basis risk within the index has negatively impacted trust in the system and has led to low uptake, with just 15% of herders having insurance.

Summary of solution using space technology

The aim of SIBELIUs is to improve the dzud-resilience of the Mongolian herding population by integrating satellite-derived environmental information into existing insurance networks. Key satellite-derived products will include those providing information on anomalies in the current year's pasture, snow or temperature. These will be integrated into a Mongolian data cube, which NAMEM will manage.

The expectation is to supplement the insurance scheme's use of livestock mortality surveys with satellite-derived data. In a scenario where a region has not reached the mortality threshold that triggers automatic payment, herders who have suffered loss would be able to make a claim that can be verified from supplementary satellite data. This would reduce basis risk, increasing trust in the index and potentially leading to a higher rate of insurance coverage.

Expected impact

Insurance companies

- Grow insurance market
- Improved decision support tools for claims verification
- Improved efficiency and accuracy in claims verification

Herders

- Reduced risk that valid compensation claims are not paid out
- Insurance coverage in the event of a livestock loss

Expected business model

Model: SIBELIUs is not aiming to generate revenue directly from the improvements to the IBLI scheme, but will be looking to provide solutions for other parts of the Mongolian insurance sector. The solution will be provided to NAMEM, which will allocate resources to maintain the system. NAMEM will provide data for the scheme to the government-appointed company running it. The Mongolian government underwrites the IBLI scheme, and steps in if livestock losses reach very high levels. This means that herders who access the insurance will effectively pay a subsidised premium.

Customer acquisition (for insurance companies): Two channels are used to acquire policy holders. One channel is via banks. While not mandatory, it is a common practice for banks to make the national IBLI insurance scheme a condition for receiving a livestock loan. In this instance the loan applicant can choose from any of the nine insurance companies under the scheme. The second channel is via insurance agents. During spring, agents travel to various regions to renew vehicle insurance, and market the IBLI insurance scheme at the same time.

Revenue streams (for the insurance companies): The insurance premiums for schemes are standardised and cannot be adjusted without government approval.

Profile two: Crop Observation, Management and Production Analysis Services System (COMPASS) – Developing tailored insurance products for farmers through the satellite data-driven 'Life Platform'

COMPASS is an IPP funded project. The consortium is working to help smallholder farmers growing sugar cane and wheat to improve crop management. The technology developed in this project will use Earth observation data and in-situ data captured by the farmers to help them identify and mitigate factors that cause the yield gap. Numerous decision support tools will be developed that will have applications for advisory services, agribusiness, co-operatives, crop insurers and governments. The focus of this case study is on the decision support tools for crop insurers.

Year project began: **2017**

Country: **Mexico**

Stage: **Research and development**

Partners

Project lead:

- **Rezatec Ltd**

Project consortium:

- **Booker Tate Ltd**
- **The University of Nottingham**

International partners:

- **International Wheat and Maize Improvement Centre (CIMMYT)**
- **College of Postgraduates (COLPOS)**

Product

Customised information platform for crop insurance companies.[55]

Target customers

Wheat and sugar cane farmers in Mexico through crop insurance companies.

Challenge being solved

Crop insurance companies in Mexico can use time-consuming and costly methods to develop premiums and verify claims. Much of this difficulty is due to limited data on farmers and their farms. To develop a premium, the insurance company needs a guarantee of the minimal yield, which relies on the farmer having proof of yield records. To anticipate and adjudicate on claims, the insurance company needs to monitor crop performance (at least at the regional level), and does this through interviews and checks that various agronomic protocols have been adhered to. This results in high operational costs and constraints the business case for operating at scale.

Summary of solution using space technology

The COMPASS project will provide a decision support tool to wheat and sugar cane farmers through Rezatec's web-based 'Life Platform'. The technology developed by the project will use EO data along with in-situ data captured with the farmers to help identify factors that cause the yield gap between potential and actual performance. There are two parts to this solution for providing insurance to the farmers. The first part relies on the farmer, and the second on the engagement between the farmer and insurance company.

Farmer: The farmer signs up to the COMPASS platform and interacts with a smartphone application. This app both requests and provides information to the farmer. The farmer is prompted to input data on the timing and completion of various agronomic practices. In return, the app provides nudges to the farmer to complete these tasks using satellite data and crop models. The farmer can view a GPS-tagged map of their fields and is alerted if there is an issue, such as under-performing crops. The farmer is also provided with estimates of their minimum and maximum yield throughout the season as they implement various crop management practices.

55 This description has an insurance focus and does not represent the COMPASS Life Platform's full suite of products under this project

Insurance company: If an insurance company uses the Life Platform and a COMPASS farmer has requested insurance, the insurance company will receive a notification of the request. The farmer can then share their COMPASS data with the insurance company. The insurance company will have access to the farmer's historical crop performance records and protocol adherence. It is expected that the farmer will receive a discounted premium tailored to their performance. The insurance company can then set the premium based on a predicted crop yield, monitor the crop performance during the season, and have robust information to make claims assessments with minimal site visits.

Expected impact

Insurance companies

- Improved decision support tools increasing efficiency and accuracy for premium pricing, portfolio monitoring and claims verification
- Reduced operational costs for insurance provision to COMPASS farmers
- Increase market share

COMPASS farmers

- Free access to tailored agronomic support to improve yields
- Discounted and tailored crop insurance premiums
- Accurate yield estimates for insurance to cover
- Reduced risk that valid compensation claims are not paid out
- Insurance coverage in the event of crop underperformance

Expected business model

Model: COMPASS plans on a business to business (B2B) model. COMPASS will collaborate with aggregators which already engage directly with farmers, in this case farming cooperatives and insurance companies.

Customer acquisition: For the model to work, COMPASS needs to acquire farmers to use the application and input at least a season of data before it can be marketed to the insurance companies. International partners are leading the farmer support programme, introducing the app to farmers, demonstrating the benefits of satellites for agriculture and supporting farmers to use the Life Platform. The COMPASS project is also in discussion with the central government insurance company to test the Life Platform. It has agreed to provide a crop insurance discount to wheat farmers using the COMPASS app from the November 2019 season. Discussions will continue following the results of the piloting stage becoming available later in 2019.

Revenue streams: Farmers and their cooperatives can receive crop information free of charge. However, once the system has been tested successfully in Mexico, crop insurance providers will pay an annual subscription fee for enhanced datasets, aggregated data and detailed analysis provided as a geospatial portal service.

Profile three: Drought and Flood Mitigation Service (DFMS) – Customised decision support tools for insurance companies to enhance risk management

DFMS is an IPP funded project.[56] DFMS is a suite of meteorological, hydrological, Earth observation and other information products that will allow decision-makers in Uganda to mitigate the impact of drought and floods and take better-informed, environmental and agricultural decisions. While DFMS is primarily aimed at mitigating the impacts of drought and floods, it will also provide information that enables improved resource planning and management to a broader range of professional users including insurance companies. The focus of this case study is on commercial information support to the insurance sector.

Year project began: **2017**

Country: **Uganda**

Partners

Project lead:

- **Rhea Group**

Project consortium:

- **UK Met Office**
- **HR Wallingford**
- **Environment Systems**
- **Pixalytics**
- **Databasix**
- **AA International**
- **AgriTechTalk International**
- **Mercy Corps**
- **Oxford Policy Management**

International partners:

- **Ministry of Water and Environment, Uganda**
- **Uganda National Meteorological Authority**
- **Office of the Prime Minister, Uganda**
- **Ministry of Agriculture, Animal Industry and Fisheries, Uganda**
- **National Agricultural Research Organisation, Uganda**
- **Kakira Sugar Company**

Product

Customised information platform for insurance companies.[57]

Target customers

Agricultural insurance companies active in Uganda, primarily through the Ugandan Agro Consortium.[58]

Challenge being solved

A major challenge for insurance companies in Uganda is the availability of frequent and dependable information. This lack of information has implications for risk assessment, premium pricing and the ongoing monitoring of the insured portfolio.

Summary of solution using space technology[59]

The DFMS project aims to provide a management decision support tool through a web-based platform for Ugandan insurance companies and other users. The service developed by the project will use meteorological, hydrological and Earth observation data (soil moisture, evapotranspiration, water height and extent, land cover and vegetation indices), along with information on crop and livestock conditions, using Pictorial Evaluation Tool (PET) methodology.

56 ESA also funded a feasibility study specifically looking at the application of the DFMS for the insurance sector: https://business.esa.int/projects/dfms4

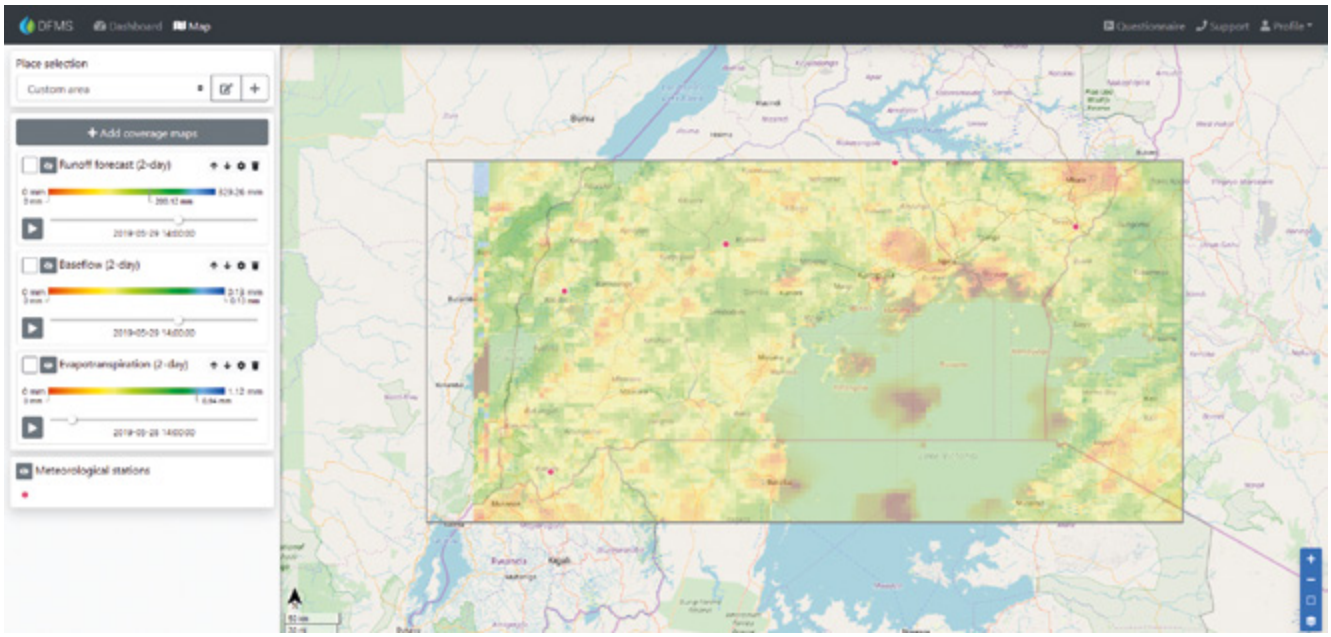
57 This insurance-focused description does not represent the DFMS Platform's full suite of products under this project

58 The Uganda Insurers Association (UIA), commonly known as the Agro Consortium, consists of insurance companies offering agriculture insurance covering crop and livestock risks in Uganda. It is implementing the Uganda Agricultural Insurance Scheme (UAIS), which provides insurance premium subsidies to farmers in order to make agriculture insurance affordable and to increase farmers' access to credit, by protecting agriculture loans disbursed by financial institutions from the effects of specified agriculture risks.

59 Note that discussions with insurance companies are ongoing

Insurance company: A customised version of the platform will be provided to insurance companies, depending on the risk being insured. DFMS's aim is to provide information for decision support. This can be enhanced through adding features that will indicate through notifications if a parameter's threshold is reached. Examples include consecutive days of rainfall or sunshine, or Normalised Difference Vegetation Index (NDVI) to indicate crop health. These customised thresholds could indicate a concern and ease claim verification. Access to historical information can also enable premium pricing with greater accuracy.

Figure 9: Screen shot of DFMS prototype



Expected impact

Insurance companies

- Improved decision support tools for greater efficiency and accuracy in premium pricing, portfolio monitoring and claims verification
- Reduced operational costs for insurance provision
- Increased market share

Customers

- Tailored insurance premiums
- Insurance coverage in the event of an economic shock

Expected business model

Model: DFMS uses a business to business (B2B) model. It aims to collaborate with insurance companies under the Ugandan Agro Consortium as a central market entry point.

Customer acquisition: After the project, DFMS plans to work with a local agent who will market DFMS and provide user support.

Revenue streams: Users will be able to access DFMS on a subscription basis, with different levels of product access and geographical coverage being provided at different rates. Customers are expected to include Government Ministries, Departments and Authorities (MDAs); development organisations; and organisations in the agricultural value chain.

Profile four: Modelling Exposure Through Earth Observation Routines (METEOR) – Facilitating Governments to insure high-risk zones using national exposure data

METEOR is an IPP funded project. The consortium is working with governments in Tanzania and Nepal to increase their resilience to natural hazards through the integration of robust and open building exposure data derived from satellite data. ***The focus of this case study is on the use case for governments to work with insurance companies to insure high risk zones.***

Year project began: **2018**

Countries: **Tanzania and Nepal**

Partners

Project lead:

- **British Geological Survey**

Project consortium:

- **Humanitarian Open Street Map**
- **ImageCat Inc**
- **Oxford Policy Management**
- **Fathom**
- **Global Earthquake Model (GEM)**

International partners:

- **National Society for Earthquake Technology (NSET)** (Nepal)
- **Disaster Management Department, Prime Minister's Office** (Tanzania)

Product

METEOR will provide a framework for structuring a measurable risk reduction policy, by providing governments with better data on building exposure and quantitative estimates of risk. This information links into the structuring of risk products provided by the insurance industry.[60]

Target customers

National governments

Challenge being solved

The response to natural disasters is not as timely or equitable as it could be, with much of the cost borne by those who are directly affected. International assistance is secured on an ad hoc basis after a disaster, and governments are forced to reallocate development funds in national budgets to crisis response. Only then can relief be mobilised towards the people who need it most, often too late.

A major challenge when making disaster risk management decisions is the data and analysis on the distribution and character of exposure to various hazards. Without this knowledge, governments may not know what zones of building exposures are at high risk, and thus cannot tailor risk mitigation plans. When insurance is used in risk mitigation plans and strategies, insurance companies require data to structure a programme to offer coverage policy for the government. Without sufficient exposure data, the programme is likely to be priced prohibitively. In many developing countries, both data and the capacity to analyse it are limited. Insurance programmes offering coverage after disasters can augment the government response, which otherwise may be delayed as government diverts its own funds and seeks international assistance.

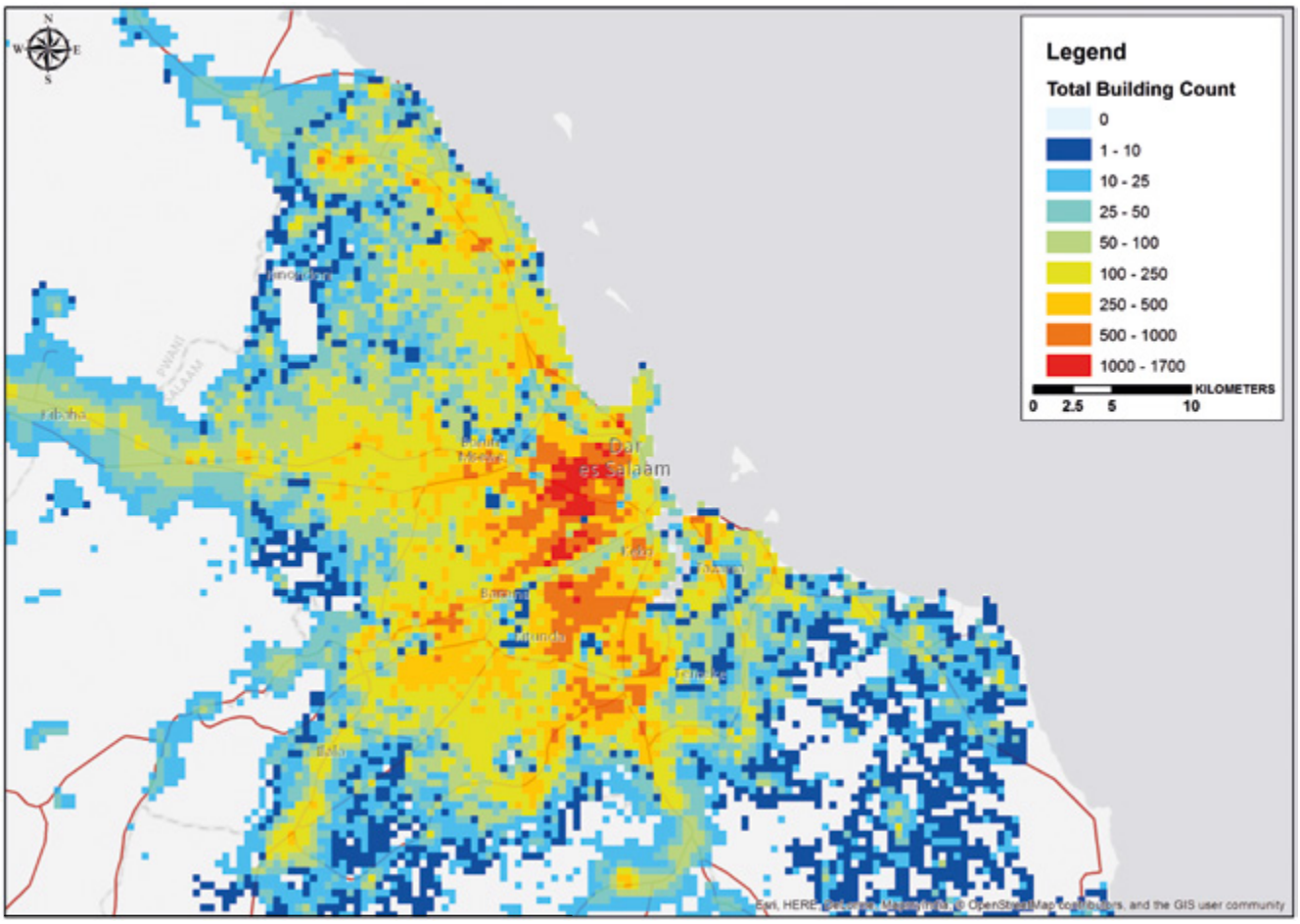
60 Here the focus is on insurance and this account does not represent METEOR's full suite of products and applications under this project

Summary of solution using space technology

Earth observation tools offer the most effective way to produce consistent and open exposure data on countries that have too little such information and have rapidly-expanding urban areas. METEOR will improve upon existing EO methods for characterising the built environment. It entails a remote-sensing solution for quantifying exposed populations and building infrastructure including private and public homes, and commercial and industrial structures. METEOR will provide a framework for implementing a measurable risk reduction policy, by providing better data on exposure and guidelines for producing quantitative estimates of exposure and risk. These outputs will strengthen a government's capacity to plan for and respond to disasters, and allow it to make informed decisions on investments for natural hazard risk reduction.

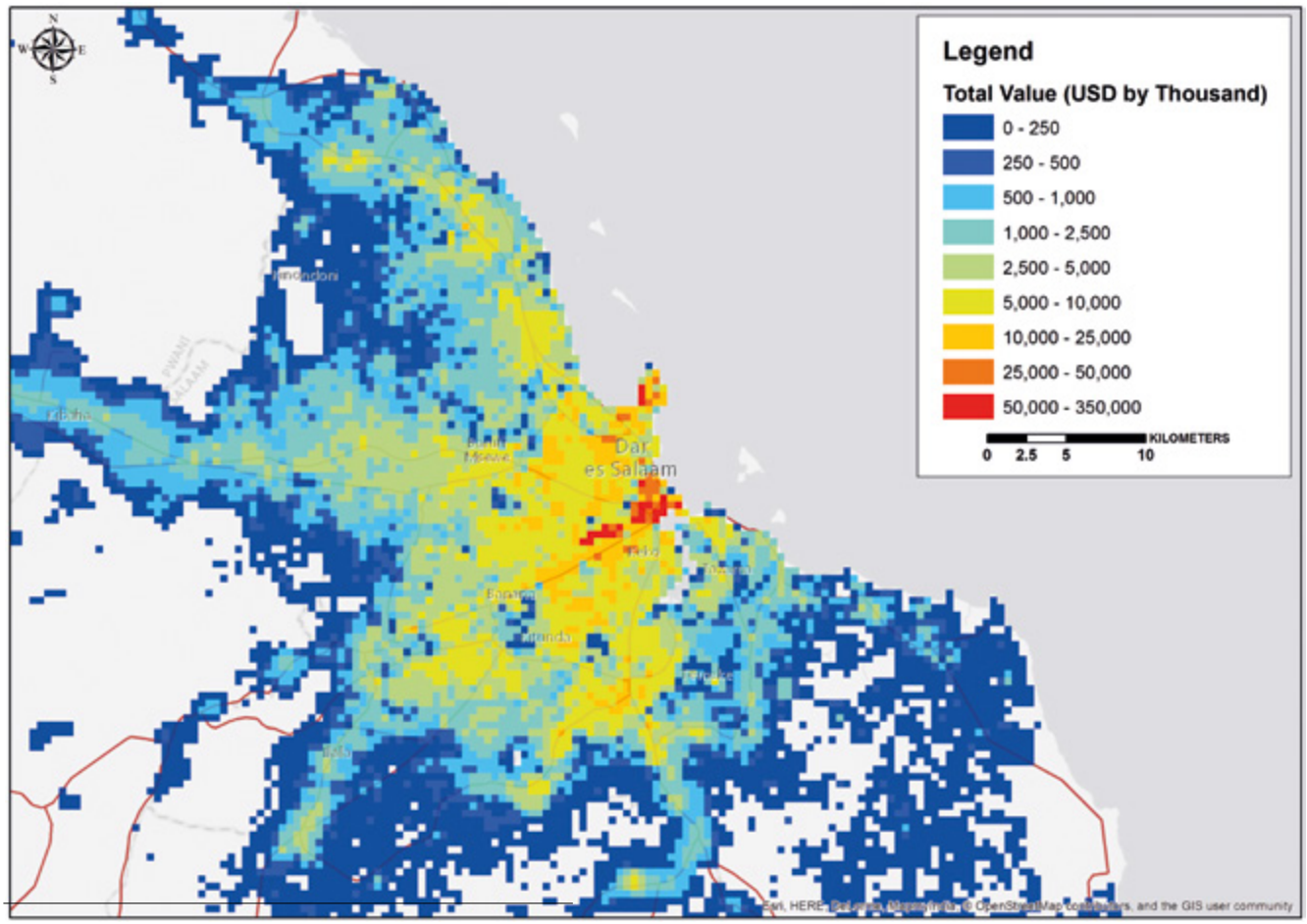
Governments may also want to insure certain risks. With the exposure databases and enhanced capacity developed under METEOR, they can approach insurance companies to structure a policy on a particular risk. In the event of a disaster, governments will receive a payout and can respond swiftly to get the economy back on its feet.

Figure 10: METEOR project example of building count mapping



Source: METEOR Project/ ImageCat Inc

Figure 11: METEOR project example of building value mapping



Source: METEOR Project/ ImageCat Inc

Expected impact

Insurance companies

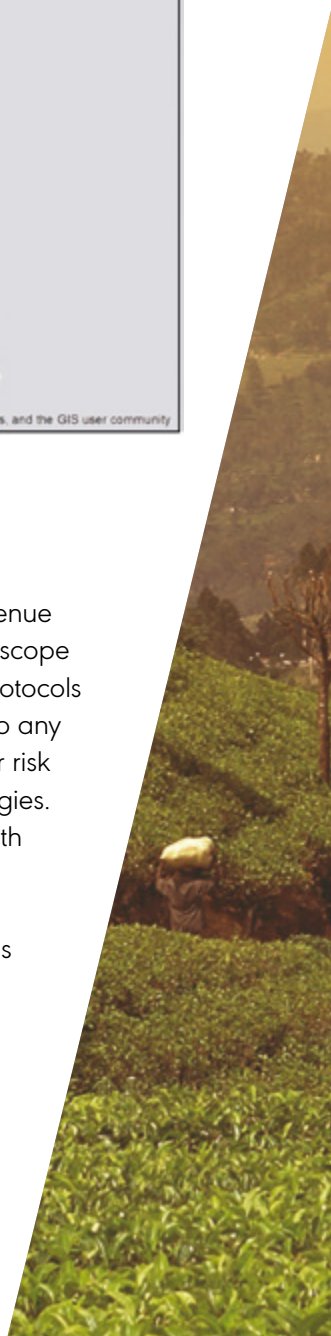
- Improved decision support tools for insurance companies on premium pricing

Governments

- Insurance coverage in the event of a disaster

Expected business model

METEOR is not aiming to generate revenue from the products delivered under the scope of the funded project. The data and protocols are open-source and freely available to any country planning to implement disaster risk management and risk reduction strategies. METEOR is facilitating conversations with governments, insurance forums and other risk financing networks so that governments are in a position to access and sustain these channels at the end of the project.



Profile five: Airbus Flood and Drought Resilience: Demonstrating the efficacy of EO data for the micro-insurance market in Kenya

Airbus Flood and Drought Resilience is an IPP funded project. The consortium is working on alleviating risk for farmers who currently have little or no access to insurance, by demonstrating the efficacy of EO data for the micro-insurance market in Kenya. The information provided will support decision-making and the development of improved insurance products, and ease the claims verification process, using indices that more accurately reflect the incidence of drought than current measures provide.

Year project began: **2017**

Country: **Kenya**

Partners

Project lead:

- **Airbus Defence and Space**

Project consortium:

- **Vivid Economics**
- **Oxford University**

International partners:

- **Building Africa (BUA), Kenya**

Product

A vegetation health index (VHI) that provides micro-insurance companies with information on drought characteristics, the nature and extent of historical droughts and projected future scenarios of droughts in a specific area.

Target customers

- Ultimately Kenyan farmers through micro-insurance companies.
- Kenyan Ministry of Agriculture

Challenge being solved

Kenya is drought-prone, with significant mortality and economic losses attributed to droughts. Insurance is a risk-reducing tool in the event of droughts. However, insurance companies have insufficient information both to price drought-related insurance products and to verify insurance claims. Claim verification is typically done through in-situ assessments which are costly to implement and through field meteorological stations which are also expensive, needing regular maintenance and the interpretation of their data requires strong support. Both methods provide only point information at field level. Without dependable and frequent information on droughts, at regional level, the business case for increasing access to drought insurance is limited.

Summary of solution using space technology

Airbus is developing a system that can detect drought areas, map the degree of severity and support claims decisions by providing a Vegetation Health Index (VHI). The VHI uses satellite imagery to monitor crops through the growing season. Information will include historical and actual information on drought occurrences. In particular, the actual information will inform a continuous monitoring process on the crop status on a 10-day and 20-metre basis. Airbus primarily uses EO data from ESA's Sentinel 2 satellite, MODIS and to support the system, the UK built DMC2 satellite, with additional data from other Airbus satellites as necessary. The data will be used in a drought indexing mechanism and the outcomes, which are expected to include present weather conditions and forecasts, will be presented to micro-insurance users via an online dashboard.

Using this satellite derived imagery, micro-insurers can access information that would enable them to develop risk profiles and price their insurance policies accordingly. Additionally, in the event of an insurance claim for drought related losses, micro-insurance companies can verify the claim, with less need to send surveyors to the site of the claim, resulting in less paperwork and cost savings to the company. The three principal actors of this business in Kenya, i.e. micro-insurers, farmers and government agencies, have also appreciated that the satellite based analysis provides an independent and transparent data source that is important to all of them.

Expected outcomes and impact

Micro-insurance companies

- Improved decision support tools for insurance companies on premium pricing, portfolio performance monitoring and claims verification
- Improved efficiency and accuracy in premium pricing, portfolio performance monitoring and claims verification
- Reduced operational costs for insurance provision
- Reduced paperwork in the claims' process

Farmers

- Tailored insurance premiums
- Insurance coverage in the event of a drought

Government agencies

- Potential coverage nationwide at sub-county level
- Faster decision process

Expected business model

Model: Generating the VHI requires efficient processing of very large amounts of data on a 10-day cycle throughout the growing season; this requires both efficient data handling and access to significant computational resources. The output is, however, a relatively simple-to-handle dataset that can be of value to many users, including companies, cooperatives and individual farmers, as well as Government Ministries, Departments and Authorities (MDAs). The Airbus-led consortium plans to use a business to business (B2B) model to offer the VHI product to market via both individual insurance companies and insurance consortia providing micro-insurance products, which will then use the data to support their own business activities and, potentially, also provide an enhanced information service to their individual customers.

Customer acquisition: The current project has enabled the Airbus-led consortium to demonstrate the VHI product to a number of insurance providers in Kenya and initial reactions have been very positive. This process is ongoing whilst a time series of VHI information is built-up for the two pilot areas within important agricultural areas, representing two of the best yet diverse farming areas in Kenya, during the project. It is anticipated that one or more of these key existing contacts will become early adopters of the product within Kenya. The approach typically employed by Airbus for local distribution of its satellite data products is to establish an approved network of local resellers. It is expected that such an approach could be applied to the VHI product with a selected early adopter or group of adopters working in partnership with Airbus to develop contacts leading to further product sales.

Revenue streams: The key cost driver is the total extent of the area processed to generate the VHI, which could vary from a few locations with concentrations of insured farmers to the whole of the agricultural belt of Kenya, amounting to roughly one-third of the country. The minimum economic area to be processed is a 100km by 100km tile. Users will be able to access products on a subscription per tile basis, with the price dependent on the total geographical area required and the level of spatial detail supplied; farm level detail, local government district, county or region. The price structure offered to all users will fully reflect the economies of scale.

Profile six: Harvesting: Improving the reach and risk management of lending organisations through digital tools, alternative datasets and artificial intelligence

Harvesting provides an Agri-Lending suite which enables financial service providers to use their own historical data alongside alternative inputs such as satellite data, and thus make the lending life cycle more efficient. Harvesting's goal is to help drive financial inclusion by providing actionable data to financial institutions to enable provision of loans.

Year established: **2016**

Countries: **Global reach – Past implementations in: Uganda, Kenya, Myanmar and India**

Stage: **Product deployment**

Partners

Harvesting works with financial service providers, typically banks and Microfinance Institution (MFIs) to improve their existing processes to better serve smallholder farmers.

Product

The full suite of Harvesting's services includes:

Pre-loan

- Mobile loan appraisal application

Loan decisioning

- Credit scores
- Loan approval dashboard

Post loan

- Loan monitoring and collection dashboard
- Land record monitoring

Target customers

Financial service providers who lend to smallholder farmers

Challenge being solved

Smaller loans often attract high interest rates, due to their higher cost of administration. In the case of agricultural loans, this interest rate takes into account changing weather patterns, the risk of defaults, and the need for high investments in risk assessments and portfolio monitoring in remote areas. One approach to reducing interest rates and increasing the frequency of loans provided to smallholder farmers is to develop solutions that lead to a sustainable reduction in operating costs. Harvesting is addressing these challenges with the use of a mobile loan applications, using credit risk scores based on alternative data, land record monitoring, and farmland monitoring, to reduce operational costs and provide tailored loans to more farmers.

Summary of solution using space technology

Using a modular, scalable and insightful platform, Harvesting has created a multidimensional approach to reducing the cost of lending to smallholder farmers. These products enable data-backed decision making using the remote sensing, mobile technology, and alternative data sets. There are a number of services in the Agri-lending suite:

- Mobile loan appraisal application allows lenders to collect traditional data about the loan-seeking farmers, along with new data points such as the coordinates of the farm.
- Credit risk system (CRS) provides lenders with a data-rich interface with the flexibility of customising variables to determine the creditworthiness of an applicant efficiently. The CRS also enables monitoring of repayment activity.
- The loan approval dashboard allows lenders to have a comprehensive view of all loan applications, credit scores, individual requirements, etc. enabling lenders to make decisions faster.

- The loan monitoring and collection dashboard empowers lenders to use satellite data to view the progress of farm development throughout the loan cycle. It also creates a two-way communication system that assesses any potential risks. Lenders can both alert farmers to take corrective actions and recognise the possibility of repayment issues.
- Land record monitoring – Land records are collected and continuously monitored by Harvesting. This streamlines the process of pulling records associated with applicants to check ownership and to ensure that multiple loans are not taken out on the same plot of land. Harvesting integrates spatial data and on-the-ground resources that are uploaded to the cloud to mark farmland boundaries.

Expected outcomes and impact

Lenders

- Improved decision support tools on credit risk and portfolio monitoring
- Improved efficiency in assessment and portfolio monitoring
- Reduced operational costs for lenders through mobile applications, credit scoring and ongoing portfolio monitoring
- Ability to reduce portfolio at risk through monitoring and alerts
- Increased market share

Farmers

- Access to credit
- Flexible lending terms

Business model

Model: Harvesting's agri-lending suite is offered as business to business (B2B) model to financial service providers (FSP) lending to smallholder farmers. Based on the FSP's need, they will choose from the available suite of services. Harvesting will then implement based on the services chosen.

Revenue streams: Subscription fees dependent on the number of farmers for which Harvesting enables lending and the acreage that is being monitored. Additional integration fees are charged if FSPs require integration with their existing digital systems and tools.

Customer acquisition: Customers are acquired through networking with governments, large MFIs and banks, and through word of mouth.

Profile seven: Pula Advisors: Increasing access to tailored insurance products for farmers through trusted intermediaries

Pula uses satellite data and farm yield measurements to understand how weather patterns affect a smallholder farmer's yield. This information is used to automate compensation in the event of a loss. Pula also provides farmers with targeted agronomic advice via SMS messaging, helping them grow more from their existing landholdings.

Year established: **2015**

Countries: **Uganda, Tanzania, Kenya, Zambia, Malawi, Nigeria, India, Rwanda, Ethiopia**

Stage: **Product deployment**

Partners

Pula is an ecosystem of various business which are centered around farmers. Pula works with:

- Insurers and reinsurers to underwrite financial products
- Various aggregators such as credit providers, seed and fertiliser companies and agro retailers which work directly with smallholder farmers

The ultimate aim is to serve smallholder farmers with insurance products

Products

Pula works with various aggregators to provide appropriate and affordable insurance products. Products can range from weather index to yield index or crop revenue insurance. Pula also provides farmers with targeted agronomic advice via SMS messaging.

Target customers

Smallholder farmers through various intermediary organisations such as microfinance institutions, agro retailers, buyers and cooperatives.

Challenge being solved

Smallholder farmers are particularly vulnerable to the effects of climate change. However, insurance, which would help mitigate that risk, is rarely taken out due to limited access to affordable and appropriate insurance products. Pula is working to address this challenge and provide access to insurance to smallholder farmers in Africa, using creative solutions.

Summary of solution using space technology

Pula uses satellite data and farm yield measurements to understand how weather patterns affect yield, and uses this information to automate compensation in the event of a loss. Pula also provides farmers with targeted agronomic advice via SMS messaging, helping them grow more from their existing landholdings. Insurance is provided for approximately 8 – 10 crop varieties, with a view to expanding to more crop types and to livestock.

The weather index insurance product utilises satellite data. When a weather index insurance product is deployed through an aggregator, Pula will monitor weather performance via EO. If there is an issue, such as too little rain, Pula would calculate the compensation for the loss. The compensation is dispersed through the aggregator who works directly with the farmers.

Expected outcomes and impact

As Pula works with a variety of actors in the value chain, each provides and receives value from using Pula products:

- **Insurers and reinsurers** provide value through underwriting risks and receive value in growing the insurance market
- **Credit providers** provide value through enabling access to credit and receive value through growing their loan book and reducing their portfolio at risk
- **Seed and fertiliser companies** provide value through paying premiums, and contribute customer and supply chain data which can enable them to reduce counterfeits and increase their sales
- **Agro retailers** provide value through supporting insurance products, and receive value through improving their product sales
- **Smallholder farmers** receive value through purchasing quality inputs, accessing insurance and credit, receiving tailored agronomic advice, and ultimately through improved yields

Business model

Model: Pula is a business to business [B2B] model. Pula works with aggregators to structure a product that works for their farmers. The aggregators will choose what it needs from the available products, for example a weather index or yield index. Pula will then develop the policy structure, obtain sign-off by the insurers, and deploy the product.

Revenue streams: The aggregator compensates Pula for the management and implementation of the product. For larger aggregators this is typically a variable fee which is renewed annually.

Customer acquisition: Customers are acquired through networking with governments, large microfinance institutions, produce buyers and word of mouth.

Profile eight: Apollo Agriculture: Providing access to high-quality farm inputs on credit backed by insurance

Apollo Agriculture works with farmers in Kenya to maximise their profits. Apollo uses machine learning, satellite data and mobile phones to deliver financing, farm products, and customised advice to smallholder farmers with efficiency and scalability.

Year established: **2016**

Country: **Kenya**

Stage: **Product deployment**

Partners

Apollo Agriculture works with agro-dealers, agents and insurance companies to provide smallholder farmers with access to inputs on credit.

Products

Apollo Agriculture's product is a customisable package of high-quality farm inputs on credit. The service also includes crop insurance and voice-based agronomic and financial advice.

Target customers

Smallholder farmers in Kenya

Challenge being solved

Many farmers lack the capital to access high-quality farm inputs such as seeds and fertiliser that would help them maximise their production. Apollo Agriculture was founded to provide smallholder farmers with access to credit to purchase such inputs.

Summary of solution using space technology

Apollo Agriculture delivers a credit product using sophisticated analytics, EO data, and machine learning. Farmers can purchase high-quality farming inputs (hybrid seeds and fertiliser) on credit with flexible repayment terms and post-harvest due dates. The package also includes crop insurance, and advice delivered through voice on mobile phones, to help farmers learn about agronomic best practices as well as financial literacy.

Central to Apollo Agriculture's model is the ability to operate with minimal field staff using a combination of mobile technology and independent agents. Farmers sign up via mobile phone. Apollo Agriculture then gathers data about each customer, including satellite data on customers' fields, which is used to build a credit score. Independent retailers distribute the inputs to customers. Each farmer's plot is GPS-mapped and satellite-tracked to provide up-to-date data on crop production. The package is also bundled with insurance and Apollo Agriculture works with Pula to structure the insurance policy.

Expected impact

Apollo

- Improved decision support tools on credit risk and portfolio monitoring
- Reduced operational costs
- Ability to reduce portfolio at risk through portfolio monitoring and alerts

Farmers

- Access to credit for inputs
- Insurance in the event of a loss
- Flexible lending terms

Business model

Model: Apollo Agriculture is a business to customer (B2C) model and uses technology to reduce the costs of customer acquisition and servicing.

Revenue streams: Apollo Agriculture earns revenue from margin on the inputs they sell.

Customer acquisition: Apollo Agriculture acquires customers through highly scalable distribution channels, mainly via radio and incentivised mobile referrals when existing customers refer new ones.

Annex two: Glossary

Algorithm – In mathematics and computer science, an algorithm is an unambiguous specification of how to solve a class of problems. Algorithms can perform calculation, data processing and automated reasoning tasks.

Area Yield Contract – A contract entitling the holder to receive a payment when the area yield is below the put or above the call option strike yield. The strike yield is the yield at which the holder of an option contract can exercise the option.

Basis risk – Basis risk in index insurance arises when the index measurements do not match an individual insured's actual losses.

Copernicus – The European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers information services based on Earth observation and in-situ (non-space) data. The Programme is coordinated and managed by the European Commission. It is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU Agencies and Mercator Océan.

Crop Cutting Experiments – A crop cutting experiment (CCE) involves a trained individual visiting a designated farm, harvesting a small area for a designated crop, waiting for the produce to dry, and then weighing it. Sample-based area yield indices are typically calculated as the average yield from a series of randomly selected CCEs in the area the index is designed to cover.

Digital Finance – Financial services accessed and delivered through digital channels.

Earth Observation (EO) – The gathering of information about the physical, chemical, and biological systems of the planet via remote-sensing technologies, supplemented by Earth-surveying techniques and encompassing the collection, analysis, and presentation of data. EO is used to monitor and assess the status of and changes in natural and built environments.

ESA – European Space Agency.

FinTech – Organisations that use digital solutions to provide financial services.

GNSS – Global Navigation Satellite System refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location.

Index-Based Insurance – Insurance that pays out benefits on the basis of a predetermined index (e.g. rainfall level) for a loss of assets and investments resulting from weather and catastrophic events.

International Partnership Programme (IPP) – A five-year, £30 million programme run by the UK Space Agency. IPP uses the UK space sector's research and innovation strengths to deliver a sustainable, economic or societal benefit to developing countries. Projects within IPP span a wide range of themes including: improving agriculture; reducing deforestation; improving disaster response; reducing maritime pollution and illegal fishing; optimising renewable energy; and improving resilience to climate change.

Light Detection and Ranging (LIDAR) – A surveying method that measures distance to a target by illuminating the target with a pulsed laser light, and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths can be used to make digital 3D representations of the target.

Machine Learning – The scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence.

Normalized Difference Vegetation Index (NDVI) – A numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum to assess whether the target being observed contains live green vegetation. It has been adopted to analyse remote sensing measurements.

Reinsurance – Insurance that is purchased by an insurance company. In the classic case, reinsurance allows insurance companies to remain solvent after major claims events such as disasters. A company that purchases reinsurance pays a premium to the reinsurance company, which in exchange would pay a share of the claims incurred by the purchasing company.

Remote Sensing – The acquisition of information about an object or phenomenon without making physical contact with the object, and thus in contrast to on-site observation, especially of the Earth. The term generally refers to the use of satellite – or aircraft – based sensor technologies to detect and classify objects on Earth. It may be split into active remote sensing when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor, and passive remote sensing, when the reflection of sunlight is detected by the sensor.

SatComms – An artificial satellite that relays and amplifies radio telecommunications signals via a transponder. It creates a communication channel between a source transmitter and a receiver at different locations on Earth. Communications satellites are used for television, telephone, radio, internet, and military applications.

Synthetic Aperture Radar (SAR) – An active system that transmits a beam of radiation in the microwave region of the electromagnetic spectrum. The data captured reveals information about the structural characteristics of the Earth's surface.

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