Extended Abstract
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Paper/Poster Title	**Malian farmer typology based on characteristics and repayment performance – An unsupervised machine learning approach**

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Abstract	***200 words max***

Formal credit has an important role for the development of the agriculture sector in developing countries because many farmers are characterized as liquidity constrained. Access to credit can increase farmers' purchasing power for inputs and agricultural technology, thus raising the overall productivity. Farmers in Mali are particularly vulnerable to shocks such as climate change. Access to liquidity to increase the resilience of the agricultural sector is essential. Therefore, higher financing volumes are required, which make the analysis of loan data in agriculture of particular interest. We explore the question of who the clients of agricultural credit are and whether they can be clustered into different groups. According to our preliminary results, there are five different groups of farmers in Mali. These five groups differ significantly. Each group has different needs. Hence, different instruments are needed to strengthen the resilience of different groups of farmers in Mali. Our findings are an important prerequisite for the design of future agricultural policies and financial products for the agricultural sector.

Keywords	Machine Learning, Farmer typology, Agricultural Finance
JEL Code	Q14 Agricultural Finance Q18 Agricultural Policy

Introduction	***100 – 250 words***

Better access to formal credit, including microcredit, commercial and agricultural banks, can help rural households mitigate risks and improve the access to inputs and other technology to modernize agriculture (Khandker and Koolwal 2016). Using credit and client data from a commercial bank in Mali, we ask the questions of who the clients of agricultural credit are, whether they can be classified into different clusters, and whether the repayment performance of these groups differs.

Mali is one of the poorest countries in the world. About 80 percent of the Malian population lives from agriculture and livestock farming and generates about one third of the GDP domestic product. The most common form is rain-fed agriculture for self-sufficiency. However, the dependence on agriculture makes Mali vulnerable to the effects of climate change. We expect that different types of client clusters in the agricultural sector in Mali exist, and that also the credit repayment performance of

these clusters differs. Each group has different needs. Hence, different instruments are needed to strengthen the resilience of different groups of farmers in Mali. Accordingly, specific programmes can be tailored for each of the clusters e.g., to ensure an effective and economically rewarding production, for food security and rural development programs of smallholders and family-based farmers.

Methodology	100 – 250 words

Unique and comprehensive loan data at the farm level, which is provided by a commercial Malian bank, is used for the analysis. The final sample consists of 10,091 customers who work in the Malian agricultural sector.

We provide a depiction of Malian farmers based on the sociodemographic characteristics as well as repayment performance using clustering analysis (such as k-means and Partitioning Around Medoids (PAM)) and Elbow method to determine optimal number of clusters. Clustering is an unsurpervised machine learning technique used to group a set of objects into meaningful and useful clusters such that the objects within the cluster are similar to each other and different from objects in other clusters. The guiding principle of clustering analysis is to minimize intragroup variability and maximizing intergroup variability by some metric, e.g., distance connectivity, meanvariance, etc. (Ramasubramanian and Singh 2017). Therefore, we can describe the structure of the data, and try to find some kind of organization that simplifies the analysis. Among the clustering methods, k-means and PAM are the most popular methods. The general procedure of k-means (or PAM) is as follows: Starting with a set of randomly k initial centers, each input point is assigned to its nearest center; revise the cluster centers as an average of the assigned observations and then reassign the input point; Select the configuration that minimizes the total dissimilarity; continues until the solution does not change between two consecutive rounds (Ghatak 2017).

Results	100 – 250 words

According to our preliminary results, five different clusters of agricultural clients exist in Mali. Hence, the ML learning technique grouped the data (n=10,091) into clusters such that the clients within the cluster are similar. The clusters differ significantly in farmers characteristics (e.g., regarding the age or the geographical location of the farmer who received a credit, number of credits received), the characteristics of received credits (e.g., the loan amount and the interest rates) as well as the repayment performance (e.g., number of overdue). Hence, we cannot reject our hypothesis that different clusters of agricultural credit clients exist in Mali. Based on the results, we develop recommendations for each cluster.

Discussion and Conclusion	100 – 250 words

Several typologies for farmers already exist. However, many of those studies focus on farmers in the Global North and only on certain characteristics or certain types of farmers e.g., dairy farmers (Methorst et al., 2017), small farms (Guarín et al., 2020), or pick different regions instead of regarding a whole country (Daloğlu et al. 2014).

We provide a depiction of commercial bank clients in the agricultural sector in Mali. Thereby, we contribute to the understanding of credit clients and their needs. Different instruments are needed to strengthen the resilience of different groups of farmers in Mali. Our findings are an important prerequisite for the design of future agricultural policies and financial products for the agricultural sector to increase the overall resilience towards the climate change as well as to contribute to the reduction of poverty in Mali, in general. This research is therefore relevant for policymakers as well as the banking sector.

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