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Council for Tropical and Subtropical Agricultural Research

ATSAF - CGIAR++ Junior Scientists Program Final Report

Name of student: Sadia Khalid
University: Leibniz Centre for Agricultural Landscape Research (ZALF)
Supervisor at University: Dr. Stefan Sieber
International Agricultural Research Center: International Potato Center (CIP)
Country: Peru
Supervisor at IARC: Dr. Stef de Haan, Henry Juarez
Start and end date of stay at IARC: -
Start and end date of remotely supervised project: 04 Jan 2021 - 04 Jul 2021
Title: How did potato, quinoa and maca farming affect land use above 4000m in the moist puna region of the central high Andes?

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Final Report Junior Scientist Program

Institute:	International Potato Center
Time frame	04.01.2021 – 04.07.2021
Location:	Remotely in Berlin due to Covid; (otherwise in Lima, Peru)
Supervisors: CIP	Stef de Haan and Henry Juarez
Supervisor Zalf:	Stefan Sieber
Research Question:	How did potato, quinoa and maca farming affect land use above 4000m in the moist puna region of the central high Andes?

1. Start of Research:

Due to the Covid Situation I was not able to start my research journey in Lima and had to work remotely in my apartment in Berlin instead. Originally, we were however still hopeful that I would be able to travel to Peru at a later point in time.

In January I started the master thesis process with an extensive literature review to gain a fundamental knowledge on the upward shift of agriculture in the Andes. Therefore, I read a lot of literature about climate change and its implications for the ecosystem in mountainous regions. Gaining deep knowledge on effects of climate change in the Andes was very interesting and frightening at the same time. I did not know how sensitive the Andes are to climate change nor about the extent of greenhouse gas emissions that are currently caused by land use change at high altitudes. In fact, carbon emissions from unsustainable land use in the high Andes is equivalent to the ones derived from deforestation of the Amazonas. My research motivated me even more for my thesis topic as understanding the issue of the upward shift of agriculture is a first step in finding eventually solutions for the reduction of GHG emissions in the Andes.

Aside from literature on climate change I read a lot about the agricultural sector in Peru and in the Peruvian Andes. Potato, quinoa and Maca play a very important part in Andean agriculture, and it was very exciting to research these crops in depth. In particular, I enjoyed learning more about quinoa and maca since I had not known a lot about these crops prior to my master thesis. Lastly, I reviewed a lot of literature about the theory of land use in order to create a fitting conceptual framework. Consultation with my supervisor Stefan Sieber has been key in this process as he supported me in finding a good model to analyze the upwards shift of agricultural practices. I chose the DPSIR framework of the European Environmental Agency, as it is a useful tool to display the relationships and the interconnectivity of the roots and consequences of environmental problems.

Overall, I found the part of literature review very interesting and challenging at the same time. The issue of the upward movement of agriculture is very complex. In order to understand papers on climate change and its effects on the Andes, I had to improve my knowledge in climatology, ecophysiology, soil science and pests and diseases. In February I continued my literature analysis but felt confident enough with the topic to talk to my supervisors in Peru to discuss the empirical analysis that I was supposed to conduct for the CIP.

2. Empirical Analysis:

2.1. Data

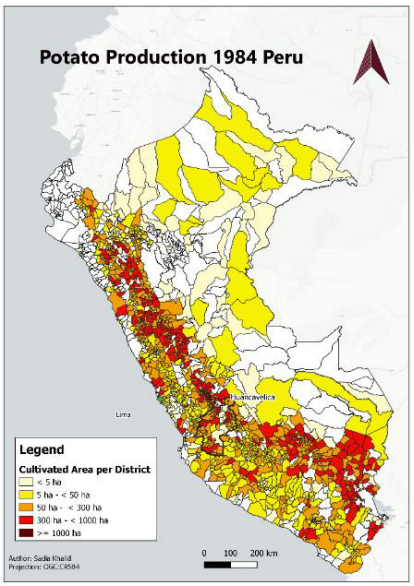
Stef de Haan, Henry Juarez and I met in two virtual meetings in February in which we decided on the data that I was going to analyze. I was provided with data from the Cenagro the Agricultural Census of Peru (*dataset 1*) about the general agricultural expansion of potato, quinoa and maca. Moreover, the CIP gave me access to a participatory GIS (PGIS) study that compared the cultivation and location of farming practices in Huancavelica in 2013 and 2017 (*dataset 2*) and another PGIS study from Huancavelica conducted in 2005 (*dataset 3a*). *Dataset 1* shows the total area cultivated in a district for potato, quinoa and maca in 1993 and 2012. In *dataset 2*, 179 families in three communities in Huancavelica, cultivating mainly potato, have been interviewed on their agricultural practices and their location. *Dataset 3a.* is similar to *dataset 2*. It shows information on 196 families in eight communities in Huancavelica Peru but contains not only information about potato, but also on quinoa and maca farming. The following two weeks I spent on understanding the data that was given to me. The datasets are quite complex, and it was challenging to understand all data points, since I was not present when the data was collected and processed nor ever visited the area where the data had been collected from the farmers. Moreover, datasets we protocolled in Spanish so I had to research various very technical expressions to fully understand the data.

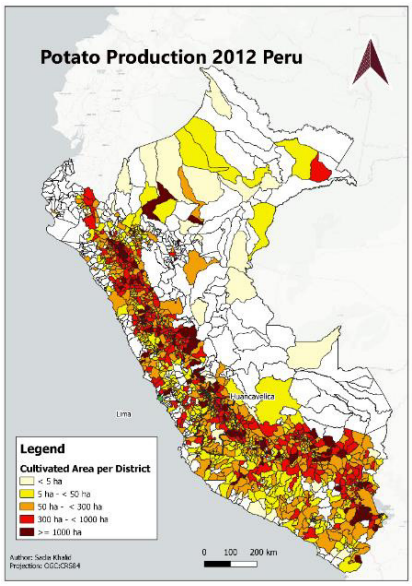
After a careful analysis of the data, I came the conclusion that it would be quite difficult to analyze an upward shift of agricultural practices in the Andes with only the data I had been provided with. *Dataset 1* only shows the agricultural expansion in districts. However, even within districts altitudes vary significantly and drawing any conclusion from this on the upward shift would be difficult. *Dataset 2* gives precise information on the altitude where farmers grow their crops, however it does only cover a time frame of 4 years and focuses only on potato cultivation. *Dataset 3a* gives the most precise information. It shows data on altitudes, fallowing periods, all the relevant crop varieties (potato, quinoa and maca). However, there was no data it was comparable to as the study has only been conducted once in 2005.

I discussed this dilemma with my supervisors in Peru and we decided on repeating the study of 2005 (dataset 3b). However, this plan stood on very shaky feet, as we did not know whether it was feasible to conduct a participatory GIS in eight communities due to Covid. This study required a massive workload, hiring external consultants that travel to the communities, interview 195 families and ask them to draw their place of cultivation on printed Maps. Therefore, we had to come up with a plan B in case the PGIS study was not feasible. We settled on the analysis of land cover data (*dataset 4*) in Huancavelica via remote sensing methods and the GIS software as a plan B.

2.2. Analysis:

I started my deep analysis with *dataset 1* with Excel and GIS software. The final products are different maps sets and graphs for the three different crops potato, quinoa and maca. They show interesting results: Potato cultivation increased between 1984 and 2012 by 66% from 221064 ha to 367648 ha. The area of quinoa cultivation increased by 48% from 16167.88 ha to 23876.5 ha. Maca showed the biggest expansion by an increase in 360% rising from 320.26 ha to 1473.1 ha. To better understand these maps, I show below the two maps that illustrate agricultural expansion of potato cultivation:





This analysis helped me to enhance my skills working with geographic information systems and excel. I proceeded my analysis by examining *dataset 2*. Surprisingly data from this short period already showed patterns that indicated an upward shift. In facts the share of total cultivation has increased at altitudes between 4200 – 4300 by 5.5 percent which could indicate an upward shift of agricultural practices. However, only an analysis of a longer time period would validate these findings. By the time I finished the analysis of dataset 2, which was in

March, we still did not have green light for the participatory GIS study that would then complement the dataset 3a. Therefore, I proceeded with the analysis of land cover change.

This analysis was challenging for me as I have never worked with remote sensing methods before. However, I enjoyed it a lot to learn a new method. The first challenge in this process was to find satellite data that showed images from a maximum distance of 300m. After I found the fitting data, I imported it as a raster into my GIS software and started the remote sensing process. Furthermore, I included contour lines to be able to analyze developments above 4000 m. Afterwards I imported the data into R and calculated a land-use change matrix which showed for example how much percentage of grassland was conversed into agricultural land for herbaceous crops. This task helped me to enhance my QGIS as well as R skills. I finished my land cover change analysis by the beginning of May.

By the beginning of May we received the good news that the participatory GIS study was permitted and that we could start with the data collection process. We decided to include this new PGIS study *(dataset 3b)* in my thesis, even though I had already analyzed the land cover change, as this new data would give much better information on the upward shift of agricultural practices. The preparations of questions for the farmers were done quickly, as the questions from 2005 only would be repeated. In addition, we listed new questions asking about effects of the covid situation. Afterwards, Stef de Haan, Henry Juarez and external consultants traveled to Huancavelica and started the interviews with the famers. They reported that the covid situation complicated the study immensely and prolonged the process. Communication with the farming communities was much more difficult due to the covid situation and the interview process took a lot more time in order to ensure that hygiene concepts were in place. In total, it took three months to gather all the information and I think that overcoming all these obstacles and conducting this study is a great achievement. In the picture to the right you can see how the farmers indicate the location of their agricultural practices. After the interviews were finished in July, all these big maps needed to be digitalized, which is done by an external consultant. I will receive the digitized data by august 20th and then continue to analyze them. As a result, my submission of the thesis will be delayed by a month which I already talked about with my supervisor from my university. I decided to wait for the data as

it improves the validity of my empirical analysis significantly and increases the chances for a publication tremendously.

3. Resumé

Participating in the junior scientist program was a great experience. I enjoyed that I had the time and resources to really focus on my research for a half a year. Furthermore, I profited immensely from the expertise of the scientists working at the CIP. My supervisor supported me if I had questions in respect to my topic and connected me to the Andean Initiative, which is a regional innovation platform aiming to facilitate collaborative science for co-innovation with an emphasis on gender, indigenous people, youth, big data and digital solutions in the Andes. In April I was given the opportunity by my supervisors to present my thesis during the bi-weekly video conferences of the Andean Initiative. In these conferences, scientists present their current research topics. This was a great chance for me to practice my presentation skills and receive valuable feedback from experts. I was nervous before presenting my results, but all scientists were really friendly and created a safe space where I felt really comfortable to answer and ask questions. Moreover, during the junior scientist program, I learned a lot about the process of data collection. Prior to my thesis, I had only analyzed already existing data but through my experience at the CIP, I had the opportunity to experience first-hand how data is collected and processed. I learned how many resources a thorough data collection required and appreciate the scientists that pour their efforts into it even more now.

Aside from all highlights, the Covid Situation put also obstacles in the way. However, overcoming these has taught me a lot. A major difficulty for me was that I was not able to travel to Peru. I could only get an impression of Andean Agriculture via the literature. During meetings with my Peruvian supervisors, I realized however that I misinterpreted information or was simply not aware of special regional circumstances. If I had worked in Peru, I would have observed much more, for example by participating in the data collection and travel to the Andean communities. However, I believe that we managed to make the best out of this situation by enhancing communication with my supervisors and more literature research.

In a nutshell, participating in the Junior Scientist Program was a great opportunity to get an insight into the working field of science. I would like to thank the ATSAF for this great opportunity to participate. Otherwise, I would not have had the resources to work for such a long time on a specific research topic. This has been a very beneficial experience for me and I would highly recommend it to other students that want to get an insight into the work of an established and renowned research center.