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Development of Innovative Risk Management Tool – Agricultural Risk Metrics Platform

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ABSTRACT

Agriculture in Croatia is greatly threatened by multiple risks, including market, value chain, price and institutional risks, but for a great part also climate change risks. Due to climate change impact on the characteristics of weather extreme events, farmers are suffering more frequently from the consequences of crop losses. Currently, there is an information gap to properly respond to these increasing risks with adaptation measures. Farmers need to gain the information they require in an understandable and practice-oriented way.

The paper describes the entrepreneurial process of developing cloud-based software that provides a holistic view of natural risks, their impact on agricultural yield, and risk management. The process encompasses start-ups tools like business model canvas, workshops with stakeholders (farmers, agribusiness managers, policy makers and researchers) and surveys. The ultimate goal is the development of cost-effective service but highly suited to enable farmers to turn their agricultural enterprise into a data-driven business that can adapt more quickly and efficiently to climate risks.

Agricultural Risk Metrics is a tool primarily developed by Genillard&Co for the purpose of the insurance industry. The University of Zagreb Faculty of Agriculture teamed up with Genillard&Co, for the development of Agriculture Risk Metrics (ARM) for farmers. The project, funded by EIT Climate KIC, finished by the end of 2021.

The ARM for Farmers' project results will contribute to more efficient decision-making on the farm level. The use in research and policy analysis will be possible too. The Agricultural Risk Metrics have been designed to help the user to self-visualize the available climate risk data into intuitive graphs, diagrams and maps, thereby allowing any inexperienced or unskilled user to understand the information relevant to her. By making farmers aware of and giving them access to decision-enabling information about one of the greatest risks threatening their sustainability, this project will contribute to making the agricultural sector in Croatia Climate Smart.

Keywords: climate change, risk management software, business model canvas, decision making

1 Introduction

Climate change is one of the biggest challenges for agriculture globally. The frequency of extreme weather events increases causing damages to crops, livestock, assets, and human lives. Losses from extreme weather events cost Croatia on average as much as 0.6 per cent of the national GDP / 9.3 per cent of the Gross Value Added generated by the agriculture, forestry, and fisheries sectors (UNDP report 2009).

Extreme weather events influence family income and resilience. It also reflects on competitiveness and, in the long run on socio-demographic characteristics of rural space. The drought is a major reported economic loss in past years. Yield reductions due to drought, not insurable (until now!) in Croatia are high despite management potential because of water availability in Croatia and insurance development within the EU Common Agricultural Policy framework.

Efficient risk management is key for stable income, higher investment capacities, and risk appetite from the farmers' side. Efficient risk management requires access to information, knowledge, efficient rural finance system (credits, insurance, hedging…), and enabling environment (unlock access to value chains for farmers, legal and policy settings).

Cloud-based software as a service Tool (SaaS) called Agriculture Risk Metrics (ARM) provides a holistic and historical view of natural risks and agricultural yields and integrates also climate change weather prediction data to complement the picture on risk. ARM is a cost-effective service developed for the insurance industry and could enable farmers to turn their agricultural enterprise into a data-driven business that can adapt more quickly and efficiently to future climate risks. The paper's objectives are to describe ARM and its features and present the development stages of the ARM for Farmers Business model.

1.1 Digital technology in agriculture

Agricultural innovation is the process whereby individuals or organizations bring new or existing products, processes, or ways of the organization into use for the first time in a specific context, to increase effectiveness, competitiveness, and resilience with the goal of solving a problem (Innovation at FAO, www.fao.org). Achieving the UN Sustainable Development Goal of a 'world with zero hunger by 2030 will require more productive, efficient, sustainable, inclusive, transparent, and resilient food systems. Digital innovations and technologies may be part of the solution. The so-called "Fourth Industrial Revolution" (Industry 4.0) is seeing several sectors rapidly transformed by 'disruptive' digital technologies such as Blockchain, Internet of Things, Artificial Intelligence and Immerse Reality. In the agriculture and food sector, the spread of mobile technologies, remote-sensing services and distributed computing are already improving smallholders' access to information, inputs, market, finance and training (Trendov et al., 2019). Digital innovations are also known under names like agri-tech. It assumes the application of disruptive digital technologies in agricultural sectors, but also in finance and insurance, and even in some combinations like agri-fin-tech. The global market size of smart agriculture is expected to grow from approximately 9.58 billion U.S. dollars in 2017 to 23.14 billion U.S. dollars by 2022. The fintech market and insurtech markets are almost ten times bigger than agritech on the global scale (Statista.com).

Platforms for improving agricultural business can be platforms for monitoring drought (Dong et al., 2017), smart decision system for digital farming (Baseca, 2019), the web-based prototype for facilitating farm management (Lowell et al., 2012) and platform for monitoring greenhouse environment (Pisanu et al., 2020).

The paper by Čop et al. (2021) provided an overview of the application and representation of information and communication technology (ICT) among agricultural producers in Croatia, Sisak-Moslavina County, and according to farm management software choice shows the future of this market in Croatia. Analysis showed that farmers are familiar with ICT, and from the interview, it can be concluded that farm management software is already applicable. The growth of the farm management software market is expected in the future because of the generational renewal of agricultural holdings. Respondents state the main reasons for not using ICT: lack of knowledge (65.2%), and lack of training (60.9%). They also stated that due to farm work they do not have enough time to use ICT (60.9%). Some of the additional constraints are the (foreign) language of applications and insufficient technological infrastructure. The presented research indicates the need for additional research on innovations, especially software for agricultural production management, which is gaining in importance and tends to bring it closer to farmers.

1.2 Croatian Agriculture

Agriculture is an important sector of the Croatian economy. Climate, soil and other factors enable a large range of agricultural products to be produced in Croatia. Out of a total of 1.5 million utilized agricultural areas, the majority is arable land (823 thousand hectares), followed by grasslands (606 thousand hectares), an area under permanent crops, production in protected areas is modest.

According to the Central Bureau of Statistics, 143,901 agricultural holdings operate in Croatia most of which are family farms (97%) (Croatian Bureau of Statistics, Agricultural census 2020). In addition to official statistics, there is also a record of agricultural holdings Register of Farmers. It is a database containing data on agricultural holdings and their resources, and the Register is managed by the Agency for Payments in Agriculture, Fisheries and Rural Development. In the year 201, 170,059 agricultural holdings were registered (140,874 family farms). About 100,000 farmers receive some sort of support.

The average size of an agricultural holding in Croatia is 10.45 hectares (Croatian Bureau of Statistics, Agricultural census 2020) while the EU average is 16.6 hectares (Farm Structure Survey, 2016). The structure of agricultural holdings in Croatia is dual. The number of large farms is increasing, but the process of concentration is accompanied by the polarization of farms on small and big ones. Almost 70% of agricultural holdings belong to the category of small agricultural holdings (Table 1).

Table 1. A number of agricultural holdings by agricultural size classes of utilised agricultural area. Republic of Croatia

	2007	2010	2013	2016
Total	181250	233280	157450	134459
Without land	4200	230	350	1785
Less than 2 ha	88680	122560	60700	50806
From 2 to 4.9 ha	46800	55430	48220	40840
From 5 to 9.9 ha	23880	30240	24690	20079
From 10 to 19.9 ha	10710	13880	12610	9466
From 20 to 29.9 ha	3210	4330	3880	3163
From 30 to 49.9 ha	1950	3470	3030	3160
From 50 to 99.9 ha	1240	2290	2610	3536
100 ha or more	580	850	1350	1624

Source: Croatian Bureau of Statistics. Farm Structure Survey. www.dzs.hr

Small and fragmented (family) agricultural farms of economically unfavourable educational and age structure of farm holders predominate. The largest number of holders (33.1%) have secondary education, while the smallest share of holders with a university degree and college (6.5%), and for 33.4% of there is no data on education. Only 2.4% of farm managers have agricultural education (EU average is 9.1%). Among young farmers, 5.2% have agricultural education. Also, the age structure of family farms is not favourable - the majority of holders of Croatian farms are older than 55 years and such farms have difficulty accessing capital and the market: 37.7% are older than 65, while only 11.5% are younger than 40 (Ministry of Agriculture, 2019). Large agricultural holdings have been created on the foundations or inherited large systems from the time of the planned economy. There is a lack of efficient medium-sized farms, as carriers of agricultural production. Transformation towards medium-sized, commercially oriented farms is hampered by structural constraints such as limited access to finance, modern technologies, the market, as well as insufficient entrepreneurial capacity and knowledge (World Bank, 2019). All farms are heavily dependent on agricultural support. The largest share of support is directed to large farms.

The income per worker in agriculture in Croatia averages about 36% of the average salary of the entire economy (data for the period 2005-2018). The economic performance of agricultural holdings in Croatia lags behind the holdings in the EU. Farm Net Value Added* per Annual Work Unit generated by an agricultural holding in Croatia is almost four times lower than in the European Union. The same applies to net income per annual unit of work.

Farmers have obsolete technology and low productivity, lack quality and food safety standards and are reluctant to cooperate with other farmers. In the combination of poor infrastructure, (irrigation, storage capacities, cold storage, logistics) and relatively high labour cost, the consequence is an inability to satisfy market demand and ensure continuity of deliveries in the required quantity. Agri-food chain has low rate of capital formation (4 times less than in EU) and Government invest 3 times less money in R&D. (World Bank, 2019.). The unfavourable position in the food supply chain is especially pronounced in times of market disturbances, as happened during the trade war with Russia (2016) or recently when African Swine fever.

*Farm net value added (FNVA) is used to remunerate the fixed factors of production (labour, land and capital) whether they be external or family factors

Farmers' access to financial products (loans, insurance, guarantees, venture capital funds) is difficult and the rural financing system is developing slowly. Grants from the Rural Development Program, mainly investment in physical assets, contribute to economic efficiency, but measures that could affect the introduction of knowledge, innovation and farmers' associations have been underused (World Bank, 2019).

Greater market orientation and increased competitiveness can be achieved by activating agricultural land, including farmers in the food chain, easier access to finance, risk management and diversification of income sources, especially small farms for the production of value-added goods, which includes a higher share of organic agriculture.

1.3. Risk management in agriculture

Farmers and the agricultural sector are exposed to different types of risk. Weather events such as drought, hail, frost, etc. cause production risks that have a big impact on production yields and business at all. Besides production risks, farmers are faced with market, legal, human and traditional risks. Lack of financial resources and indebtedness impact the farm business. To cope with different types of risks farmers and the government need to implement a risk management framework. According to Hardaker et al. (2004), risk management is defined as the systematic application of management policies, procedures, and practices to identify, analyse, assess, treat and monitor risk.

Farmers are mostly risk-averse (European Commission, 2017; Njavro, 2016) and they need to adapt and adjust to various risks. The occurrence of extreme climatic events, their impact, and the need to increase farmers' concern impact the process of how to reduce risks and implement an adequate risk management approach (European Commission, 2017). According to Hardaker (2004), Njavro et al. (2005) risk management strategies are divided into two groups, on-farm strategies, and strategies to transfer risks. On-farm strategies that can be used on farms are crop diversification, liquidity, and stocks, applying modern production technology, infrastructure, agricultural extension, and new technologies for business decisions (big data, sensors, robots, artificial intelligence). According to Meuwissen (2000) research, risk-sharing strategies are more important than on-farm strategies. Some of the risk-sharing strategies are production and marketing contracts, hedging, financial leverage and external financing, and insurance (Meuwissen, 2000). Croatian wine farmers from north-western sub region Zagorje – Međimurje emphasized production and human risks in businesses while for coping with risks farmers mostly use strategies such as ownership of land and property, intuition and personal gauge, various methods of sales and distribution (Smrkulj and Njavro, 2016). Wine farmers from Dalmatia stated the same risks as in the before-mentioned research: human risk and climate risks; and most important risk management strategies are the use of own land, life-long learning, irrigation, and off-farm sources of income (Gugić et al., 2008). In Slavonia and Baranja most important risks were the health of farm members, climate risks, and price risks. Farmers as the most important risk management strategy stated the application of appropriate production technology (Njavro et al., 2005).

Risk management is an important component of Common Agricultural Policy (CAP). There are three risk management tools: subsidized insurance, mutual funds and income stabilization tool (Article 36 of Reg. 1305/2013). First were implemented subsidized insurance schemes and mutual funds and lately, income stabilization tool (European Commission, 2017). For catastrophic risks (e.g. drought/floods) or systemic risks, that cause and make a negative impact on business, public aid was implemented only because it is not profitable for private companies to provide instruments to cover large-scale losses (European Commission, 2017). Some of the ex-ante policies that can be used are income stabilization tool, subsidized insurance (crop and livestock) and mutual funds for production risk, CAP market measures, basic payment schemes, and for ex-post, ad hoc disaster aid. Risk management tools from RDP will be further discussed below.

Crop insurance is used to cover yield losses caused by climate risks. The main aim of insuring crops and livestock is to compensate for the losses that result from a negative event which leads to a decrease in a farmer's income (Lipińska, 2016). Crop insurance can be against a single peril (cover only from one risk e.g. hail or frost), and multi-peril (cover a few types of risks, e.g. hail and fire). On EU level, Germany (72%), Austria (60%), and France (32%) insure climate risks much more with single peril insurance, and Hungary (>75%), Italy, and Spain (60 to 75%) are nations that in higher per cent insure with multi-peril insurance (European Commission, 2017). Besides private insurance schemes, some EU member states subsidized insurance under CAP such as Croatia, Italy, France, The Netherland, Estonia, Latvia, Lithuania, Hungary, Malta, and Romania. Other member states such as Austria, Bulgaria, Czech Republic, Poland, Spain, Slovenia, Portugal subsidized insurance through national schemes. In the frame of Reg. 1305/2013 subsidized insurance represents financial contributions to premiums for a crop, animal, and plant insurance against economic losses to farmers caused by adverse climatic events, animal or plant diseases, pest infestation, or an environmental incident.

Mutual funds (MF) are the results of the joint action of farmers that invest money for future risks in business. Mutual funds are more used in livestock production, and less (Italy, France, Denmark, and Belgium) in crop production. Mutual funds represent financial contributions to mutual funds to pay financial compensations to farmers, for economic losses caused by adverse climatic events or by the outbreak of an animal or plant disease or pest infestation or an environmental incident (Reg. 1305/2013).

An income stabilization tool (IST) is a financial contribution to mutual funds, providing compensation to farmers for a severe drop in their income. For example, farmers becoming eligible for compensation when income drops more than 30% or 20% (sectoral IST) in the preceding three-year period or a three-year average based on the preceding five-year period excluding the highest and lowest entry (Reg. 1305/2013). IST protects against income variability and it can be an interesting insurance product for farmers, but on the other hand, lack of experience in cooperation and business linkages could be a constraint in the development of IST and challenging for policymakers (Čop et al, 2020). Of all three mentioned risk management tools, only subsidized insurance is in use among Croatian farmers.

2. Methodology

The paper describes steps conducted on the project Agricultural Risk Metrics, ARM-SaaS Tool for the needs of Farmers, financed by EIT Climate KIC under the program EIT RIS Matchmaking Innovation Market, 2021. Those steps should be considered as the methodology in developing innovative tools, from idea to minimum viable product. On the Project, the following steps were used:

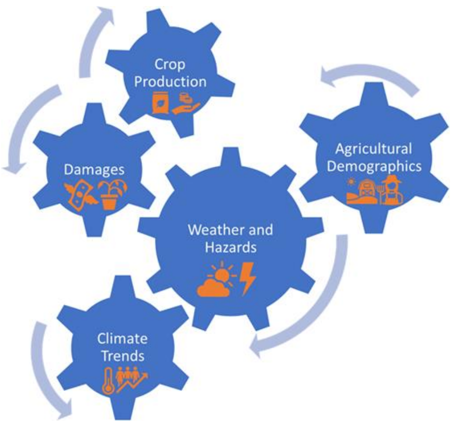
- Surveying farmers. To present the current version of ARM (developed for use in the insurance sector) to the farmers and get their feedback.
- A design-thinking workshop. To receive input from the farming community on the kind of climate risk management tool features they need in running farms.
- Development of business model and commercialization strategy
- Development of the ARM for farmers tool as Minimum Viable Product (MVP)
- Back-to-back workshop. To give farmers the chance to test the new tool and give further input to validate the commercialization strategy.

In the communication process with stakeholders and within the project partners web-based tool Miro (www.miro.com) was used. Miro was used in brainstorming, strategic and business planning. In the workshops, Miro was used in the storytelling process and product development.

3. Results

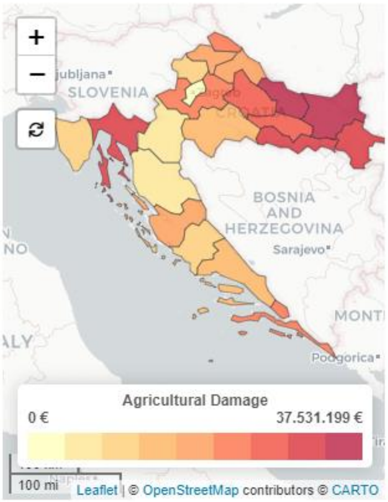
3.1. Agriculture Risk Metrics (ARM) for Farmers

Agricultural Risk Metrics is a risk data platform employing a web-based portal, self-service data visualization features and a cloud-based data warehouse. This platform is designed to understand, monitor and manage agricultural risks from natural perils. Data is mined from different open or public sources, quality checked, processed and structured, after which it is visualized in maps, graphs, charts and tables in online dashboards. Data selection in the dashboards is based on self-service features (e.g. enabling choice of a time period, location, averages), enabling the user to flexibly assess risk in high detail. Data updates are performed in real-time and on a regular and continuous basis, rendering live data available to the user 24/7. Current features of ARM for Insurers consist of five data modules. Modules are a) damages from natural disasters, b) weather and hazard, c) climate trends d) crop production and e) agricultural demographics.



Picture 1. Current features of ARM for insurers
Source: Authors

a) Reported economic "damage" to agriculture from different natural hazards from 2013-2019.
This data is made available by the Croatian Ministry of Finance and includes reported damages caused by natural disasters to crop production, including working capital in agriculture, and livestock. Damages are assigned to the following perils: Earthquake, Storm and hurricane winds, Fire, Flood, Drought, Frost, Hail and freezing rain, Frost, Heavy Rain, Plant disease, Landslide, Extraordinarily high snow, Snow cover and avalanche, Ice accumulation on watercourses, and other phenomena.
The dashboard shows the historical total reported losses in € per year and county. Single years or the Long-Term Average (LTA – average over all years) can be selected for a single, multiple or all hazards (drought, fire, flood, frost, hail, landslide, other, plant disease, rain, storm/hurricane). Regional differences (NUTS3 level) are visualized in a map and in a stacked bar chart, the share of different perils to total damage is visualized in a pie chart, total losses per peril are listed in a table and a line chart shows the damage time-series per year as well as the mean loss.



Picture 2. Average reported economic damage (€) from weather perils in Croatia per county over the years 2013-2019

Source: ARM®

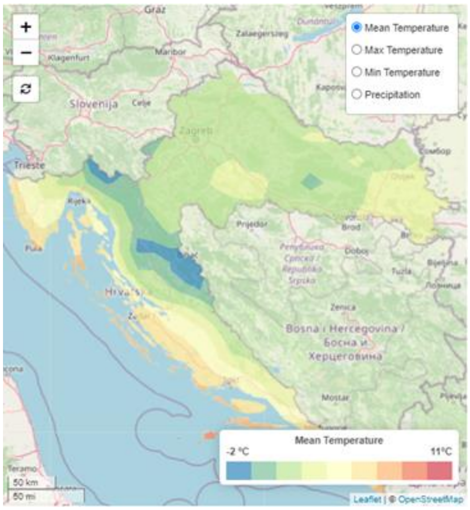
Picture 3. Average annual number of frost days for all counties in Croatia for the period 1978-2020

Source: ARM®

b) Weather and hazard data from 1978-2020 respectively 2008-2020.
This data is derived from the meteorological data provided by the Monitoring Agricultural Resources (MARS) group from the Joint Research Centre (JRC), from weather event reports in the European Severe Weather Database, and from the online weather observations data of the Croatian Meteorological and Hydrological Service. Weather parameters included are minimum, maximum and average temperature, annual or monthly cumulative precipitation, while the different weather perils included are frost days, heavy rain days, and drought, storm and hail events. Monthly or yearly values are visualized per region in an interactive map, a bar chart of monthly values averaged over a time period and a bar chart showing the yearly development. In

addition, for each weather peril, a pie chart shows the share of different event categories. Self-service selection of single years and months or time periods, a weather parameter or peril is possible, as well as a geographical selection of one or several counties (NUTS3 level).

c) “Climate change” prediction data for the periods 2011-2040, 2041-2070 and 2071-2100 according to two climate change scenarios (RCP 4.5 and RCP 8.5).
This data originates from the CORDEX database and allows the assessment of future risks that may arise from temperature and/or precipitation changes. For each forecasting period, the predicted maximum, minimum, average temperature or precipitation is shown. In addition, the deviation of the predicted climate variable from the baseline period’s value (1976-2005) can be assessed. Spatial information via contour maps is shown depending on the selection of variables, time periods and climate change scenarios.



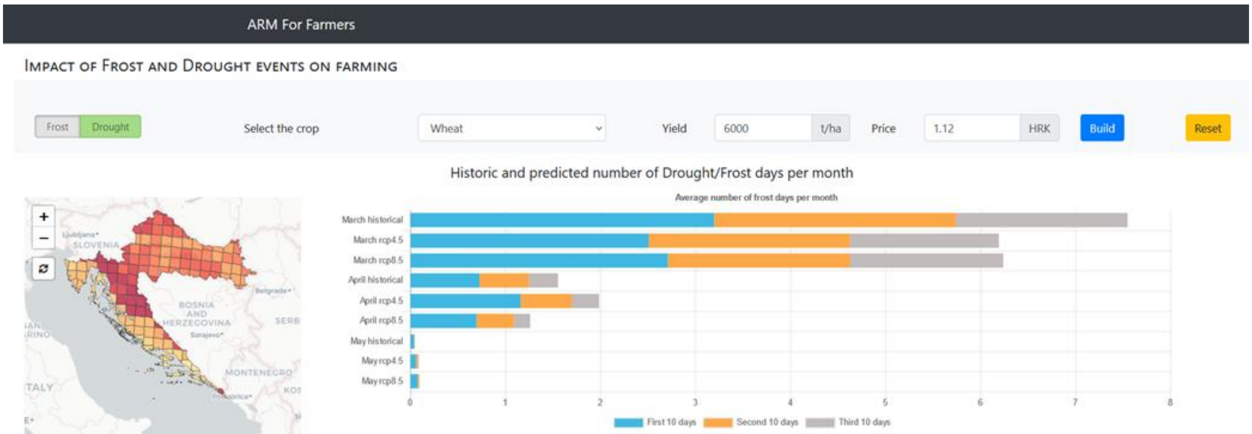
Picture 4. Mean predicted annual temperature in Croatia over 2011-2040 according to the RCP 4.5 scenario

Source: ARM®

d) “Crop production” data in volumes (tons), area (ha) and yield (t ha-1) from 2000-2018.
This data is retrieved from the statistical database of the Food and Agriculture Organization and give information on national production. Shown are for a multitude of crops and selected timeframe: the total crop production, crop production area, crop yield, and the gross production value per year.

e) Data on “Agricultural Demographics” according to the latest release of data.
This dashboard shows data from the Croatian Paying Agency for Agriculture and Fisheries (APPRRR) and enables to identify the risk population in the region and the demographic characteristics of agriculture (e.g. farm ownership type, age, gender, education, farm type, distribution of land use types and a number of farms and area according to farm size categories).

During the project, the prototype **Agriculture Risk Metrics (ARM) for Farmers** was developed. ARM for farmers enables risk analysis in crop production based on the risk sources, probability of occurrence and financial consequences of the risk (influence on gross margin). After selecting the farm location on a risk map of Croatia, the peril, and the crop of interest in a drop-down menu, the user also can interact by typing in farm-specific data of her or his own experience about yield and price values for calculating crop revenues. If no input is given by the user, the data from the database is applied. Finally, data of the level of crop damage due to drought or frost occurrences has been incorporated into the tool originating from research papers. Together with the compiled data of historic weather events and predicted weather derived from climate change models, the tool provides a risk assessment for the given area in terms of frequency and severity of damaging weather events. The current version includes the perils frost and drought. Additionally, the user receives the short- and long-estimation of revenue and profit reduction caused by yield reduction due to such events. The user experience is enhanced by self-service visualizations via maps, charts and selection boxes so that the user easily receives the information he or she is asking for.



Picture 5: Screenshot from the webbased app of ARM for Farmers

Source: ARM®

In detail a list of information displayed on the ARM for Farmers dashboard:

- A map is showing the historical frequency of frost or drought events in Croatia on a 25x25km grid level.
- A bar chart is showing the historical and predicted frequency of frost and drought events for the given time periods (10-day period or month). Two climate change scenarios referring to the concentration of carbon dioxide in the atmosphere are used for calculating the predicted frequency of frost and drought events: RCP 4.5 as the optimistic scenario limiting the global warming to not more than 2.6 degrees, and RCP 8.5 as the pessimistic business-as-usual scenario with an expected global temperature rise of 5 – 6 degrees
- Display of the historical yearly and averaged farming budget with costs and revenues for cultivating and selling the selected crop product. The user can further compare it to own experience by typing in new values for price and yield.
- Visualization of the annual effect on the user's revenue in a bar chart, further depending on
  - Timepoint of frost or drought event during the crop season
  - The development stage of the crop
  - The severity of the frost (minimum temperature) or drought event (precipitation anomaly)
- Visualization of the long-term effect on the user's revenue from 10 to 50 years in a grouped bar chart

A business model canvas (BMC) and a commercialization plan were developed as well.
The ARM for Farmers is a niche product for small to medium-sized farmers in Croatia. On the one hand, customers with a higher affinity for digital products (potentially younger people) and customers who are not so familiar with such technology (potentially older people). It can also be seen that the size of the land ownership plays a decisive role. If the land ownership is so small that commercial management is uninteresting, a digital tool such as ARM for Farmers is not needed, but the land ownership becomes too large, such a diverse and professional tool is needed that ARM for Farmers is currently not yet able to provide. The marketing should be tailored to farmers with medium area sizes of 20 to 1000 ha and address the two types of customers. In the case of the technically less affine customers, this means above all to provide the advantages in a targeted manner and to point out the ease of use.
We identified the major competitors in the Croatian market and global markets. We identified three similar farm/risk management software available on the domestic (Croatian) market and a number of products available globally. Agrivi (www.agrivi.com) is a globally known product that offers services for small and medium as well as to large farms and cooperatives solutions. Agrivi is oriented on plant products only. It offers tailored-made solutions for the agri-food industry in creating an efficient supply chain. Agrivi offers IoT solutions too. The tool is available in all main World languages. While Agrivi provides production and financial numerical, Agrodox (www.agrodox.hr) is farm management software oriented on recording production data and optimizing production processes (fertilization, spraying, irrigation and similar). E-savjetnik is an app offered by Croatian Extension Service. It complements extension work with news, weather data, plant protection consultancies. We extracted a number of innovative risk management tools/products/services available on the global market. Stable Price (www.staleprice.com) is an innovative price risk management company based in London. Based on price indexes it hedges prices of agricultural commodities. Indigo Ag (www.indigoag.com) is

oriented toward marketing services, but also to sustainability solutions. Farm Business Network(www.fnb.com) is a farmers' club with the vision of democratizing information, providing unbiased analytics and creating competition for farmers' business. Positioned on the USA market it offers its members (cooperative principle) access to inputs, finance and insurance, brokerage and marketing services and business analysis. Sharing data and information between member, Farm Business Network optimize farm decision management. A long list of farm management software tools that try to exploit the newest advances in digital technologies exist. Harvest profit (https://www.harvestprofit.com/) is farm business software. Granular (https://granular.ag/) and AgWorld (https://www.agworld.com/eu/) are similar. All use big data and precision agriculture solutions in the decision-making process. Hummingbird Technologies (https://hummingbirdtech.com/) use artificial intelligence, deep learning and remote sensing data to help farmers and businesses in measuring, predicting and optimization of the process within the value chain, from production to logistics and sale. P2P Agri (https://p2pagri.com.au/) is a holistic enterprise risk management tool.

Surveys conducted during two stakeholder workshops with interested farmers have shown that most of them would be prepared to spend a monthly fee to purchase a license for the tool. Based on these statements, financial planning was designed to serve also the smallholder farmers with a low budget. The market entry in Croatia is therefore initially created via the project's own website and with the help of online advertising for the sale of an MVP. A customer base must be achieved via our own webinars and workshops. Also, the influencer network must be established. The business analysis also shows that due to the further development of ARM for Farmers both in the area of features and in the area of new distribution channels, the business model is viable and could generate a continuous cash flow. However, the focus must be on the first experiences and the knowledge gained from them since own experiences are missing so far. Three revenue scenarios were created for the cost-benefit analysis (optimistic, realistic, pessimistic) and the expected break-even point, as well as the return on investment, were assessed.

Derived from the three expected revenue cases mentioned above, a Monte-Carlo simulation was created for the period from 2022 to 2026 with 1,000 repetitions for risk analysis. The risk analysis resulted in a probability figure showing the risk of suffering a financial loss. This probability figure will help understanding how long the enterprise is risking operation with red (negative) figures, and when in the black (positive) figures.

Measures that could reduce the risk are application of online marketing campaigns, early entry into new markets with great customer potential, expansion of distribution channels, low price for the customer and easy payment methods and regular expansion of features.

An MVP for the ARM for Farmers prototype has been developed. Nevertheless, in the validation workshop farmers indicated that expansion of the tool (data) to further crops and perils would be greatly appreciated. A problem encountered was the complexity of the designed minimum viable product (MVP), in terms of quality data available. While several academic research results are available reporting an effect of weather events on crop yield, no structural data for all crops or perils required was available, and no clear link to the weather and climate data could be established. Also, our own analysis testing the correlations between crop yield and weather indices did not return satisfactory results, due to the limited availability of (trustworthy) yield data of high spatial resolution and limited time to explore all weather metrics possible. In the end, we could mitigate this issue by setting the MVP's focus on the two systemic risks of drought and spring frost and adapting the output to the gathered academic research results which will be updated in a constant manner.

3.2. Business model for ARM

A business model describes the rationale of how an organization creates, delivers, and captures value. Business models are sometimes referred as art. And like art itself, it's one of those things many people feel they can recognize when they see it (especially a particularly clever or terrible one) but can't quite define. (Ovans, 2015). Ovans (2015) referred to Lewis in providing the simplest of definitions "All it really meant was how you planned to make money". Ovans provided a very comprehensive literature review of the business models. One of the authors she cited (Joan Margetta) describes business models in the term of the value chain. A business model has two parts: "*Part one includes all the activities associated with making something: designing it, purchasing raw materials, manufacturing, and so on. Part two includes all the activities associated with selling something: finding and reaching customers, transacting a sale, distributing the product, or delivering the service. A new business model may turn on designing a new product for an unmet need or on process innovation. That is it may be new in either end*."

Osterwalder created, probably today most used method, a **business model canvas (BMC**). The BMC is a tool for describing, analyzing, and designing business models. It captures above mentioned dimensions of business models. The BMC consists of nine parts. The right side deals with the market, the left side with production and resources while value is in the middle of the canvas (Osterwalder et al., 2010). Christensen et al. (2016) evaluated 26 business models to study the success or failure of the business model. A business model is made up of four elements: (1) a value proposition for customers; (2) resources, such as people, money, and

technology; (3) the processes that the organization uses to convert inputs to finished products or services; and (4) the profit formula that dictates the margins, asset velocity, and scale required to achieve an attractive return.
An innovation has no value until an ambitious builder creates a business model around it and turns it into a product or service that customers will buy. (Clifton and Badal, 2018). On the other hand, introducing a better business model into an existing market is the definition of a disruptive innovation. (Ovans, 2015).
Innovation in business model (business model journey) has three stages: Creation of the new business unit and its business model, sustaining and growing the business unit, efficiency (Christensen et al., 2016). Business model innovation (BMI) has the ability to make companies resilient in the face of change and to create growth unbounded by the limits of existing businesses. To achieve successful BMI, focus on creating new business models, rather than changing existing ones (Christensen et al., 2016). There is general agreement that BMI is continuously needed due to market liberalization, increased competition and changing socioeconomic conditions. There are two types of BMI. The first refers to the design of novel business models for newly created organizations (business model design), the second to the reconfiguration of an existing business model (business model reconfiguration), in which managers acquire new or reconfigure existing resources to change their business model (Donner & de Vries, 2020).

4. Conclusions

Due to the increasing difficulty in assessing weather extremes, farmers in Croatia are suffering more frequently from the consequences of crop losses. Currently, there is a data gap in agriculture and in the insurance industry too to properly respond to these upcoming risks and to make adaptations with climate change into consideration. A great effort in research and data processing is necessary to fill this gap. Furthermore, farmers would have to be able to interpret this data correctly.
The paper describes the work conducted on the project Agricultural Risk Metrics, ARM-SaaS Tool for the needs of Farmers, financed by EIT Climate KIC under the program EIT RIS Matchmaking Innovation Market, 2021. Those steps should be considered as the methodology in developing innovative tools, from idea to MVP.
Agricultural Risk Metrics is a tool primarily developed by Genillard&Co for the purpose of the insurance industry. The University of Zagreb Faculty of Agriculture teamed up with Genillard&Co, for the development of Agriculture Risk Metrics (ARM) for farmers.
An MVP for the ARM for Farmers prototype has been developed. It is essential to mention that the involvement of farmers (co-design) during the development of such tools is necessary. It might help farmers to turn their agricultural enterprise into a data-driven business that can adapt more quickly and efficiently to future climate risks. ARM applies Big Data analytics of natural perils and weather patterns of current and future climate, providing damage and hazard information from multiple sources. It is also the perfect platform to facilitate analytics in the form of crop models, to provide real-time crop monitoring through remote sensing, and market price modeling for the key crops.
The business planning showed how the ARM business model could be financially feasible and sustainable. Nevertheless, it depends on two major factors. ARM future development in creating a complex algorithm for yield and price predictively and their correlations with weather and market trends. Such upgrades could help ARM to position itself as leading farm management software, but also as an R&D platform for research of economic impacts of climate change in agriculture.
ARM has the potential to overcome knowledge, educational and cultural constraints and help to create a common understanding among farmers on the risks they are facing from climate change and the potential measures that are available to manage the risks. In addition, it can enhance the financial emancipation of farmers and incentivize them to collaborate and empower themselves.

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