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# Smart contracts for agricultural insurance

## FinTech and Blockchains – Final project


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## Abstract

Given the high risk involved in carrying out diverse agribusiness activities, insuring against adverse weather conditions can secure and protect farmers, breeders and the like whose income is highly dependent on the outcome of such activities. This project aims at building a prototype of a platform through which the above mentioned parties on one side, and potential investors on the other, can write or decide to subsidize a customized contract or a standard one. Such contracts are an example of parametric insurance, meaning that, at the time of creation, both an index and a threshold against which this has to be evaluated are chosen; contracts are then deployed on a blockchain and, at the end of the evaluation period, payments are automatically sent out to either party according to the outcome of the contract, which is objectively evaluated. Given that weather conditions are most important for small farmers in developing countries, the platform is developed having these users in mind as the main target. As a consequence, much emphasis is placed in developing tools that can enhance their trust in a technology they may not be familiar with – so that they can fully exploit the potentiality of this platform, which can grant them protection which is both cheaper than traditional insurance contracts, and more immediate in terms of receiving payments.

## 1. Introduction

Agriculture holds a central role in the economy of developing countries. This sector is exposed to many risk factors and thus suffers from fragility and volatility, positioning itself as a constant background issue to developing economies. One of such risks is represented by weather conditions: excessive rain or drought periods can severely harm the crops, causing shocks in the economy both on a macroeconomic scale and on a microeconomic one. Due to adverse climate conditions and events, farmers can have difficulties sustaining themselves and their families, which would lead to terrible welfare conditions in agricultural-based countries, also triggering the rise in commodity prices which could damage an entire country's position in the international trade environment. Because of these reasons and the strategic importance of the agricultural sector for many countries, governments of such countries often intervene in the crop's insurance process; however, this process is often inefficient, and many frictions can arise. With this work we aim at creating a more effective and efficient crop insurance process, which would benefit both individual agents and the economy as a whole. Our goal is that of leveraging publicly available weather API services to automatically activate weather index-based insurance.

## 2. Natural Risks and Perils

Production and natural resource risks are relevant in the discussion of crop insurance since both quantity and quality losses can result from them. These risks include adverse climate conditions such as excessive rain, flood, hail, drought and many others. We decided to focus mainly on excessive precipitations since it is easier to obtain an objective measurement in this case.

Crops need water, and much of the developing world's arable and horticultural production relies on rainfall. However, at the same time, too much rain can damage crops as well. The first danger point is represented by excessive rain just after germination and emergence. Entire crops can be washed out of the ground, necessitating re-sowing. The next common point of vulnerability is at or near to harvest. Grains can sprout prematurely while still growing in the field. Various fruits can be damaged by excessive rain or even any rain just prior to harvest. Other crops can be lost when excessive rain prevents harvest. Moreover, from a purely underwriting point of view, drought, for example, poses great difficulties for a standard crop. This happens because losses are very large since drought affects a large number of growers in the same season. Secondly, drought may have an extension period of over more than one year, meaning that the actuarially calculated premiums would be very high.

## 3. Criticalities of State-of-the-Art Crop Insurance Methods and New Insurance Products

Traditional insurance methods in this sector are inefficient in different ways. In a traditional crop insurance policy, evidence of damage to the actual crop on the farm, or in the area of the farm, is needed before an indemnity can be paid out. However, verifying that such damage has occurred is expensive, and making an accurate measurement of the loss on each individual insured farm is even more costly and can also lead to disputes between the insured and the insurer. This often leads smallholder farmers to have little trust in traditional insurers due to histories of delayed or absent payouts.

Moreover, the overhead and administrative costs that big insurance companies need to incur in order to run their businesses necessarily raises premia, leading to excessively expensive insurances. An index-based policy with meteorological measurement can be used as the trigger for indemnity payments, resulting in cheaper and more efficient contracts.

## 4. Index-Based Insurance

Index based insurance is an innovative and increasingly popular approach to insurance provision. The product involves contracts where a claim is defined with reference to a predetermined index. If a certain parameter is satisfied, then the policyholder receives a predefined pay-out. Moreover, if the agricultural insurance is built on a blockchain system, the latter brings additional transparency and reliability. For example, if a certain rain threshold is hit, with weather data being provided regularly by sensors in the field, then an immediate payout is made and drafted on the smart contract. Therefore, once the smart contract is written, it cannot be changed and it will be triggered only if and when the threshold is satisfied and without manual intervention.

Index-based insurances can also overcome many other inefficiencies of the traditional crop ones. Firstly, it facilitates fair, transparent and timely payouts by removing the ambiguity around the payment of claims both in terms of whether the claim should be paid and in terms of the amount of such payment. With an index-based insurance, payments are performed automatically and instantly. This happens because the claim becomes payable as soon as the threshold is hit and because the claim amount is pre-agreed by the two parties at the time of creation of the contract.

Secondly, it reduces the claim settlement time, as there is no manual intervention involved in order to verify the claim. This also means that offering crop insurance in remote areas becomes possible and efficient because the high cost to verify the claim event is avoided. Additionally, the implementation of parametric insurance provides several benefits over traditional crop insurance by reducing moral hazard and asymmetric information.

## 5. Weather data

In order to build weather index-based insurance, we leveraged publicly available API services. In particular, we relied on Meteostat, a weather and climate database providing detailed weather data for more than five thousands weather stations worldwide. Stations report hourly measurements and usually refer to a 30-year period. Daily weather records are made available by NOAA's (National Oceanic and Atmospheric Administration) Global Historical Climatology Network and are enriched with aggregations of Meteostat's hourly data basis. Meteorological parameters like temperature, precipitation, air pressure and many others are stored in the database.

## 6. Prototype of the smart contract

To develop a prototype for our contract, we used the tester version of Web3, a Python library that contains specific functionalities for the Ethereum ecosystem and allows the user to interact with a blockchain using default accounts provided by the modules contained in Web3. We then used the Solidity compiler to write the smart contract in Solidity and make it readable for Python.

The attributes of the contract are the following:

- Location: the agent specifies a district, province or city, and then the closest weather station is identified.
- Month: since the duration of the contract is one month, the user selects the month for which he wants to insure.

- Weather Index API: in this specific case, precipitation as aggregated by Meteostat databases.
- Evaluation Period: the period over which the rainfall index is averaged, with a maximum of 30 years. As soon as the evaluation period is over, the index will be evaluated and the pay-out will be sent out automatically.
- Threshold: the benchmark we use is the average of precipitations in the evaluation period for the specific month chosen. For example, if the user wants to insure for the month of September and, at the end of that specific month, the level of precipitations is higher than the 10 year historical average for September's rainfalls for the chosen location, then the payment is sent out.

## 7. Increasing Ease of Usage

One of the main issues we believe could hamper the success of such platform consists in the potential difficulties in spreading it to farmers in developing countries. Indeed, such people are not generally familiar with technologies such as the blockchain, and this could cause such a lack of trust that they would prefer the higher costs of traditional insurance policies over something they do not completely understand.

As a direct consequence of this, one of our main focus has consisted in developing the platform in such a way so as to make it as easy as possible to understand by people having little or no knowledge of a technology such as the blockchain.

Our main goal was to develop a platform such that the user would be confident about:

(i) how it should be used;

(ii) what different parameters and variables can be set when writing one's own contract;

(iii) what will happen after the creation of such contract, and what the farmer should expect to happen in the future, once the evaluation period is over.

We did this by developing a chatbot, called Pacman, which behaves as an insurance agent, asking the right questions to farmers and finally explaining what is going to happen at the end of the contract period.

### 7.1. Pacman

Pacman has been developed with the Natural Language Understanding support provided by the Google platform DialogFlow. This allows to build “agents” that can have different intents and entities, and the flow of the conversation can be shaped thanks to follow-up intents as well as input- and output-contexts, which control when a specific intent can be triggered by a given user query.

As of now, Pacman welcomes the user and asks for a series of details mainly regarding one’s land, such as the size and location of such land, as well as the type of weather condition one would like to insure against. The process is extremely intuitive, and options – when not clear – are suggested to the user through different buttons. Throughout the conversation, all these variables are stored and, once the user confirms the creation of the contract, they are sent to the script managing the contract on the blockchain and the contract is actually deployed.

Pacman is currently active on Facebook Messenger, where users can chat with it (from the page Pacman Weather Insurance) and it can be seamlessly activated on any device supporting the Google Assistant. In developing countries, computers may not be very spread, but cellphones typically are: according to Suvankar Mishra, co-founder of eKutir, a social enterprise providing technology-enabled farming solutions to smallholders farmers: “India has 120 million farmers, out of which 30 millions use smartphones and have basic sense of understanding about digital marketplaces”.

Also because of climate change, the agricultural sector is more and more endangered and technology approaches are increasingly seen as a potential solution. For example, in India, many “agtechs” are arising: companies which use machine learning and technologies to help levigate the difficulties of this sector of the economy. Since technology solutions are spreading, and smartphone usage across farmers is increasing, by taking advantage of those trends we believe that our solution might actually work. Moreover, the possibility of deploying the chatbot also in several other platforms, such as Slack, Viber, Twitter, Skype, Amazon Alexa and many others, as well as over the phone, could potentially increase and speed up the spreading process.

## 8. Business model and economics behind our choice

We already stated that farmers would surely benefit from the choice of our application; and if we reach a large user base, the whole country they live in would be better-off thanks to this transition to a digital and automatic parametric insurance. But what are the incentives farmers would have to use our system? And how would we sustain financially? In this section we deal with those issues.

What we offer gives farmers the possibility to be more secure about their crop, as they would be with a traditional insurance, but since the technological aspect is prominent in our case, users may not be encouraged to go with this solution. In fact, farmers may not understand technology or not even trust it; for this reasons, we are aware that it might be difficult to be growing immediately, and we expect a period of loss in the very first years. But since we believe that the advantages with respect to traditional insurance methods are huge, and that technological solutions are spreading more and more even in developing countries, we think that after some years from the launch we could actually have a consistent user base.

Our sources of revenue would mainly consists in the a minimal percentage of the premia paid for insurances by farmers and in small transaction fees paid by both parties (i.e. farmers and investors) when, respectively, creating or deciding to subsidize a contract. However, especially during the first period after the launch, we envision that it would be better to avoid charging fees for such transactions, since this would necessarily raise the price for both farmers and investors and it would therefore imply slower penetration. We hence plan on initially charging zero commissions, and only add these in a future moment, once the user base has already grown.

At that moment, we also plan on adding advertising slots on our platform and on the website that will, by that time, have been launched. This would be both attractive for advertisers and would likely allow us to reduce transaction fees and therefore the overall cost of the insurance – leading to an even larger growth of the user base.

## 9. Potential problems and future improvements

As we stated all along in the paper, there is a significant need for an effective and efficient mechanism to help farmers in lower income countries, but some criticalities of our project may still arise.

Since the damage assertion done by a person would be abolished by adopting our index-based insurance, we would have to rely 100% on the sensor readings in order to quantify a field's damage. If the sensor is located a few miles away from a farm, it might happen that just by chance the spot where the sensors is located is where the raining is concentrated; this would trigger the smart contract to activate, even though no huge damages to the crop has occurred. Similarly, the opposite can happen, leading to no payment even though a farmer actually suffered a great loss. Therefore, the whole application to work effectively, we need the data provider to be reliable; but the absolute trustworthiness of the sensor cannot completely guaranteed. Moreover, bad behaviours of the agents may arise: sensors might be manipulated to fake data.

We believe that many improvements need to be done in order to refine this application. First of all, a website through which users (especially investors) can look at different contracts and choose the best one should be included. In this website we will also include a chat plugin through which users can talk with Pacman – that, in the future, will likely be able to help investors choose the contract that best suits their needs, besides helping farmers create their own contract. Secondly, another limitation of the platform as-is consists on the deployment of Pacman only in Facebook Messenger. Other platforms should be added in order to spread even more the application.

For what concerns the weather API, additional index support should be added so as to consider additional parameters beyond millimetres of rain for the activation of the smart contract. In later stages of our application, we think that an important additional improvement should consist in offering farmers the possibility to insure against other natural events rather than just excessive rains. For example, against tornadoes, periods of great heat, and so on; however, to do so we would need other data sources and this would necessarily imply additional costs; we hence believe that a good way to start is to just offer the contract to insure against excessive rainfalls, and, as we grow bigger and expand our user base, to launch additional kind of contracts, protecting farmers from other natural disasters.

Still with respect to weather data, some weather stations might not report precipitation data at a specific time, either because the sensor could be broken or because, if the record is considered suspicious, it is removed from the Meteostat database (see mail in the Appendix). That is also the reason why additional data support is needed. In fact, if more than one API was available, users would be able to choose the data source from which records should be retrieved and allow, in case data from the chosen source are not available, to retrieve the same data from a different source.

Another crucial improvement should be a direct link of the amount of the payment to one's land's size and type of crops, which would make the claim amount more proportionate to the actual damage. As of now, we assumed a fixed payment for each contract, but this would clearly benefit small farmers while likely not covering the whole damage suffered by farmers with bigger lands or cultivating more expensive crops. This needs to be revised in order to ensure each farmer gets a payment that truly reflects the suffered loss.

Lastly, also micro-contributions to contracts should be integrated: this will allow different investors to subsidize one single contract, so to lower the risk of paying too much money in the case the threshold is exceeded.

## Appendix

After having noticed that some weather station reported NaN for average precipitation in some locations, we asked Meteostat the reason why this happens. Here is the answer we received:

*"Hi,*

*Basically, both no value and NULL mean that the respective weather station did not report precipitation data at that time. However, it does not necessarily mean that the weather station has no precipitation sensor at all. It could also be broken or the record was suspicious and therefore removed from the database.*
*We will further improve the documentation and the actual data of the project in the future. I'm glad you're finding it helpful and that you're using the data in your project.*

*Best regards,*
*Christian"*

This confirms what stated above with respect to additional data sources. Since records might be missing for all of the above mentioned reasons, we cannot take for granted that, if the Meteostat APIs give a null value, then this is because no rain was recorded for the chosen period in the selected location. Since this could lead to wrong payments in both directions (i.e. payment to the farmer that should not have been paid, or vice versa, no payment what a loss occurred), additional data sources are necessary for an effective functioning of our platform.


Figure 1. An example of a conversation with Pacman through the Facebook Messenger app (please, see the GitHub repository for a demo video of Pacman in action).

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