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# Remoteness as an inhibitor or a promotor for cocoa farm-level socioeconomic and environmental sustainability in Ecuador


Auteur·es : Joséphine Piette

Promoteur·rices : Prof. Éric Lambin, Lina Tennhardt

Lecteur·rices : Prof. Veerle Vanacker


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CATHOLIC UNIVERSITY OF LOUVAIN-LA-NEUVE

Faculty of Science - School of Geography

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***Author:***

Joséphine Piette

***Supervisors:***

Prof. Éric Lambin

Lina Tennhardt

***Reader:***

Prof. Veerle Vanacker


*Master [120] in Geographical Sciences, general orientation, in-depth finality*

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# Abstract

In a context where the cocoa sector is facing challenges in terms of socio-economic and environmental sustainability, many factors can influence the adoption of sustainable farming practices (SFP). Among these factors, remoteness is still little studied in this specific context. Therefore, this study aims to assess the influence of remoteness on the sustainability of cocoa farms in the northwestern part of Ecuador. In this region, a series of farms are required to sell their products to specific intermediaries in town in order to guarantee their participation in a sustainability program. However, their distance from this intermediary could have an impact on their level of socioeconomic and environmental sustainability, and this is what this study seeks to define. Firstly, a literature review defines the concept of remoteness and explores the links, highlighted in previous studies, between remoteness and socioeconomic sustainability indicators. The assessment of remoteness is then based on calculations of distance, weighted distance, travel time and weighted travel time. A Spearman correlation analysis is used to establish links between sustainability variables and remoteness. In addition, multivariate regression models are applied to measure the relationship between groups of predictors and SFPs. The objective is to show the influence of slope-weighted distance (representing here remoteness) on the adoption of these practices. The results of this study do not show strong relationships. However, they do shed light on influences at the level of certain sub-samples. Indeed, it was shown that some socioeconomic variables could be negatively impacted by remoteness in some groups of farms. On the other hand, remoteness may positively influenced some environmental sustainability variables. Weighted distance has not been demonstrated to have an impact on the adoption of SFPs.

# Contents

# Chapter 1

# Introduction

For the past few decades, the need to improve food security while reducing the environmental impacts of the current agricultural system has been the focus of attention (Foguesatto, Borges, and Machado 2020). And this also concerns the cultivation of cocoa which is now facing two phenomena : on the one hand, an increase in demand for mass markets and, on the other hand a shift towards a more specialised market offering high quality products with a particular focus on the origin and quality of the beans (Rueda et al. 2018). In this context, more and more companies at the end of the chocolate production chain are committed to improving cocoa production in terms of sustainability (Tennhardt et al. 2022).

Regarding sustainability, the cocoa sector faces several challenges in terms of human rights and, living income of cocoa producers and farm workers and environmental protection (Fountain and Huetz-Adams 2020). Progressively, by acting on the mechanisms of the supply chain, the actors of the sector have tried to improve sustainability at the level of the producing farms, notably by introducing voluntary sustainability certifications or via own schemes (Tennhardt et al. 2022). In many tropical countries, the development of the cocoa sector can achieve certain social and economic objectives, but this implies a compromise with environmental objectives (Mithöfer et al. 2017). Sustainable farming practices (SFP) that include all three dimensions of sustainability (i.e. the environmental, social, and economic dimensions) have a key role to play in meeting this challenges (Foguesatto, Borges, and Machado 2020).

Many factors (endogenous or exogenous) can influence the sustainability of cocoa farms and the implementation of SFP. Several studies have demonstrated the importance of spatial factors like farms' distance to markets, infrastructure, and social services (Foguesatto, Borges, and Machado 2020). However these remain less widely studied in the literature. Among these spatial factors, remoteness, which may refer to physical isolation (distance) (Bocco 2016) and disconnection to certain opportunities and/or markets (Zimmerer et al. 2017, Alasia 2017, Panagiotopoulos and Kaliampakos 2018), could influence farm sustainability (UNCTAD 2021).

In this study, the link between sustainability and remoteness is explored with the aim of complementing the vast literature on the factors influencing sustainability and adoption of SFP (Foguesatto, Borges, and Machado 2020). Indeed, a better understanding of these complex relationships may help to improve certain production systems and thus respond to the demand for a more sustainable cocoa market (Rueda et al. 2018) and, more broadly, to some of the challenges of global agricultural systems, moving towards greater resilience (Zeweld et al. 2017).

The study focuses on Ecuador, a country known worldwide for its high-quality cocoa. It uses a data set of 190 farmers in northwestern Ecuador that form part of a corporate sustainability program (Tennhardt et al. 2022). Program farmers have to sell their produce to specific program intermediaries in the city which are partly located far away from their farms (Tennhardt et al. 2022). The objective is to assess the relationship between their remoteness and their level of sustainability by answering to the following question :

"*Is remoteness a promotor or an inhibitor for cocoa farm-level socioeconomic and environmental sustainability ?*"

To answer this question, the remoteness of each farm will first be evaluated by calculating four distinct indicators: distance, distance weighted by slope, travel time and travel time weighted by slope. Then, the relationship between remoteness and sustainability will be assessed in two ways: via simple linear correlations, then, via multivariate regression models allowing the inclusion of control variables.

The following chapter aims to review the literature on cocoa, remoteness, sustainable agricultural practices and the link between these elements. The hypotheses are also stated in this chapter. Afterwards, the methodology to answer the question posed is described. Then, the results are presented and interpreted. Finally, before concluding, the limitations of the study are discussed.

## 1.1 Study Framework

This thesis is part of a larger research project the Research institute of organic agriculture (FiBL) whose overall objective is to assess the different factors related to the implementation of sustainable agricultural practices while looking at the socio-economic co-benefits of environmentally friendly agriculture. The study is conducted on two samples of cocoa farms, located in Ecuador and Uganda, which supply two Swiss chocolate companies. The sampled farms are certified or are part of a sustainability program. Most of the data used in this thesis are therefore derived from this research.

# Chapter 2

# Literature review

The literature review is divided into several sections. The first section deals with cocoa production in a broader way, in order to have an overview of it in terms of importance on world and regional markets, value chain, or geographical distribution. Then, cocoa production is detailed in relation to the studied country, the Ecuador. The second section aims to define the main concepts mobilized in this work: remoteness and sustainability. The concept of remoteness is first broadly defined with regard to the literature before being redefined more precisely in order to correspond to the precise context of this study. Then, the links that may exist between remoteness and sustainability are described and the literature on similar topics is summarized to have a look on what has already been done and what are the gaps to be filled. Finally, the last section aims to expose the hypotheses driving this study.

## 2.1 Cocoa culture

Cocoa, by its scientific name, *Theobroma cacao* (Delgado-Ospina et al. 2021), is a product grown mainly by hand, with little mechanization (Voora, Bermúdez, and Larrea 2019). It is originally produced in Latin America, although it is now grown in most tropical regions and mainly in Africa (Delgado-Ospina et al. 2021) ). In 2019-2020, the countries producing the most cocoa was Ivory Coast, Ghana, Indonesia, Nigeria, Ecuador, Cameroon and Brazil (Delgado-Ospina et al. 2021). It is a commodity traded all around the world (Tennhardt et al. 2022) and Latin America produces about 18 percent of the cocoa in the world (Decker 2017). According to the International cocoa organisation (ICCO), 4735 thousand tons of cocoa were produced in the world for the period 2019-2020, the estimates for the year 2020-2021 reach 5226, while the forecast for the current year is around 4955 thousand tons (ICCO 2022a). Productions of cocoa beans by regions are listed in the figure 2.1 (ICCO 2022a). The demand for this commodity is constantly increasing (Tennhardt et al. 2022) and it is expected that the cocoa sector will continue to grow following an increase in the popularity of the product but also its wide use in the food sector (Voora, Bermúdez, and Larrea 2019).

| | 2019/20 | | Estimates 2020/21 | | Forecasts 2021/22 | |
|---|---|---|---|---|---|---|
| **Africa** | **3549** | **74.9%** | **4044** | **77.4%** | **3752** | **75.7%** |
| Cameroon | 280 | | 290 | | 280 | |
| Côte d'Ivoire | 2105 | | 2248 | | 2200 | |
| Ghana | 771 | | 1047 | | 822 | |
| Nigeria | 250 | | 290 | | 280 | |
| Others | 143 | | 169 | | 170 | |
| | | | | | | |
| **Americas** | **903** | **19.1%** | **930** | **17.8%** | **939** | **19.0%** |
| Brazil | 201 | | 200 | | 210 | |
| Ecuador | 342 | | 365 | | 370 | |
| Others | 360 | | 364 | | 359 | |
| | | | | | | |
| **Asia & Oceania** | **283** | **6.0%** | **253** | **4.8%** | **264** | **5.3%** |
| Indonesia | 200 | | 170 | | 180 | |
| Papua New Guinea | 41 | | 42 | | 42 | |
| Others | 42 | | 41 | | 42 | |
| | | | | | | |
| **World total** | **4735** | **100.0%** | **5226** | **100.0%** | **4955** | **100.0%** |

Figure 2.1: Productions of cocoa beans by region in thousand tonnes (ICCO 2022a).

Cocoa production is mainly ensured by small farms (Delgado-Ospina et al. 2021) and it is an important source of income mainly in so-called "developing" countries (Voora, Bermúdez, and Larrea 2019). Unfortunately, this sector is linked to many environmental, economic but also social issues, such as poverty, child labor or deforestation (Tennhardt et al. 2022).

First transformed into liquor and then into butter or powder, cocoa is then used to produce a variety of foodstuffs such as chocolate, or non-foods, such as cosmetics (Voora, Bermúdez, and Larrea 2019). In 2017, the chocolate industry consumed 43 percent of the world's cocoa production (Voora, Bermúdez, and Larrea 2019). This cocoa processing sector is determined by a specific global value chain which can be simplified into 5 main steps as represented on the figure 2.2 (Gayi and Tsowou 2017). This study focuses mainly on the first two stages of this chain. And more particularly to the link between these two stages. This is why these will be described more deeply.

To produce the cocoa beans they will send, cocoa farmers follow different steps on their farm. First, the growing part : of cocoa trees are grown on small plots of land and mostly they are planted in the shade of other tree species like banana, palm trees or plantains (Gayi and Tsowou 2017). The trees are bearing pods from about their fifth year and they are most productive for 25 to 30 years (Gayi and Tsowou 2017). After growing, the cocoa pods are

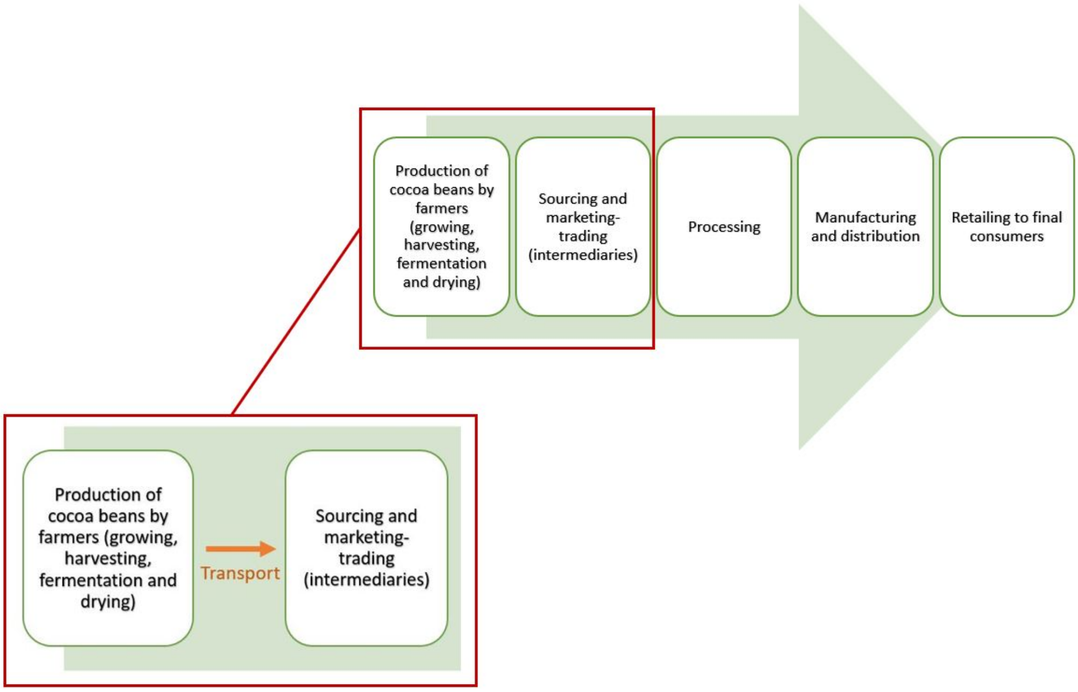


Figure 2.2: Global value chain of chocolate production with particular interest in the two first stages (Gayi and Tsowou 2017).

harvested manually and opened to extract the wet beans (ICCO 2022b). Generally, cocoa trees flourish and produce beans two times a year (Gayi and Tsowou 2017). After harvesting, some farmers take care of the fermentation and the drying of the cocoa beans, others sell their cocoa fresh without fermentation and drying for lower prices (ICCO 2022b).

Then, cocoa beans are ready to be sold. Between cocoa farmers and exporters, the cocoa marketing channel can vary substantially depending on the country or even the region (ICCO 2022b). In some regions, cocoa is sold from farmers through several intermediaries to exporting companies. In other supply chains, farmers or cooperatives sell their cocoa directly to exporters (ICCO 2022b and Gayi and Tsowou 2017).

### 2.1.1 Cocoa cultivation in Ecuador

Just as other tropical countries, Ecuador is highly dependent on cocoa production. With a wide spread of crops over the coastal region, cocoa was historically the country's main export. In Ecuador, most cocoa is exported for the manufacture of chocolate (Pérez Neira 2016). Taking into account the territory, the economy and employment, cocoa is one of the main crops. It occupies no less than 12% of cultivated land and employs about 4% of the active population of Ecuador (Pérez Neira 2016). On the territory, cocoa crops represent 525,435 ha (FAO 2022) and the average production is 0.540 t/ha (FAO 2022)). Also, the national GDP is increased by 0.56 percent by the cocoa value chain, which represents 496.63 million dollars Pérez Neira 2016. For Ecuadorian rural communities, cocoa is a good lever to reduce situations of poverty (Blare 2013). Among sampled farms for this research, the income from cocoa production has a median value of 1295 USD/year. In 2018, the amount received by a producer per kilo of dry cocoa produced was 1.91 USD and 0.76 USD/kg of fresh cocoa (Tennhardt et al. 2022). While in 2020, the average price of a kilo of cocoa on the world market was 2.37 USD/kg (ICCO 2022a).

In Ecuador, two varieties of cocoa coexist and they are highly different in terms of taste, productivity, susceptibility regarding diseases, etc. : *Nacional* and *CCN-51*. The first is mainly produced in agroforestry while the second is mainly produced in a monoculture system with the objective of greater profitability due to increased resistance. Obviously, the variety making Ecuador famous for its high quality is *Nacional* cocoa (Blare 2013). Indeed, according to the FAO, Ecuador was the fifth largest cocoa producer in the world in 2020 (FAO 2022) and it is the first producer of fine flavour cocoa, with its own variety : *Nacional*, it accounts for 70 percent of the world's fine flavour cocoa production (Anecacao 2022), making it the global leader in this market.

Regarding the specific value chain used as a case study in this research, most of the Ecuadorian farmers sell their cocoa production to middlemen situated in close towns. Then, the production is sold to an export company (large multinational trader) which finally exports it to chocolate companies (Tennhardt et al. 2022).

## 2.2 Remoteness and sustainability

### 2.2.1 Definitions of remoteness in the literature

The concept of remoteness is a complex idea which can be highly pertinent in geographic studies. A remote place could be defined as a place which is isolated, distant or placed apart, existing far a way in space (Bocco 2016). According to Bocco, remoteness has two dimensions, an absolute and a relative one. Absolute remoteness refers to geometric and geographic distances while relative remoteness refers to connectivity and scale rather than distance. These two components are complementary and permit to understand the differences between a remote space and a remote place (Bocco 2016). Three important aspects of a region can be affected by remoteness : the environment, the economic development and the local communities and culture. These impacts can be either positive or negative (Panagiotopoulos and Kaliampakos 2018).

Additionally, it is impossible to talk about remoteness without mentioning accessibility. In the literature, these two concepts often appears to be linked, and most of the time they are used as antonymous. However, remoteness is more likely used in broader contexts, identifying physical isolation. While accessibility is often used in social studies assessing availability of services mainly at personal level. Thus, considering the fact that remoteness is the opposite concept of accessibility it can be define as *«the geographical inaccessibility to certain location»* (Panagiotopoulos and Kaliampakos 2018).

The research domains in which these concepts are used are various, including geography, economics, transportation, health or social studies. For that reason, there is no predominantly accepted definition in the literature and this results in diverse methodological and conceptual approaches (Alasia 2017).

Nevertheless, geography is the discipline at the core of remoteness literature. Spatial analysis is a common approach in accessibility and remoteness research. From this point of view, geography emphasis remoteness as *«physical isolation and distance from agglomerations»* (Alasia 2017). Another geographic definition for remoteness is proposed by Zimmerer *et al.*, who characterized remoteness as a *«low degree of connectedness to powerful national and global territories and sites»* (Zimmerer et al. 2017).

In transportation planning, accessibility can be seen as how easy a coveted destination may be reached. However, this definition can be rephrase to include relevant factors like time dependency which may be an important parameter to assess accessibility for public transport (Taylor and Susilawati 2012). Accessibility can also include the aspect of freedom. Indeed, it could quantify the individual's freedom to take part into some activities in the environment (Taylor and Susilawati 2012). However, all of these aspects do not take into account the road network on which rural or more remote areas rely on. So according to Taylor and Susilawati, accessibility can be redefined as *«the ease with which services and facilities can be reached while using the road network »* (Taylor and Susilawati 2012). Considering the fact that regional road network and population in rural areas are more likely to be dispersed, it may be relevant to use the inverse of accessibility. Then, remoteness can be described by *«the difficulty in accessing services and facilities while using the road network »* (Taylor and Susilawati 2012).

Also, in economics, remoteness is a central issue for socioeconomic outcomes, high transaction costs (for example when a product is transported to major market centres) with the idea that the level of isolation can be improved through public interventions like the provision of public goods and/or infrastructure development (Alasia 2017).

Finally, even if the concept of remoteness has numerous definition in the literature, it is obvious that distance takes a central place to most people's understanding (Glover and Tennant 2003). In this study, remoteness is seen as the inverse accessibility, but a precise definition should be constructed on the basis of what is found in the literature. The elaborated definition of remoteness fitting with this study frame work is the subject of the next section.

### 2.2.2 Definition of remoteness for this study frame work

As observed in the literature, the concept of remoteness is coated with different nuances depending on the discipline or the context of study. Often linked to the concept of accessibility, which appears to be its opposite, it is not, however, uniquely defined.

The first objective of this study is to quantify the remoteness between cocoa-producing farms regarding their distance to the intermediaries to whom they sell their produce. It is therefore a measure of distance between two defined entities and not a form of disconnection at certain services or poles as described by Taylor or Zimmerer (Taylor and Susilawati 2012, Zimmerer et al. 2017). But, it could be seen as the disconnection to a specific economic opportunity which are the intermediaries. However, the distance between farms and intermediaries appears as a central element. Indeed, for this study, the absolute dimension of remoteness, as described by Bocco (Bocco 2016), takes on more importance than the relative dimension. Therefore, the geometric measurement of distance can be weighted by the ease or difficulty of reaching the service considered, in particular by involving the topography.

Finally, in the context of this study, the concept of remoteness can be defined as the ease or difficulty with which a certain distance is travelled using the road network. Which refers to a certain degree of physical isolation.

### 2.2.3 Sustainability and Sustainable Farming Practices (SFP)

The concept of sustainable agriculture is define as an agricultural system that meets the needs of the present without compromising the needs of future generations in all three dimensions: social, economic and environmental (Whinney 2022).

The five attributes of sustainable practices are: conservation of resources, environmentally non-degrading, technically appropriate, socially acceptable and, economically viable. (Foguesatto, Borges, and Machado 2020).

In the cocoa sector, sustainable practices, can be agronomic, environmental and socioeconomic. Through programs, farmers get access to inputs and trainings with the aim to increase yields. (Tennhardt et al. 2022). SFPs, such as agroforestry systems, can improve productivity, enhance economic growth and food security, improve fertility, reduce the use of harmful inputs, or increase system resilience. They encompass all agricultural activities with economic, societal and environmental dimensions (Zeweld et al. 2017).

Regarding sustainability, the cocoa sector faces several challenges in terms of human rights (poverty, malnutrition, child labour, human trafficking, labour rights, safe working conditions, lack of education and healthcare), living income (low farm, gate prices, low yields, high risks) and environmental protection (deforestation, degradation, loss of biodiversity, high use of agrochemicals, climate change) (Fountain and Huetz-Adams 2020).

### 2.2.4 Link between remoteness and sustainability

In the latest report published by the United Nations Conference on Trade and Development (UNCTAD) on the Sustainable Development Goals (SDGs) the link between remoteness and sustainability is explored in a broad way (UNCTAD 2021). According to the report, remoteness can impact on sustainable development in all its aspects (UNCTAD 2021). It can be linked to vulnerability but sometimes, remoteness can induce more resilience and preserve certain ecosystems (UNCTAD 2021). From an economic point of view, remoteness, which can mean a higher distance to markets, leads to high costs to connect to value chains (UNCTAD 2021).

At farm level, the link between remoteness and sustainability has not been explored much so far. However, a number of studies looking at factors that may influence the adoption of sustainable agricultural practices, have incorporated spatial factors. In the literature, the factors that influences (or whose influence is studied) the adoption of sustainable agricultural practices are varied and can be both extrinsic and intrinsic (Meijer et al. 2015) including farm factors, farmer factors, social factors, factors related to the value chain, economic characteristics. (Mozzato et al. 2018, Lynch and Lovell 2003, Foguesatto, Borges, and Machado 2020, Tennhardt et al. 2022). Only several studies focus on geographical characteristics, including distance (to market, to the centre of the district, between farm plot and home, to urban center, to main roads, etc.) (Foguesatto, Borges, and Machado 2020, Mozzato et al. 2018).

In general, studies show that proximity to urban centers, roads or local markets has a positive effect on the adoption of practices (Mozzato et al. 2018, Kassie, Teklewold, et al. 2015, Démurger and Pelletier 2015), although in some cases the opposite is observed (Gibreel 2013).

**Remoteness and socioeconomic sustainability**

Remoteness can have different impacts at the socioeconomic level. First, it limits employment and the possibility of alternative income (Belcher, Achdiawan, and Dewi 2015). Distance from markets and sources of supply can be negatively related to per capita income (Redding and Venables n.d.). In particular, the high price of imported goods and equipment in remote areas can cause wages to fall (Redding and Venables n.d.). Remote populations have to travel long and costly distances to sell or trade their products, causing losses and making them vulnerable to low offers or uncertain prices (Belcher, Achdiawan, and Dewi 2015). Besides, in a study of Nigerian farms, Fonta et al. found a negative relationship between distance to market and cocoa net revenue per hectare (Fonta, Ichoku, and Urama 2011).

Another possible consequence of remoteness for the populations concerned is a form of neglect on their part by the government. Lack of education, health care services, training in agricultural techniques, and other services are to be deplored for these populations (Belcher, Achdiawan, and Dewi 2015). More precisely, remoteness can have an impact on education. Schools in isolated locations, often in rural areas, have lower resources to meet the needs of dispersed populations and tend to offer a lower quality of education (Mangione and Cannella 2021).

Other studies show that distance to market can impact on a farm household's costs of accessing information, support organisations (e.g. to obtain credit), information and technology (Kassie, Jaleta, et al. 2013 and Kassie, Teklewold, et al. 2015). Also, the amount of labor and capital intensity can be increased due to distance by increasing the price ratios of output to inputs (Kassie, Teklewold, et al. 2015).

#### Remoteness and environmental sustainability

Remoteness also plays a role from an environmental point of view. For example, forests located close to the market might be more likely to be converted to agricultural land or urban areas than forests located far away, which would be more likely to be preserved (Belcher, Achdiawan, and Dewi 2015).

In a study conducted by Gibreel on the effect of distance to market on the adoption of agroforestry in gum arabic cultivation, significant results show that farmers far from the market are more likely to practice agroforestry. According to this study, this is because this crop is the only source of income for remote populations who cannot participate in the market and benefit from non-agricultural opportunities (Gibreel 2013).

Also, a high cost to reach markets offering inputs and outputs leads the inhabitants of these remote areas to turn to less intensive mixed subsistence systems (Belcher, Achdiawan, and Dewi 2015).

## 2.3 Hypotheses

The previous section provided indication of the relationships between remoteness and sustainability. Past studies have shown that spatial factors, often approached by the distance to the market, influence specific socioeconomic or environmental characteristics of farms either positively or negatively, highly depending on the practice and the context. The trend observed is that, in most cases, remoteness has a negative impact on socioeconomic variables and a positive impact on environmental variables. As for the adoption of sustainable practices, remoteness most often has a negative impact, notably due to the difficult access to the necessary technologies and information. Based on these observations, three main hypotheses can be tested.

1. Remoteness is an inhibitor for farm-level socioeconomic sustainability
2. Remoteness is a promotor for farm-level environmental sustainability
3. Remoteness is an inhibitor for sustainable farming practices adoption

Hypotheses 2 and 3 may seem contradictory because although remoteness seems to have a positive effect on the environment, several studies on the adoption of SFPs show that remoteness would rather be a brake on the implementation of such practices.

# Chapter 3

# Data and Methodology

This study examines the effect of remoteness on the sustainability level of cocoa farms in four Ecuadorian provinces (Manabí, Esmeraldas, Los Río, and Cotopaxi). Two main objectives are pursued:

1. To assess the level of remoteness to intermediaries for each farm

2. To shed light on the relation between remoteness and sustainability at farm level

To do that, several methodological steps are followed. All of the calculations and analysis as well as some graphs and figures are made using the R software.

## 3.1 Study area

The study area is located in the northwestern part of Ecuador and includes 4 provinces: Manabí, Esmeraldas, Los Río and Cotopaxi. The area was defined by Tennhardt et al. 2022 and the choice fell on this region in order to limit regional differences within the sample due to a wide distribution of cocoa producers in the country even if the majority of land used for cocoa cultivation is located within this coastal region (INEC 2020). Eight suppliers groups had been selected within the four provinces : one in Cotopaxi, one in Los Rios, two in Esmeraldas and four in Manabí. Then, between 20 and 24 farmers per group were subsampled randomly. The eight groups of sampled farms are represented on the map above (Map 3.1).

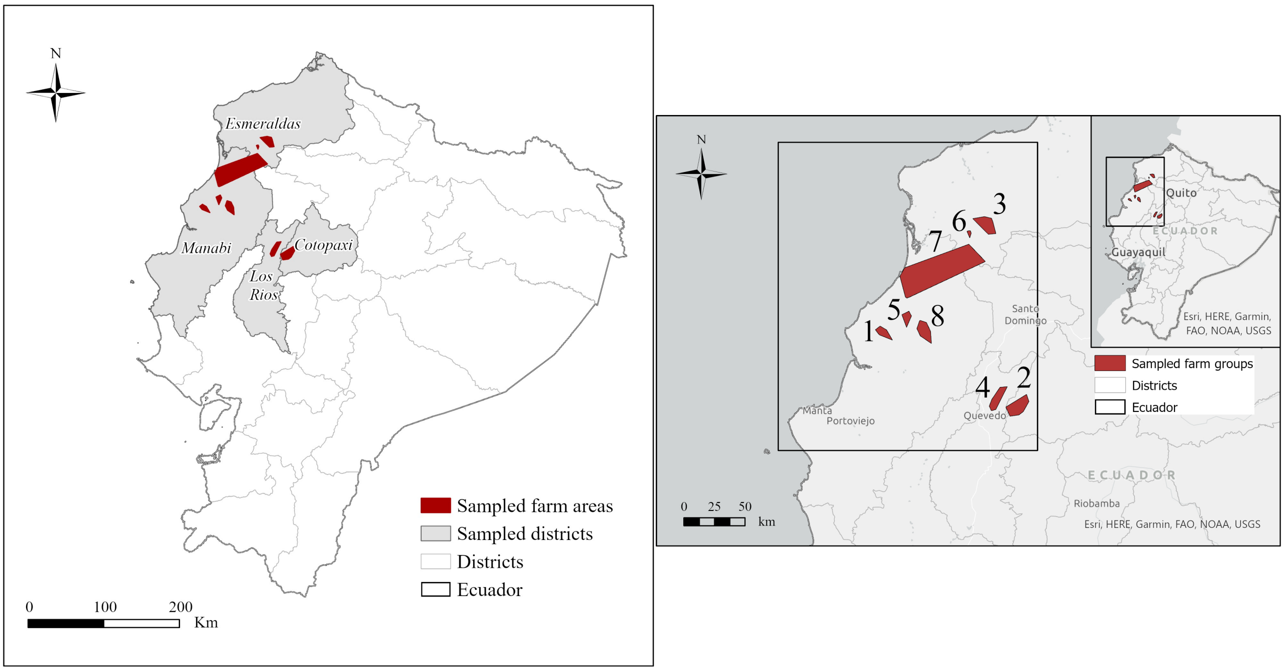


Figure 3.1: Map of the study area and localisation of the sampled farm groups (Ecuador shown here without Galapagos islands).

## 3.2 Materials

### 3.2.1 Spatial data

For this study, the required spatial data were : the intermediaries (middlemen to whom farmers sell their production) and farms coordinates, the road network and the elevation of the region.

The geographical coordinates of the 189 farms and the eight middlemen were provided by Tennhardt et al. 2022. The complete road network (displayed on the Map 3.2) has been derived from Open Street Map (OSM) and downloaded from Humanitarian Data Exchange (HDX) website (Exchange 2022). OSM is an open source and collaborative mapping project which provide quite complete data sets. In this case all of the features came with interesting attributes (stored in the attribute table). But only highway is really usefull for this study. Indeed, the highway key of OSM data is used to identify the different kinds of roads, streets and paths. The following table shows the different values and the descriptions of this attribute (Table 3.1) (Wiki 2022).

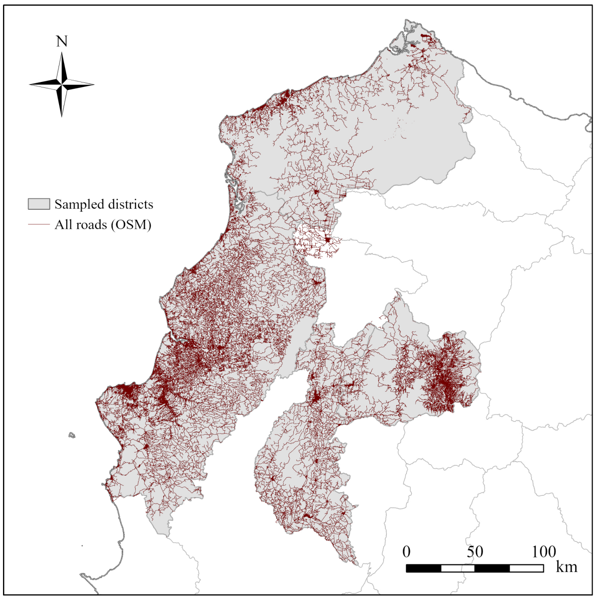


Figure 3.2: Road network of the 4 interesting provinces; all road types combined (data from Open Street Map).

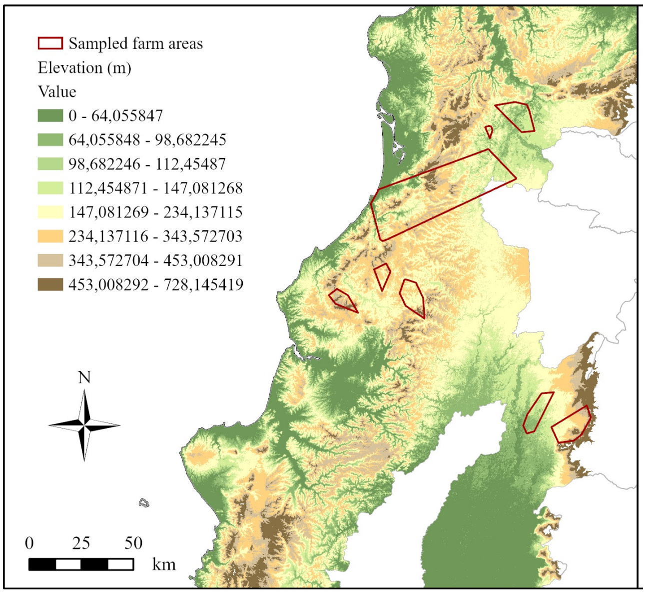


Figure 3.3: Elevation of the study area (DEM).

| **Highway** | |
|---|---|
| **Value** | **Comment** |
| Trunk | The most important roads in a country's system that aren't motorways |
| Primary | The next most important roads in a country's system (often link larger towns) |
| Secondary | The next most important roads in a country's system (often link towns) |
| Tertiary | The next most important roads in a country's system (often link smaller towns and villages) |
| Unclassified | The least important through roads in a country's system : minor roads of a lower classification than tertiary, but which serve a purpose other than access to properties (often link villages and hamlets) |
| Residential | Roads which serve as an access to housing, without function of connecting settlements (often lined with housing) |
| Service | For access roads to, or within an industrial estate, camp site, business park, car park, alleys, etc |
| Track | Roads for mostly agricultural or forestry uses |
| Footway | For designated footpaths : mainly/exclusively for pedestrians, this includes walking tracks and gravel paths |
| Bridleway | For horse riders, pedestrians are usually also permitted, cyclists may be permitted depending on local rules/laws, motor vehicles are forbidden |
| Path | A non-specific path |
| Cycleway | For designated cycleways |

Table 3.1: Values and comments associated with the OSM key : Highway. All the comments are taken from the original descriptive table on OSM wiki website (Wiki 2022).

Then, the elevation data was extracted from NASA's Earthdata website and are from the *Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer* (ASTER) *Global Digital Elevation Model* (GDEM) Version 3 (ASTGTM). The spatial resolution is 1 arc second wich means that one pixel is equal to 30 square meters (Team 2019). The data are displayed on the map 3.3 using a manual classification.

### 3.2.2 Farms and sustainability data

The data used comes from a study conducted by Tennhardt et al. 2022. They were collected in the field through interviews conducted by qualified enumerators between July and September 2019. The SMART-Farm tool (Schader et al. 2016) was used to create the database of indicators (farm management and sustainability). In addition to these indicators contextual data about the farm, the supply chain and the farmer were collected.

## 3.3 Preliminary data manipulation

To calculate a Remoteness score for each farms, it is necessary to carry out some manipulations in order to set the data. First, the spatial data described before are implemented in QGIS software, the geographical coordinates of farms and intermediaries, originally in the form of tables, are projected. Then, several layers are added: the province and country boundaries (from HDX), the Digital Elevation Model (DEM) covering the entire area and the complete roads file derived from Open Street Map (OSM).

In order to quantify remoteness, as defined for this study, distance values separating the farms from their respective intermediaries are needed. To obtain these values, a hypothesis must be established: it is assumed that farmers take the shortest route using the known road network (provide by OSM) to sell their production to the middlemen. On this basis, the optimal routes in terms of distance are obtained thanks to the QGIS *shortest path* tool. The tool is applied to each of the eight groups studied. The routes are projected and the related attribute table contains the departure and arrival coordinates as well as a cost value (equivalent to distance).

More manipulations are carried out using Argis Pro. First, point (farm and intermediaries), line (shortest paths), and raster (DEM) files are implemented in the software. Then, the elevation profile of each route is obtained in the form of a table with the *stack profile* tool after having *clipped* the DEM by all of the lines representing the shortest paths. Once the elevation and distance data are ready, a compiled table for each group is exported in csv format for further manipulations.

## 3.4 Calculation of remoteness indicators

In the present research, remoteness between farms and intermediaries can represent, in most cases, the remoteness between farms and the nearest main town (where the market is), except for some cases in which the town where farmers sell their produce is not the nearest urban centre. Indeed farmers are part of a sustainability program and they need to sell to these specific intermediary to remain part of the program.

In a study focusing on the link between location and technology adoption at the level of Kenyan smallholder dairy farmers, Staal et al. identify different approaches to measure market access. These methods are the main ones on which this study is based. Indeed, as suggested distance was used as a simple measure with the possibility of adding impedance levels which, in this case, was a weighting of the distance by adding the slope factor. They also propose to assign speeds to specific road types or surfaces. This approach was followed to calculate a travel time and a weighted travel time (Staal et al. 2002).

It is known from Tennhardt et al. that the most common mean of transportation to get cocoa from the farm to town is a bus or a pick up truck. Farmers bring their harvest by donkey or horse to the next main road and wait there with their harvest by the street until a bus or pick up truck passes by and takes them. When harvest quantities are high, some farmers unite and organize transportation by pick up (Tennhardt et al. 2022).

In order to reflect reality as well as possible, several scenarios are defined. The indicators resulting from these scenarios are used to evaluate remoteness:

- **Distance** : the distance is sufficient to qualify the remoteness, the slope is not a significant factor to consider for travel.

- **Weighted distance** : the slope is an important factor due to the region topography with steep terrain, weighted distance is used to qualify remoteness.
- **Travel time** : farmers travel to intermediaries in motorised vehicles (by taking a bus) that are sufficiently efficient to negotiate the slopes without difficulty. Travel time is a good indicator of remoteness.
- **Weighted travel time** : farmers travel to intermediaries in non-motorised or low-powered vehicles and slopes impact their journeys. Travel time with weighted distance is used to define remoteness.

These approaches of remoteness are developed in the following subsections.

### 3.4.1 Distance weighted by the slope

In this case study, the slope-weighted distance is an interesting value to evaluate the remoteness. Indeed, the slope represents the difficulty in reaching a destination using the road network (Li 2014) and this parameter can induce a more or less significant physical isolation.

The *stack profile* tool used to obtain the elevation profiles of each of the routes returns a table containing two columns useful for the calculation of the weighted distance: FIRST-DIST and FIRST-Z. In concrete terms, for each elevation change, the distance travelled is evaluated. FIRST-DIST represents distance travelled values and FIRST-Z represents elevation values. In order to calculate the slope-weighted distance, the total distance is segmented into small sections which correspond to the difference in the values of FIRST-DIST (FD) ($d = FD_{j+1} - FD_j$). For each section, the slope is calculated by taking the difference in the values of FIRST-Z (FZ) ($w = FZ_{j+1} - FZ_j$). Then the weighted distance of each segment is the distance of the segment multiplied by the difference in elevation on the same segment.

The slope weighted distance of an entire path between farm and intermediary ($wd_i$) is the sum of all weighted distances of each segment and it is calculated on the basis of the simple equation proposed by Li et al. :

$$wd_i = \sum_j w_{j,k}\ d_{j,k} \quad with \quad k = j+1 \tag{3.1}$$

However, this first equation was not adequate. Indeed, when the difference in elevation (the slope) is smaller than the distance travelled, i.e. when the angle of the slope is less than 45°, then the weighted distance of the segment is smaller than the actual distance. The distance must be increased to account for the difficulty of climbing a hill. Therefore, the equation has been modified by adding a factor of 1 :

$$wd_i = \sum_j d_{j,k}\,(1 + w_{j,k}) \quad with \quad k = j + 1 \tag{3.2}$$

In this study, only the positive difference in elevation is considered as binding. Therefore, a condition is applied to the calculation: negative elevation differences are given a value of 0. More concretely, the calculation is done by running a for loop in R with R studio. The results obtained are, for each sampled farm, a weighted distance value and the related elevation profile. But defining remoteness only by a weighed distance is not a complete enough analysis . Indeed, the type of roads has a major role to play in the remoteness index as using a main road can be more efficient/rapid and less difficult than using a path or a track. It also depends on the mean of transport used. So, the travel time is calculated on the basis of differential speed values for different types of road. This is the object of the next section.

### 3.4.2 Travel time calculation using weighted distance

The assumption under which the travel time calculation is made is as follows: Farmers travel to the first main road by light transport and then wait for a bus to pick them up. This assumption is logical with the fact that the road types (track, footway, bridleway, path, cycleway) are mostly located between the farms and the first main road (trunk, primary, secondary, tertiary, unclassified, residential, service).

#### Mean speed calculation

Considering the fact that types of road will impact the travel from farms to intermediaries, mainly because of their different speed limits, mean speed value is calculated for each paths. This calculation is made under the hypothesis that farmers use the different roads at their speed limits.

Firstly, limiting velocity values were assigned to the different highway features described above (Table 3.1). These values are derived from a logical reasoning and from official sources concerning Ecuadorian road code regulations (SES 2022, ANT 2022). The table below contains the established speed limits in kilometer per hour (Table 3.2).

| Speed limits | |
|---|---|
| **road type** | **km/h** |
| Trunk | 70 |
| Primary | 70 |
| Secondary | 70 |
| Tertiary | 40 |
| Unclassified | 40 |
| Residential | 30 |
| Service | 20 |
| Track | 20 |
| Footway | 5 |
| Bridleway | 10 |
| Path | 10 |
| Cycleway | 10 |

Table 3.2: Speed limits of the different kind of road.

An average speed is then calculated for each trip considering the contribution of the different road types via the following equation (3.3) :

$$ms_i = \frac{\sum_j \ l_{j,k} s_{j,k}}{\sum_j \ l_{j,k}} \quad with \quad k = j + 1 \tag{3.3}$$

Where, $l_j$ is the length of the type of road $j$ and $s_j$ is the speed limits of the type of road $j$.

**Travel time calculation**

Finally, the travel time is measured by dividing the weighted distance ($wd_i$) from the previous section (3.2) by the average speed ($ms_i$) as follows:

$$T = \frac{wd_i}{ms_i} \tag{3.4}$$

### 3.4.3 Distance and travel time

The unweighted remoteness indicators are also evaluated. The distance is taken directly from the tool *shortest path* used in the preliminary processing and, the travel time is calculated using the unweighted distance.

## 3.5 Data Analysis

The objective of this study is to answer the question: is remoteness a promotor or an inhibitor for farm-level socioeconomic and environmental sustainability ? To do that, two types of analysis were performed. First, a simple linear correlation analyse were carried out to identify relationships between remoteness and specific socioeconomic, and environmental variables of interest. The goal was to test hypotheses 1 and 2. Then, a single remoteness indicator (Weighted distance) was selected to be implemented in an analysis using multivariate mixed regression models. This analysis aimed to highlight the effect of this variable among a set of control variables that were also expected to have an effect on the implementation of sustainable practices (hypothesis 3).

### 3.5.1 Relation between remoteness indicators and sustainable farm variables

#### Correlation variables selection

Eight variables were selected to test their correlation with remoteness represented by four variables illustrating the different scenarios. To address the hypotheses 1 and 2, the variables are classified according to the dimensions of sustainability:

- **Environmental sustainability:**
  shade trees density (per hectare), shade tree planting (number of shade tree planted the year before the data collection), agroforestry share (percentage of the total exploitation), use of pesticides (liters), use of pesticides per hectare;

- **Socioeconomic sustainability:**
  farmers' cocoa revenues (USD/year), daily wage (USD/day), education (number of years the farmer has been in school), farm area.

Regarding the farm area variable, this can be related to both socio-economic and environmental sustainability. Indeed, the size of the farm represents the physical capital (Kassie, Jaleta, et al. 2013) (socio-economic sustainability) and, larger farms can more easily become extensive by practising less intensive agriculture compared to smaller farms (Kassie, Jaleta, et al. 2013) (environmental sustainability).

These data were selected for practical reasons. Indeed, they were interesting quantitative variables present in the database provided. The selection was conditioned by the availability of data and it is clear that this is not an exhaustive selection.

**Spearman correlation**

In order to identify relationships between remoteness indicators and socioeconomic and environmental variables, spearman correlation tests were performed. First, an analysis was performed for the whole sample (n=189). Then, in order to highlight the group effect which may reflect the importance of the region, the intermediary considered, or even the city, analysis was also carried out by group. Spearman correlation test is one of the most frequently used method for comparing ranked variables. This test was chosen over pearson test because of a non-normal distribution of the variables. Indeed, all of the variables present a positive skew in their distributions. In order to check the most appropriate method a Pearson correlation test was still performed on the transformed variables (log10) for the whole sample.

To answer hypothesis 1, it is expected that the socio-economic variables are negatively correlated with the remoteness indicators.

To answer hypothesis 2, it is expected that the environmental variables are positively correlated with the remoteness indicators except for pesticides use.

### 3.5.2 Influence of remoteness in the adoption of SFP

**Sustainable farming practices (SFP)**

The sustainable farming practices are indicators derived from the data set collected by Tennhardt et al. in 2019. These practices are considered important for a social, economic and environmental sustainable cocoa production. Eight SFPs were identified to test hypothesis 3:

- **Environmental practices:** Pesticide-free cocoa production, Agroforestry share, Shade trees (more than 12 per hectare) (1/0), Shade tree planting (1/0);
- **Socioeconomic practices:** Use of personal protective equipment (1/0), Off-farm income (1/0), Fermentation and drying of cocoa (1/0), Secure farm succession (1/0).

The data does not address all facets of sustainable exploitation (Tennhardt et al. 2022), but the study is limited by the data provided.

### Multivariate mixed regression models

Finally, in order to test hypothesis 3, a regression analysis is performed. But not all remoteness indicators could be included in the analysis because of an issue of multicollinearity. Indeed, travel time, weighted distance, distance and, weighted travel time are highly correlated. Then, weighted distance was chosen to get include in the regressions models because it involves less assumptions.

The weighted distance was therefore added to groups of explanatory variables (social, economic and environmental). Then, based on the methodology provided by Tennhardt et al, multivariate regression models were run. The SFPs were defined as dependent variables. The use of regression models permits to control the results with the others groups of predictors (supply chain factors, farm factors and farmer factors).

# Chapter 4

# Results

## 4.1 Assessment of remoteness

Several indicators can be used to qualify remoteness depending on the scenario: distance, slope-weighted distance, travel time and travel time using weighted distance. These values were obtained for each journey (defined by the shortest path) between farms and intermediaries.

### 4.1.1 Descriptive statistics

The results obtained to qualify remoteness are summarised in the table below (table 4.1). For the distance measurements (farm to intermediary), the distances vary between 85 m and 86.5 km and up to 178.0 km for the weighted distances. The average unweighted distance is 13.3 km and 29.4 km for the weighted distance. These very different results highlight the importance of including positive slopes. Furthermore, the standard deviation of the weighted distance is greater than the one of the simple distance. As for the travel times, they vary between a few seconds and 2 hours and 4 minutes for the simple travel time or 4 hours and 20 minutes if the weighted distance is taken into account. The mean values are 17.4 minutes and 38.4 minutes respectively, with standard deviations of 20.2 and 43.3. The standard deviations are very large and are due in particular to the extreme values. We can see that the unweighted and weighted values evolve in the same way (almost doubling). The slope factor is on average 2.21 in both cases. As illustrated in the histogram (figure 4.1) the majority of farms (90%) are within 24 km (distance), 60 km (weighted distance), 32 minutes (travel time) or 80 minutes (weighted travel time) from their intermediaries.

| Summary Statistics | | | | | |
|---|---|---|---|---|---|
| **Statistic** | **N** | **Mean** | **St.Dev.** | **Min** | **Max** |
| Distance | 189 | 13.271 | 14.111 | 0.085 | 86.469 |
| Weighted distance | 189 | 29.396 | 30.535 | 0.085 | 178.013 |
| Travel time | 188 | 17.369 | 20.202 | 0.082 | 124.486 |
| Weighted travel time | 188 | 38.408 | 43.579 | 0.130 | 256.278 |

Table 4.1: Speed limits of the different kind of road.

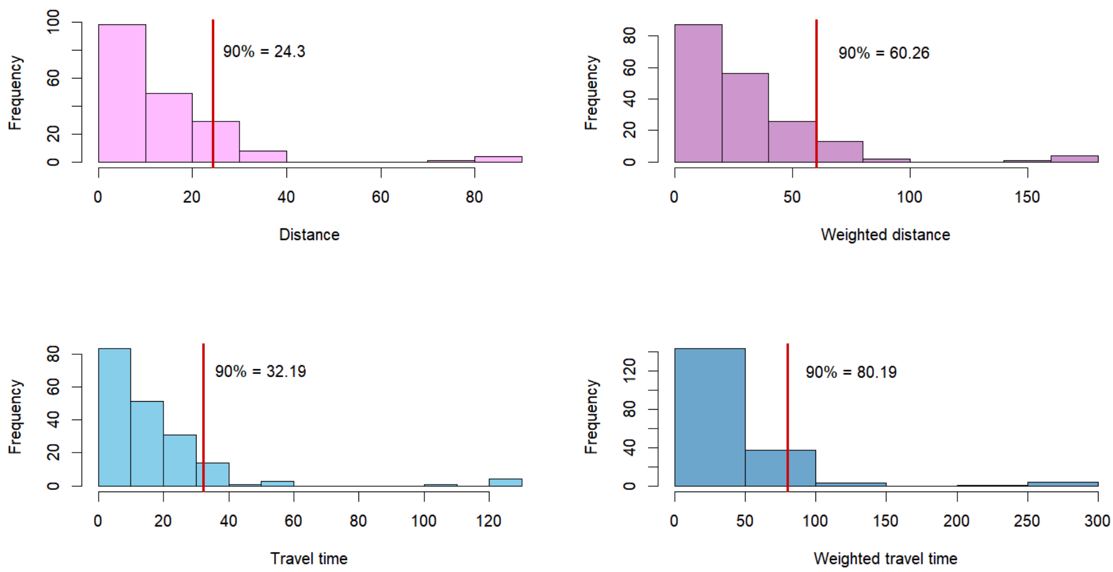


Figure 4.1: Histogram of the remoteness indicators.

The eight groups of farms sampled on the basis of the eight intermediaries are spread over a wide area of northwestern Ecuador (map 3.1). In order to verify the influence of the group factor, a Kruskal-Wallis test was performed. This test compares the means of each group for a dependant variable. The test was performed for the four dependant variables: distance, weighted distance, travel time and weighted travel time. For each variable, the group means were significantly different, with the group factor explaining a large part of the variability (results are plot for weighted distance on the figure 4.2). It is therefore interesting to look at the statistics by group to see if certain of them may influence the results of the entire sample.

Table 4.2 exemplary shows the great variance in remoteness indicators within the eight groups. The values depicted for intermediary group 5 and 7 differ greatly from the values of the entire sample group. Indeed, the group corresponding to intermediary 5 has lower values and the group corresponding to intermediary 7 has higher values (table 4.2). The values of the means differ greatly from the values for the whole group. This can be explained by the fact

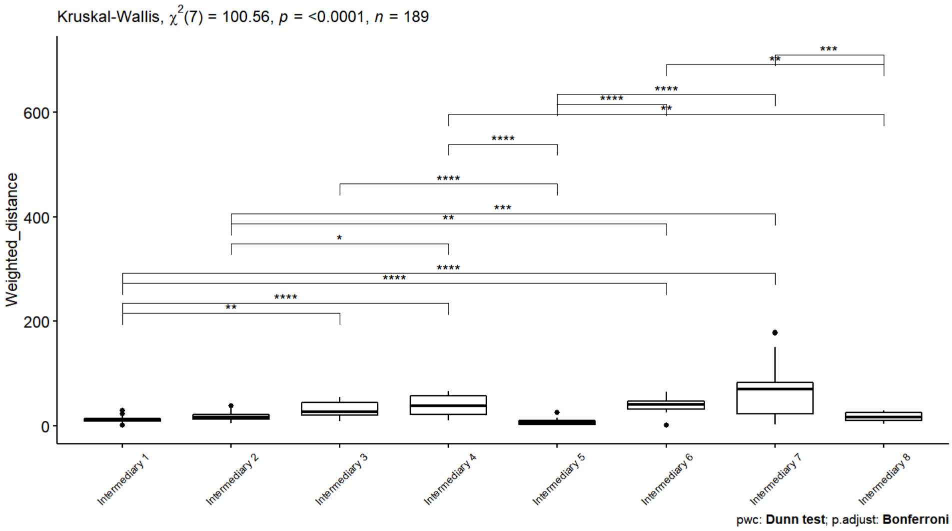


Figure 4.2: Visualization of the Kruskal-Wallis results for weighted distance : boxplots with p-values.

that the mean is a trend that is sensitive to extreme values, and the two groups considered have very small and very large values. It is these groups that have the extreme values. Obviously the overall mean is also influenced by the extreme values but to a lesser extent due to the sample size and the distribution of values of all other groups. The statistics for all groups are shown in table 6.1 in the Annexes.

Intermediary 5

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Distance | 23 | 3.064 | 2.356 | 0.085 | 10.069 |
| Weighted_distance | 23 | 6.298 | 5.716 | 0.106 | 24.936 |
| Travel_time | 22 | 4.988 | 3.559 | 0.128 | 15.104 |
| Travel_time_W | 22 | 10.226 | 8.658 | 0.159 | 37.404 |

Intermediary 7

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Distance | 24 | 34.052 | 28.050 | 0.721 | 86.469 |
| Weighted_distance | 24 | 72.174 | 58.354 | 1.575 | 178.013 |
| Travel_time | 24 | 47.599 | 42.179 | 1.334 | 124.486 |
| Travel_time_W | 24 | 101.295 | 88.168 | 2.916 | 256.278 |

Table 4.2: Summary statistics of intermediaries 5 and 7.

### Illustration of the results

The shortest paths taken by intermediray groups 5 and 7 and their respective elevation profiles are shown in figure 4.3. For group 5, the profiles had many negative slopes, which were not taken into account in the weighting calculation. On the other hand, group 7 had profiles with more positive slopes, which means that the weighting of the distance will be more important. Similar figures were produced for all groups, the objective being to illustrate the data used and the results obtained. All the representations are shown in Annex 1.

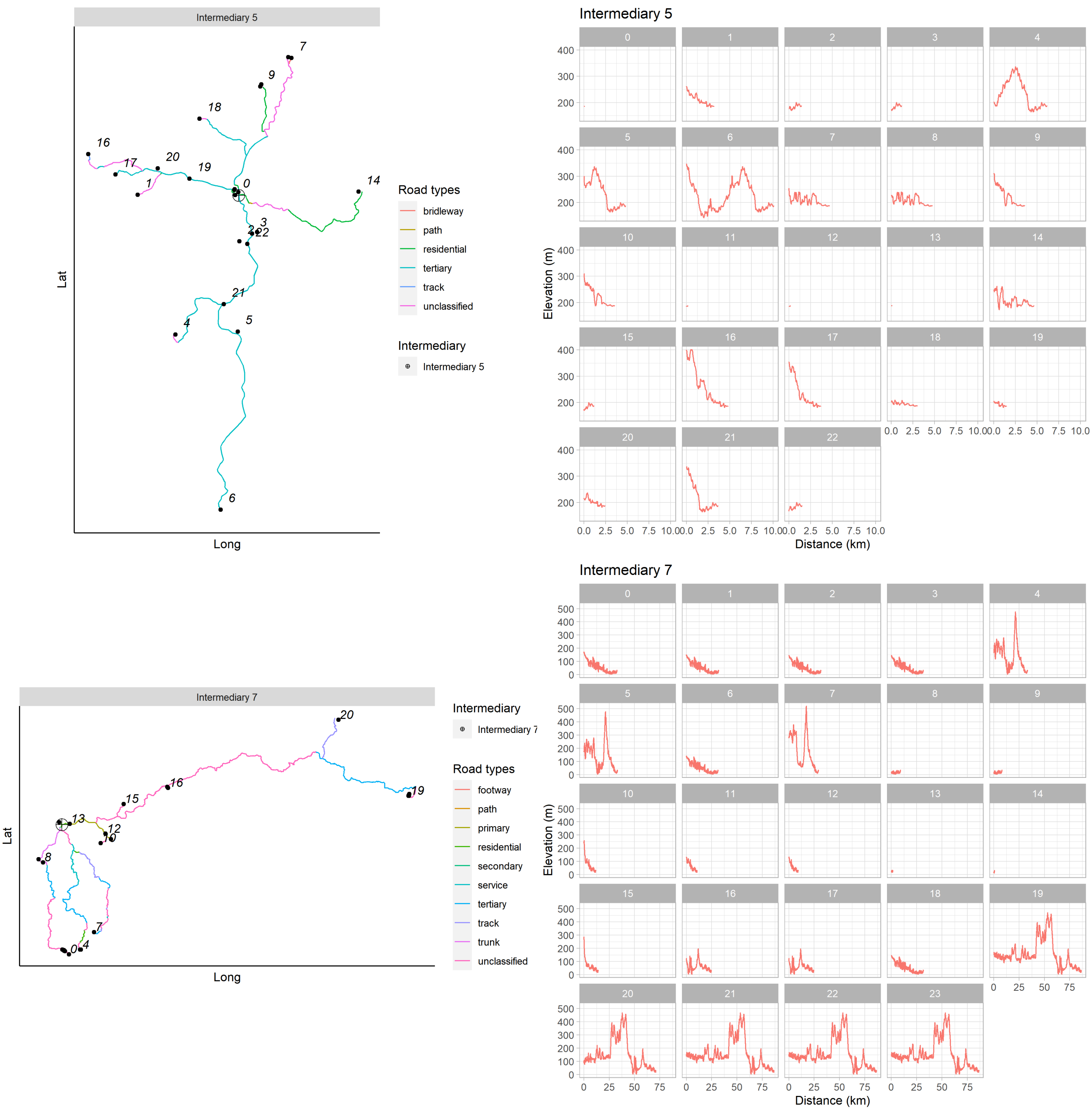


Figure 4.3: **Left:** representation of the paths and road types used between the farms and the intermediary; **Right:** elevation profiles of each path. **Note:** The representations of the other sampled groups are included in the Annexes.

## 4.2 Spearman correlation between remoteness indicators and sustainability variables

### Correlation using the entire sample

The results obtained do not highlight really strong correlation within the variables and few relations are significant. The correlation matrix of the two methods are displayed. As the results obtained are very comparable, it was decided to keep and comment only on those obtained by the Spearman method. The correlation matrix resulting from the Pearson correlation on the transformed variables is shown for illustration purposes (figure 4.4). Spearman correlation analysis shows highly significant inverse correlations between the agroforestry share of farm area and shade tree per hectare with all remoteness indicators. Farm managers' education is negatively correlated with distance, weighted distance, and with the values of travel time and weighted travel time. The pesticide quantity is correlated with the weighted values. Finally, cocoa revenue is correlated with weighted distance. In general, the relatively low correlation coefficients indicate that there are no linear relationships between the variables (the linearity of the relationships established is low).

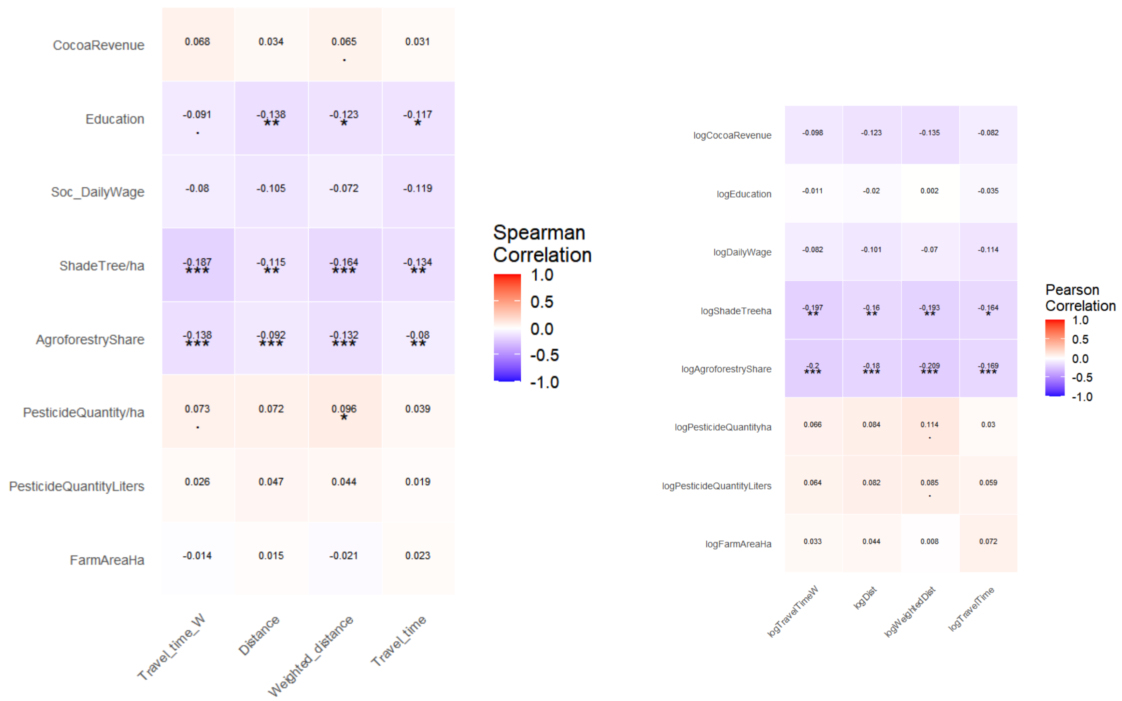


Figure 4.4: Correlation matrix for the all sample: using Spearman's method (left), with transformed data and using Pearson's method (right). **Note:** *p<0.05; **p<0.01; ***p<0.001.

## Correlations by group

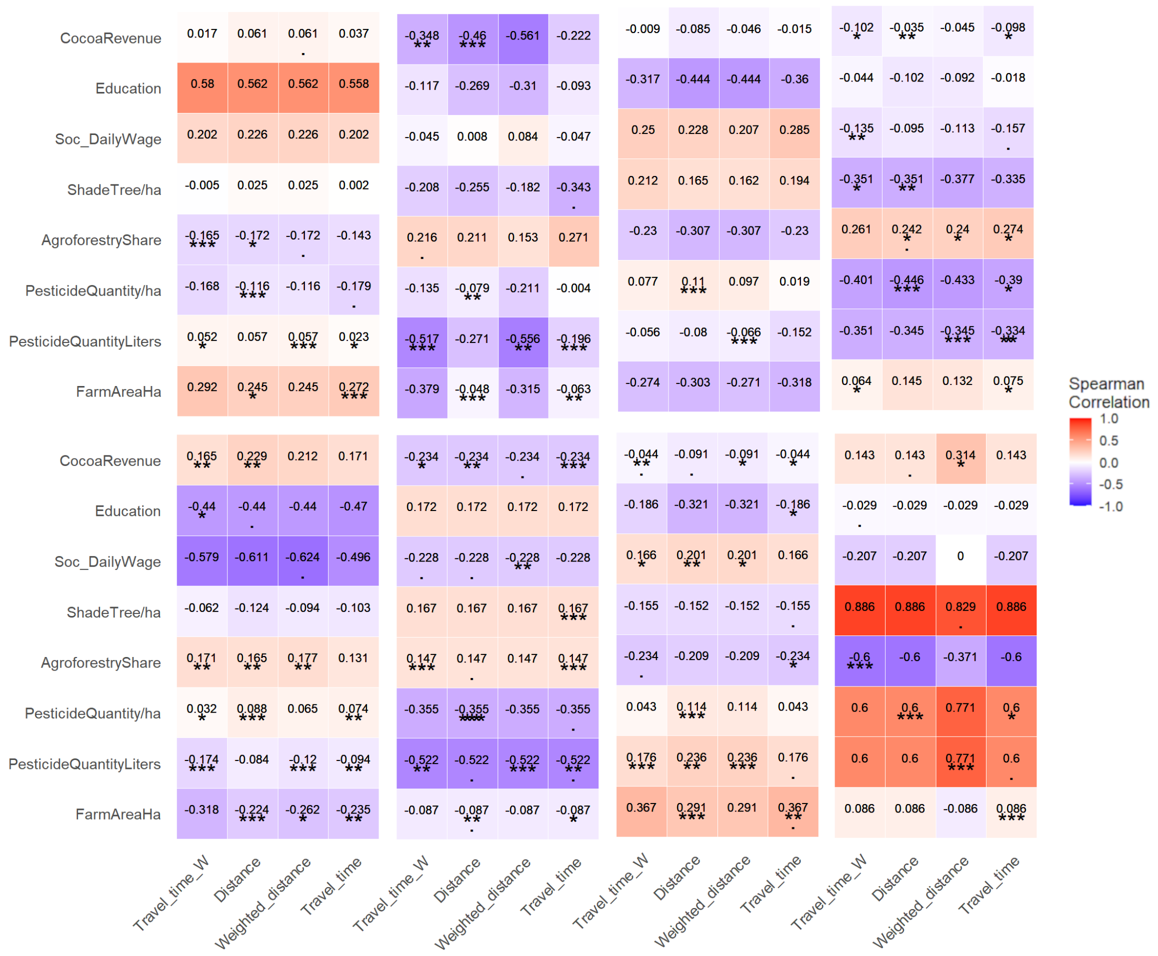


Figure 4.5: Correlation matrix per group. Above: group 1 to 4; below: group 5 to 8. **Note:** *p<0.05; **p<0.01; ***p<0.001.

The results of the correlation for each group are presented within the correlation matrix (figure 4.5). Stronger correlations appear but again few are significant. Highlighting some results we can see that :

Pesticide quantity (liter) presents strong negative correlations with remoteness variables for groups 2, 4 and 6. While the correlation is positive for groups 7 and 8.

Pesticide quantity per hectare is also quite well related with remoteness form most groups. It is positively related for groups 3, 5 and 7 and negatively for the rest.

Cococa revenue is mainly negatively correlated with remoteness. The correlation are stronger for groups 2 and 6. Groups 5 and 7 present positive correlations between the variables.

Farm area is positively correlated with unweighted variables in groups 1 and 7. While it is negatively correlated with the same variables for groups 2, 5 and 6.

Comparing the results for the whole sample with the results per group, we notice that we obtain generally higher correlation coefficients per group as well as higher significance levels. The variables correlated with remoteness for the whole sample are: share of agroforestry, shade tree per hectare, education and pesticide quantity per hectare. While, by group, additional relationships appear notably with farm area, pesticide quantity in liters and cocoa revenue.

## 4.3 Link between remoteness and the adoption of sustainable farming practices (SFP)

### 4.3.1 Results from multivariate mixed regression models

The results of the different regression models are presented in the summary table below (table 4.3). The aim was to establish the relationship of remoteness represented by one predictor (weighted distance) on the adoption of sustainable farming practices (SFP).

The expected results for weighted distance should be negative relationship between the predictor and the SFP. We can see that all of the relations are negative except for Agroforestry system, the use of protective equipment and the fermentation. Unfortunately, the results obtained for weighted distance are not significant which mean the probability that the observed relationship is due to chance is high.

| | Pesticide-free production (1/0) | Agroforestry system (1/0) | Shade trees >12/ha (1/0) | Shade tree planting (1/0) | Use protective equiptment (1/0) | Off-farm income (1/0) | Fermentation (1/0) | Secure farm succession (1/0) |
|---|---|---|---|---|---|---|---|---|
| | *generalized linear mixed-effects* | *generalized linear mixed-effects* | *generalized linear mixed-effects* | *logistic* | *generalized linear mixed-effects* | *generalized linear mixed-effects* | *generalized linear mixed-effects* | *generalized linear mixed-effects* |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Constant | $-1.37^{***}$ (0.38) | 0.72 (0.72) | $2.57^{***}$ (0.71) | $-1.73^{***}$ (0.25) | $-1.18^{**}$ (0.40) | $-0.85^{***}$ (0.18) | −2.54 (1.57) | $1.61^{***}$ (0.37) |
| Age | −0.33 (0.27) | 0.47 (0.30) | 0.37 (0.26) | −0.26 (0.27) | 0.06 (0.24) | $-0.38^{*}$ (0.19) | −0.10 (0.32) | −0.19 (0.28) |
| Female | −0.32 (0.25) | −0.01 (0.28) | −0.27 (0.24) | −0.22 (0.26) | −0.09 (0.24) | 0.21 (0.18) | 0.13 (0.30) | −0.12 (0.26) |
| Education | −0.37 (0.33) | $0.62^{*}$ (0.31) | 0.54 (0.28) | −0.27 (0.28) | 0.21 (0.26) | −0.10 (0.20) | 0.11 (0.36) | −0.56 (0.31) |
| VerbalCommitmentSustainability | $0.97^{***}$ (0.27) | 0.32 (0.29) | $0.82^{**}$ (0.30) | 0.21 (0.22) | | | | |
| ClimateChangeKnowledge | 0.09 (0.26) | −0.50 (0.30) | −0.34 (0.26) | $0.56^{*}$ (0.25) | | | | |
| FarmSize | 0.02 (0.27) | −0.30 (0.34) | $3.03^{*}$ (1.54) | $0.54^{*}$ (0.26) | 0.19 (0.27) | −0.02 (0.23) | −0.34 (0.80) | 0.58 (0.49) |
| LandOwnership | −0.20 (0.25) | 0.10 (0.29) | 0.11 (0.26) | 0.10 (0.23) | | 0.10 (0.18) | 0.18 (0.33) | 0.05 (0.27) |
| SufficientFarmNetIncome | | | | | −0.19 (0.24) | −0.21 (0.19) | 0.31 (0.31) | 0.07 (0.28) |
| OffFarmIncome | 0.21 (0.25) | 0.24 (0.28) | −0.33 (0.26) | 0.06 (0.24) | 0.02 (0.24) | | $-0.64^{*}$ (0.32) | −0.26 (0.27) |
| HouseholdFoodSecure | | | | | −0.04 (0.28) | | | |
| PaidWorkers | −0.10 (0.27) | −0.29 (0.33) | −0.11 (0.27) | −0.19 (0.23) | 0.09 (0.28) | | | |
| LabourShortage | −0.01 (0.28) | $-1.23^{**}$ (0.39) | −0.67 (0.35) | 0.01 (0.26) | 0.09 (0.25) | | | |
| CocoaArea | −0.10 (0.29) | $1.01^{*}$ (0.41) | $-1.60^{**}$ (0.57) | −0.10 (0.27) | | | | |
| CCNCocoaVariety | $-0.92^{**}$ (0.28) | $-0.84^{*}$ (0.34) | −0.61 (0.33) | −0.35 (0.27) | | | | |
| FamilyWorkers | | | | | −0.17 (0.25) | | | |
| CocoaRevenue | −1.03 (0.57) | −0.45 (0.32) | 0.20 (0.28) | 0.47 (0.24) | −0.01 (0.27) | −0.11 (0.21) | −0.47 (0.37) | 0.45 (0.45) |
| AccessExtension | $-0.63^{*}$ (0.29) | −0.02 (0.32) | −0.50 (0.31) | $0.52^{*}$ (0.26) | 0.42 (0.30) | 0.19 (0.20) | −0.44 (0.38) | −0.11 (0.29) |
| TrainingDays | 0.25 (0.27) | 0.66 (0.52) | 0.43 (0.43) | −0.24 (0.26) | 0.48 (0.31) | 0.01 (0.22) | −0.08 (0.53) | −0.04 (0.32) |
| DependencyCocoaRevenue | −0.30 (0.40) | −0.58 (0.44) | $-1.19^{*}$ (0.50) | −0.08 (0.35) | −0.46 (0.39) | 0.18 (0.26) | 0.38 (0.54) | −0.09 (0.38) |
| DependencyMainCustomer | −0.08 (0.33) | 0.14 (0.42) | 0.36 (0.44) | −0.18 (0.30) | 0.06 (0.33) | −0.13 (0.23) | −0.23 (0.43) | 0.55 (0.35) |
| CocoaBuyers | −0.39 (0.31) | 0.43 (0.27) | 0.13 (0.25) | 0.11 (0.22) | −0.10 (0.29) | −0.50 (0.27) | −0.28 (0.35) | 0.18 (0.26) |
| RelationshipCocoaBuyers | $-0.57^{*}$ (0.28) | −0.33 (0.35) | 0.59 (0.32) | −0.11 (0.23) | 0.25 (0.24) | −0.37 (0.21) | $-1.21^{*}$ (0.59) | 0.25 (0.32) |
| **WeightedDdistance** | −0.14 (0.30) | 0.21 (0.37) | −0.39 (0.48) | −0.07 (0.26) | 0.31 (0.30) | −0.19 (0.24) | 0.51 (0.63) | −0.49 (0.41) |
| Observations | 173 | 173 | 171 | 173 | 144 | 173 | 173 | 122 |
| Log Likelihood | −66.10 | −64.05 | −66.27 | −72.65 | −72.86 | −100.17 | −52.90 | −55.55 |
| Akaike Inf. Crit. | 176.21 | 172.10 | 176.54 | 187.29 | 185.72 | 232.34 | 139.81 | 145.11 |
| Bayesian Inf. Crit. | 245.58 | 241.47 | 245.65 | | 245.11 | 282.79 | 193.41 | 192.78 |

*Note:* $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 4.3: Results from multivariate mixed regression models.

# Chapter 5

# Discussion and limits

In this chapter, the results presented above are discussed in order to confirm or refute the hypotheses stated at the outset. Then, the limitations of the study are outlined and suggestions are made on how to improve some of the methodological aspects.

## 5.1 Discussion and interpretation of the results

The results are discussed in details regarding the initial assumptions in the next subsections.

### 5.1.1 Remoteness of the farms

The first objective of this study was to assess the level of remoteness to intermediaries for each farm of the sample. It was evaluated using four values according to four scenarios supposed to take into account different real situations. This evaluation was carried out using a definition constructed for this case study on the basis of previous definitions found in the literature. As a reminder, the definition formulated is the following:

*«Remoteness is the ease or difficulty with which a certain distance is travelled using the road network an it refers to a certain degree of physical isolation.»*

Looking at the results, farms were mostly located at reasonable distances and travel times from their intermediaries, on average 13 km and 17 minutes. Moreover, as illustrated in the figures in the appendix, the majority of the road types are major roads on which the estimated speed varies between 40 and 70 km/h. Therefore, taking into account the definition, we can conclude that the majority of farms are not really remote. However, the field experience reported by the data collection team tells us that a number of farmers find it difficult to travel to sell their produce. The weighted values are in this case a way of doing justice to the reality reported. Moreover these values represent the importance of topography in these mountainous regions and consequently the ease or difficulty to reach the destination.

Nevertheless, if some farms have a high level of remoteness because they are situated far from their intermediaries this does not mean that they are more remote than others which are situated closer. Indeed, an important aspect of remoteness is physical isolation. That is why it would have been more accurate to evaluate remoteness on the basis of the distance, or even weighted distance, between farms and the first main road. Unfortunately this data was not available and, field measurements would be required.

### 5.1.2 Remoteness is an inhibitor for farm-level socioeconomic sustainability (hypothesis 1)

Considering the entire group the results on the relationship between farms' remoteness and socio-economic variables show a mixed picture. For some variables, like farmers' formal education level, a clear negative relationship was identified across the entire sample. This is consistent with the fact that remoteness could cause some form of neglect of the population by the authorities by providing less services (Belcher, Achdiawan, and Dewi 2015) making remote rural population struggleling with eductaion (Mangione and Cannella 2021).

Farm size showed no relationship with remoteness values for the entire sampled. But, when looking at the group level it was negatively associated with remoteness, yet only for three out of eight groups of farmers. In particular, a decrease in farm size is observed mainly when distance or travel time increases. For these three groups, remoteness seems to be linked to a lower physical capital.

At the group level, Cocoa revenue is negatively correlated with remoteness, mainly for the weighted travel time and for the distance. Income from cocoa production effectively appears to be lower when distance or weighted travel time increases for four of the groups. This is in line with past literature on Nigerian farms (Fonta, Ichoku, and Urama 2011).

It can be concluded that the first hypothesis is only partially verified an it must therefore be regarded in a nuanced way given that the correlation, although significant, is relatively weak.

### 5.1.3 Remoteness is a promotor for farm-level environmental sustainability (hypothesis 2)

Again obtained results are mixed and no clear trend can be concluded that would confirm or reject hypothesis 2. Contrary to what was expected, the environmental variables agroforestry share and shade tree per hectare showed an inverse relationship with remoteness in all four scenarios. This means that the more remote the farms are, the less agroforestry they practice and the less shade tree per hectare they have. As suggested by Wezel and Ohl an explanation could be that the difficulty of reaching an urban market to sell the products from these trees may dissuade farmers from planting them (Wezel and Ohl 2005).

Farm size partially confirms hypothesis 2 for four groups. Specifically, an increase in farm size is observed mainly when the distance or travel time increases. For these four groups, remoteness could be linked to more extensive farms like described by Belcher et al. (Belcher, Achdiawan, and Dewi 2015, Kassie, Jaleta, et al. 2013). And this supports the findings of several studies in Madagascar and Nepal which showed that remoteness was linked to an increase in the size of farms or their plots (Eastwood, Lipton, and Newell 2010).

For four out of eight groups, the share of agroforestry increases when farms are more remote in terms of travel time, weighted travel time and distance. These results are consistent with those obtained by Gibreel in a later study (Gibreel 2013). Pesticides use in litres also seems to validate the second hypothesis. Indeed, its use decreases with remoteness (mainly weighted values) for five groups. The quantity used per hectare follows the same trend for four groups. These are expected results since remoteness in relation to the intermediary (being in town) gives a good indication of remoteness to the markets supplying the inputs (Belcher, Achdiawan, and Dewi 2015).

### 5.1.4 Remoteness is an inhibitor for sustainable farming practices adoption (hypothesis 3)

The results of the multivariate regression models do not allow the third hypothesis to be validated due to their non-significance for the weighted distance predictor. However, apart from three practices (agroforestry, protective equipment and fermentation), if they had been significant, the relationships obtained could confirm the hypothesis that remoteness is an inhibitor for sustainable farming practices adoption. Also, if the results had been significant it would have been logical to see that having an agroforestry system is positively correlated with weighted distance since this is consistent with the results of the correlations analysis and with the Gibreel' study (Gibreel 2013).

As observed for the previous hypotheses, the fact that remoteness does not seem to be related to the adoption of SFP may be due to the fact that farms are part of a sustainability program. It is therefore interesting to note that being part of a sustainability program could encourage farms to move beyond their isolation to adopt new sustainable practices. But this is only a new hypothesis that merits further investigation. Especially since the most isolated farms whose remoteness would be truly related to their sustainability may not be part of the program and therefore were not included in this study.

### 5.1.5 Main messages

The study highlights some forms of influence of remoteness on variables related to the sustainability of the farms analysed. On the entire sample the results are not robust enough to really conclude that there is a clear and linear influence. However, at the group level some relationships could be identified, which underlines the importance of the group factor which may contain the effect of the city where the intermediary is located, the intermediary itself or the effect of the region where the sub-sample is located.

If the hypotheses can only be partially validated, if not totally invalidated, this does not mean that remoteness is a factor to be dismissed in the study of the sustainability of cocoa farms and their adoption of new sustainable practices. Indeed, several factors play a role in the difficulty of obtaining conclusive results: limited data, uncertainties about the reality of the field or the specific context of the farms studied.

## 5.2 Limitations and perspectives

### 5.2.1 Remoteness evaluation

Several limitations can be discussed regarding the assessment of remoteness. First, the exact routes to reach the intermediaries are not known precisely. They are approximated by using the road network from OSM which, although fairly complete, may not be exhaustive. Existing and used roads (like paths or tracks) may not be included in the database. Also, the shortest route is not always the most suitable or fastest depending on road conditions, traffic in the city, or the type of road. In addition, some regions are impacted by the rainy season, which makes some routes impassable. Yet, it is not possible to quantify the impact of these floods without field measurements.

Another issue is that some farms that are located too far from the known road network have a distorted distance score because the starting point is at the beginning of the first (nearest) road and not at the farm itself. This is why several farms have the same score even though they are not located in the same place. However, it is probably between the farm and the first road that the difficulty of the journey really exists. This problem is particularly visible for Group 6 in the figure below (5.1). Indeed, many farms do not seem to be connected to the OSM road network. Several elevation profiles are therefore similar as they illustrate an identical route.

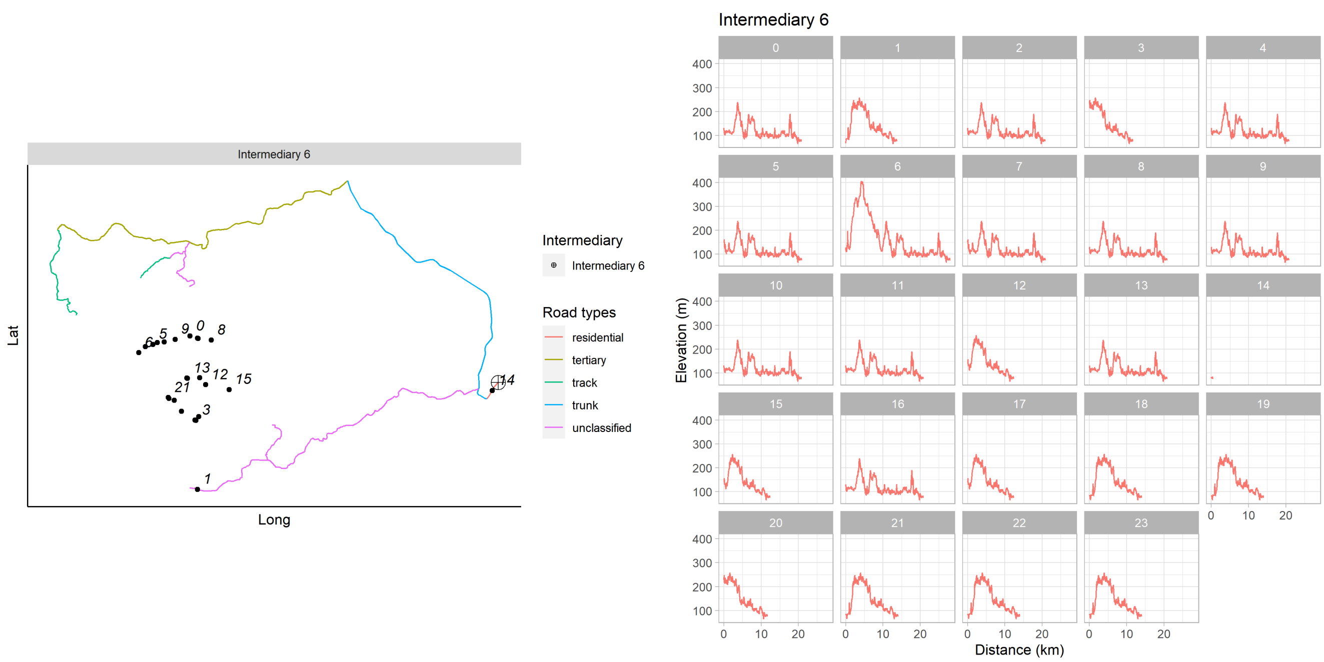


Figure 5.1: Shortest paths colored by road types and elevation profiles for Intermediary 6 sub sample.

Also, four values have been calculated to assess remoteness under different scenarios. It would therefore be useful to know exactly which scenario is the most representative of reality. Or, to know the adequate scenario for each farm. Moreover, the unweighted values are valid for both directions of travel, which is not the case for the weighted values which are valid only from farm to intermediary. However, the return journey is also part of the difficulty and could be taken into account in the assessment of remoteness.

For the majority of the groups, the location of the intermediaries corresponds fairly well to the centre of the nearest town. However, this is not the case for two groups. Firstly, for group 4, the town where the program intermediary is located does not correspond to the nearest large town, although the two are not very far apart. Secondly, in the case of group 7, the town where the intermediary is located does correspond to the nearest large town except for some of the farms which are very far from their intermediary and yet relatively close to another large city. Moreover, the farmers are part of a sustainability program and have no choice but to sell to these specific intermediaries if they want to remain part of the program.

Finally, the calculation of travel time also has its limitations. Indeed, the speed limits determined for each type of road are uncertain, especially since the speed actually reached will depend on the vehicle used. Also, if trips are made by bus on main roads, the weighted travel time is likely to be exaggerated compared to reality since the slope will not have the same importance and bus stops to on- and offload are not considered. This could be corrected by applying the appropriate scenario to the real situation as already mentioned.

### 5.2.2 Spearman correlation

In general, the obtained correlation coefficients are low, indicating low linearity in the relationships between the variables where significant relationships exist. Further analysis could provide a better understanding of the nature of the relationships between the variables. The correlation study to test hypotheses 1 and 2 showed some weaknesses which can be discussed.

Correlation assumes either, other things being equal, or a cancellation of other potential influences. However, other factors may have a more important influence than remoteness which may cancel out the contribution of remoteness. This is why, the fact that farmers are part of a sustainability program is probably one of the main reasons why the results from the correlations are not as significant as expected. Indeed, this is a parameter that can easily counteract the assumed effect of remoteness as farmers choose to face the possible difficulties of joining their intermediary to take part in the program.

### 5.2.3 Perspectives

This study had difficulty in drawing clear conclusions about the relationship between remoteness and sustainability. However, it did suggest that spatial factors could indeed play a role in the adoption of sustainable practices. Further research in this regard could lead to a true understanding of remoteness issues on cocoa farms in this region of Ecuador. To do this, new measurements should be carried out in order to better understand the reality on the field. Additional data would then be needed, including: the geographical coordinates of the places where farmers wait for the bus, the routes actually taken, the means of transport, and the identification of impassable roads in the wet season.

Moreover, in order to account for all the facets of remoteness, it would have been interesting to obtain a standardised index allowing the comparison of farms with regard to their access to the nearest town or main market via the road network and integrating the services offered in town (education, health, welfare etc.) (Glover and Tennant 2003). However, as such data were not readily available, distance and travel time including a weighting for slope were chosen as values to define the remoteness of the farms.

# Chapter 6

# Conclusion

The cocoa sector faces many challenges in terms of socio-economic and environmental sustainability (Fountain and Huetz-Adams 2020). More and more, chocolate companies are trying to improve their supply chain (Tennhardt et al. 2022). In this context, sustainability programs coexist with certifications (Tennhardt et al. 2022). Some of the literature focuses on factors that can influence the adoption of sustainable practices at farm-level (Foguesatto, Borges, and Machado 2020 and Mozzato et al. 2018). Among these, spatial factors such as remoteness seem less studied. However, many studies link remoteness to various socioeconomic and environmental variables. In the rural and hilly regions of the northwestern equator, the distance or travel time between farms and the town where their products will be sold can be an indicator of remoteness. Even more when the difficulty of reaching the town, caused by the terrain, is included via a weighting. This study therefore aimed to assess the extent to which remoteness of Ecuadorian cocoa farms could be related to their socioeconomic and environmental sustainability and the adoption of sustainable practices.

The results could not show a tangible effect of remoteness in the entire sample. However, the hypotheses could be partially verified at the level of sub-groups defined by the intermediary to whom the cocoa production is sold. Indeed, it was shown that some socioeconomic variables (education, farm size and the share of income from cocoa) could be negatively impacted by remoteness in some groups of farms. On the other hand, remoteness positively influenced environmental sustainability variables (less pesticide use and the share of agroforestry in the farm area). Weighted distance has not been demonstrated to have an impact on the adoption of SFPs. Its effect, among other predictors used as control variables, could not be evidenced in this study.

These results, although attributed to certain sub-samples and therefore not necessarily unanimous, do shed light on the importance of remoteness for sustainability at farm level. Several ideas are proposed to improve this research, for example: to collect more precise data on the routes taken and their conditions and to create a standardised index of remoteness in order to be able to compare the farms.

Finally, it is not possible to give a definitive answer to the question raised but it can be concluded that remoteness is a factor that can have a crucial influence, although its analysis is complex and depends on many factors including the specific context of the study. Nevertheless, future research should continue to consider remoteness and its influence on sustainability.

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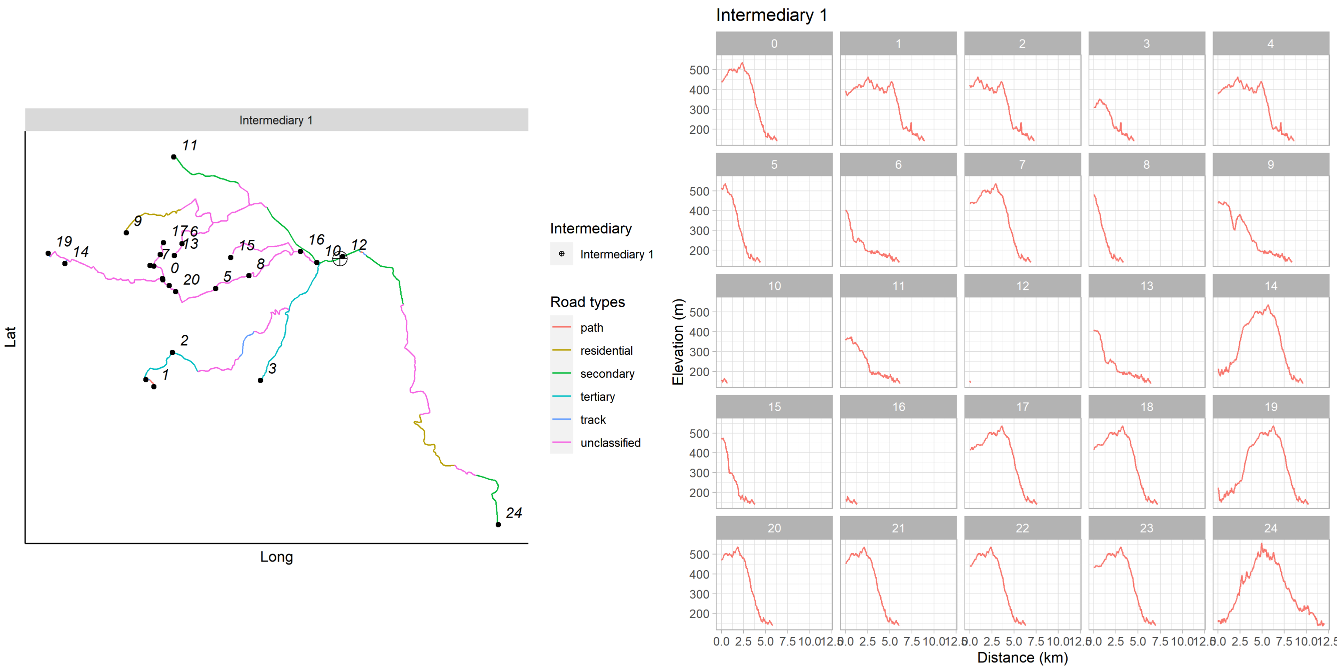
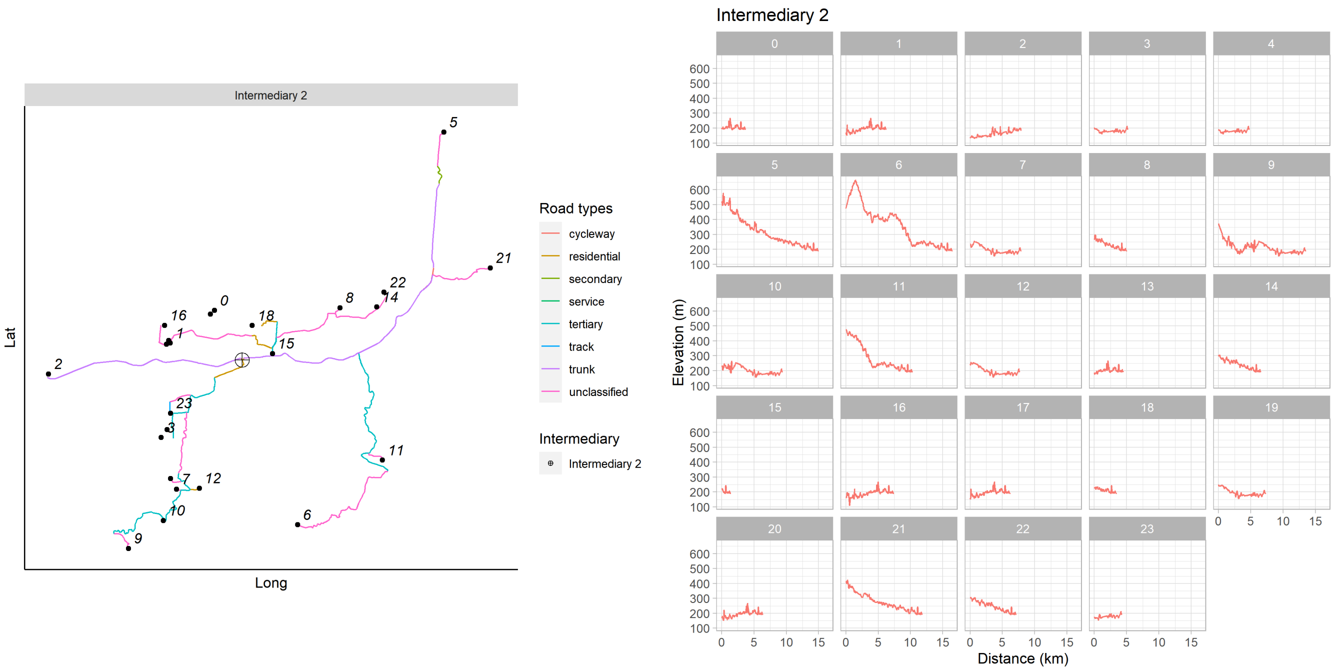
# List of Tables

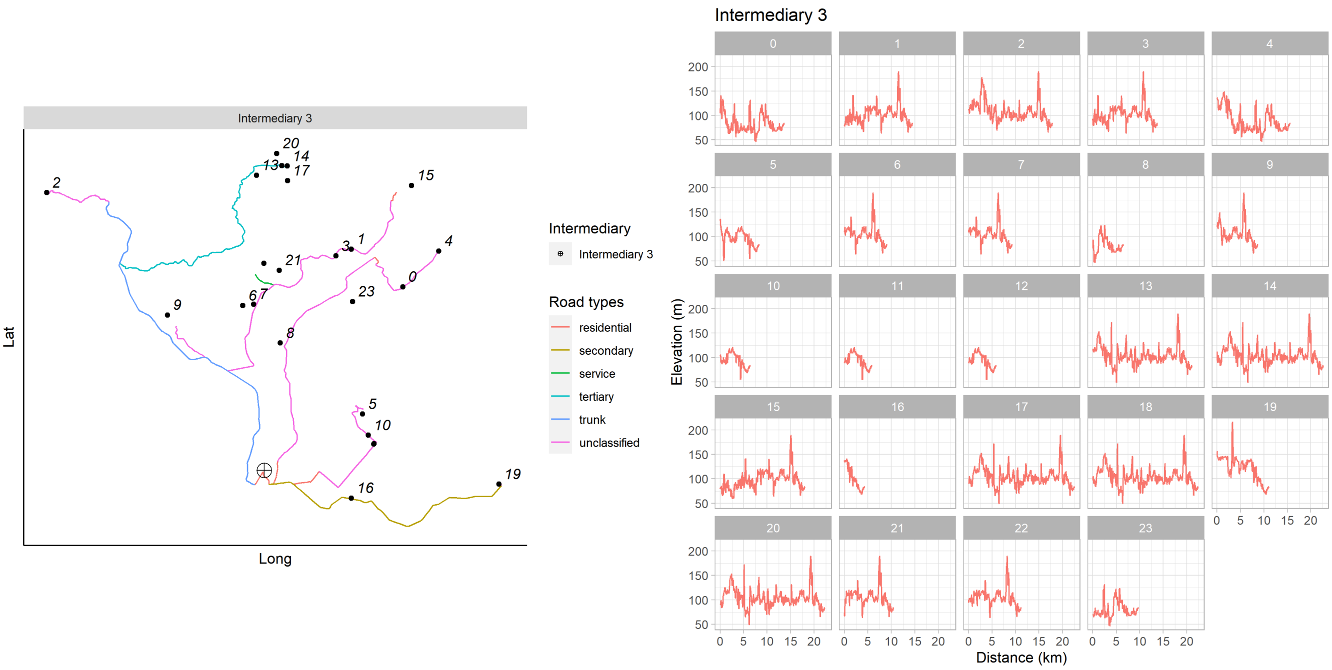
# List of Figures

# Annexes

## Annex 1 - Shortest paths and elevation profiles

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Intermediary
Intermediary 3
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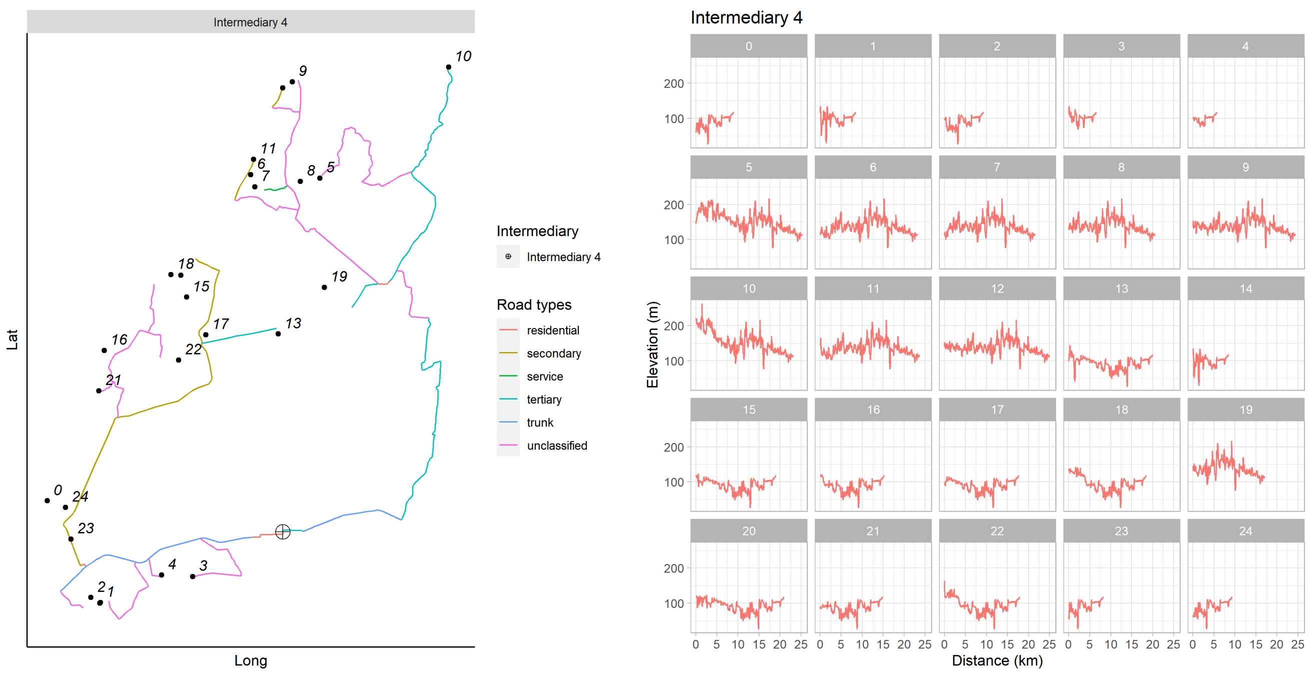
secondary
service
tertiary
trunk
unclassified
Lat
Long
Elevation (m)
Distance (km)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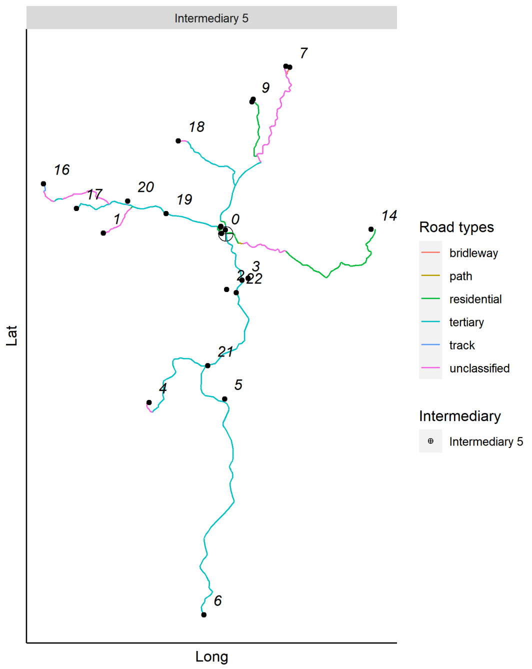
Distance (km)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Road types
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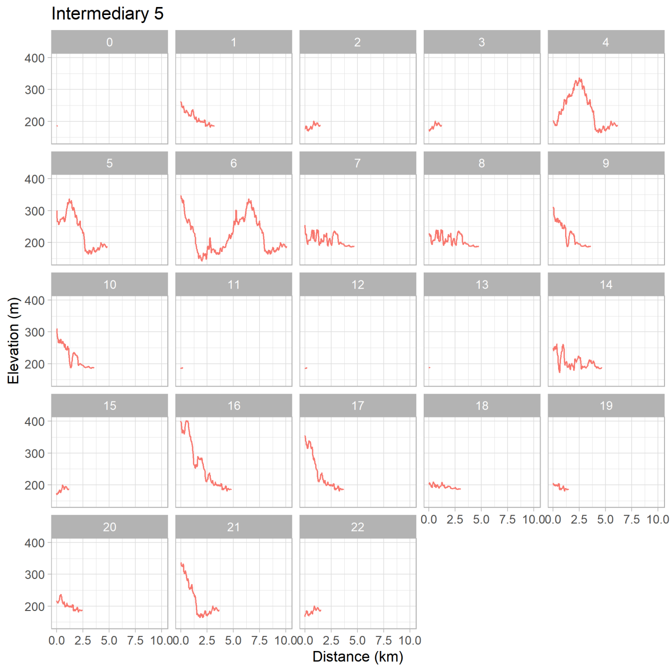
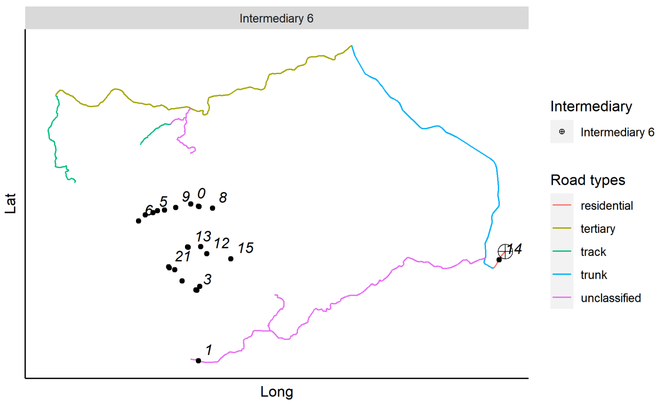
Intermediary
Intermediary 5


Intermediary 5
Elevation (m)
Distance (km)


Intermediary 6
Lat
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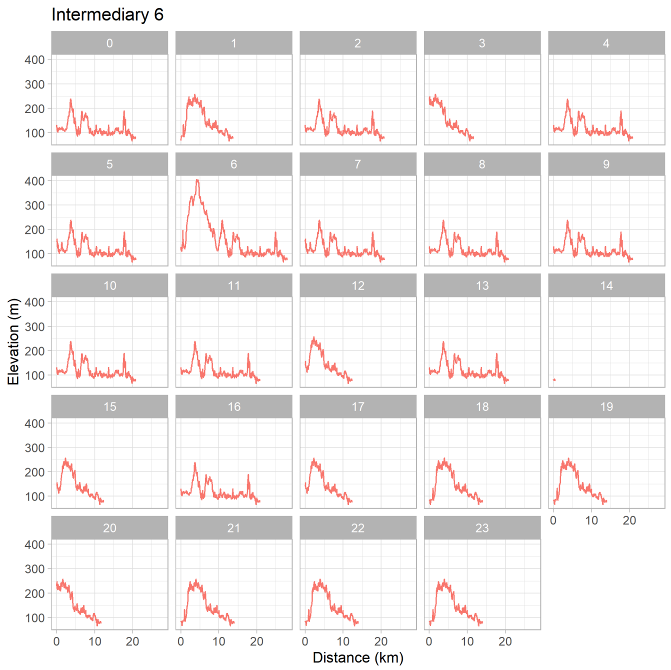
unclassified


Intermediary 6
Elevation (m)
Distance (km)

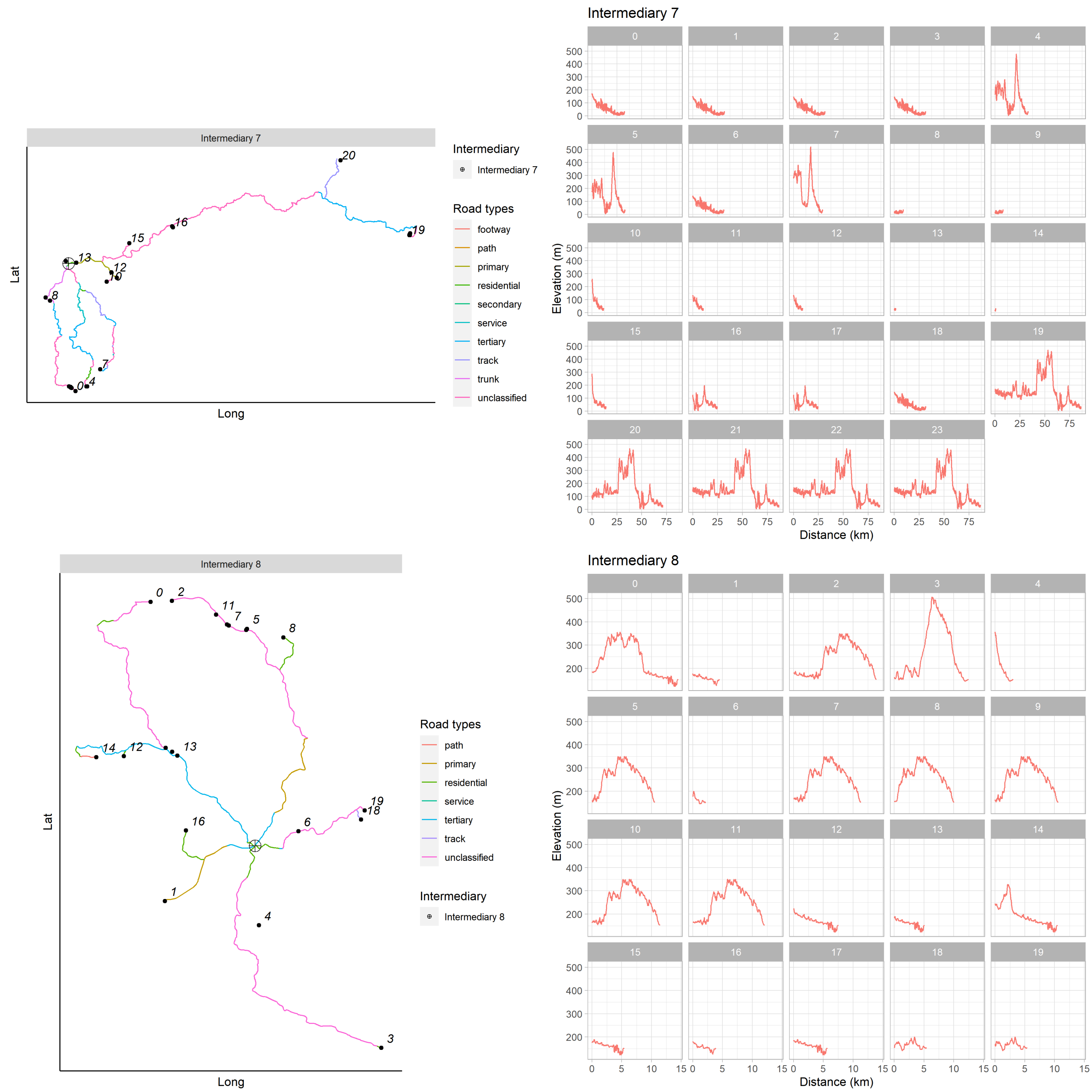



Figure 6.1: Shortest paths colored by road types and elevation profiles for each group (Intermediary).

**Annex 2 - Summary statistics of remoteness indicators for all the (intermediary) groups**

| **Summary Statistics per group** | | | | | |
|---|---|---|---|---|---|
| Statistic | N | Mean | St. Dev. | Min | Max |
| Distance | 25 | 6.198 | 2.858 | 0.096 | 11.970 |
| Weighted_distance | 25 | 11.510 | 6.536 | 0.152 | 29.201 |
| Travel_time | 25 | 8.357 | 4.140 | 0.082 | 14.775 |
| Travel_time_W | 25 | 15.522 | 9.185 | 0.130 | 36.043 |
| Distance | 24 | 7.453 | 3.686 | 1.367 | 16.403 |
| Weighted_distance | 24 | 17.672 | 8.391 | 3.901 | 37.729 |
| Travel_time | 24 | 9.862 | 4.539 | 1.283 | 20.825 |
| Travel_time_W | 24 | 23.257 | 10.052 | 3.662 | 47.774 |
| Distance | 24 | 12.921 | 6.024 | 4.296 | 22.563 |
| Weighted_distance | 24 | 31.009 | 15.184 | 8.398 | 53.733 |
| Travel_time | 24 | 15.272 | 6.590 | 4.002 | 24.612 |
| Travel_time_W | 24 | 36.667 | 16.995 | 7.823 | 59.298 |
| Distance | 25 | 16.461 | 6.471 | 5.693 | 25.212 |
| Weighted_distance | 25 | 39.214 | 17.982 | 9.889 | 66.314 |
| Travel_time | 25 | 19.090 | 9.560 | 6.013 | 34.356 |
| Travel_time_W | 25 | 46.183 | 27.059 | 10.445 | 90.364 |
| Distance | 23 | 3.064 | 2.356 | 0.085 | 10.069 |
| Weighted_distance | 23 | 6.298 | 5.716 | 0.106 | 24.936 |
| Travel_time | 22 | 4.988 | 3.559 | 0.128 | 15.104 |
| Travel_time_W | 22 | 10.226 | 8.658 | 0.159 | 37.404 |
| Distance | 24 | 16.669 | 5.615 | 0.403 | 27.881 |
| Weighted_distance | 24 | 38.152 | 12.839 | 0.588 | 64.237 |
| Travel_time | 24 | 20.740 | 5.459 | 0.806 | 34.739 |
| Travel_time_W | 24 | 47.519 | 12.815 | 1.176 | 80.037 |
| Distance | 24 | 34.052 | 28.050 | 0.721 | 86.469 |
| Weighted_distance | 24 | 72.174 | 58.354 | 1.575 | 178.013 |
| Travel_time | 24 | 47.599 | 42.179 | 1.334 | 124.486 |
| Travel_time_W | 24 | 101.295 | 88.168 | 2.916 | 256.278 |
| Distance | 20 | 8.247 | 3.832 | 2.174 | 14.438 |
| Weighted_distance | 20 | 16.339 | 9.017 | 3.281 | 28.653 |
| Travel_time | 20 | 11.303 | 5.091 | 3.709 | 22.074 |
| Travel_time_W | 20 | 22.170 | 11.658 | 5.597 | 43.734 |

Table 6.1: Summary Statistics per group (Intermediary). Data are displayed and ordered from Intermediary 1 to Intermediary 8 (top-bottom).

## Annex 3 - Kruskal-Wallis results

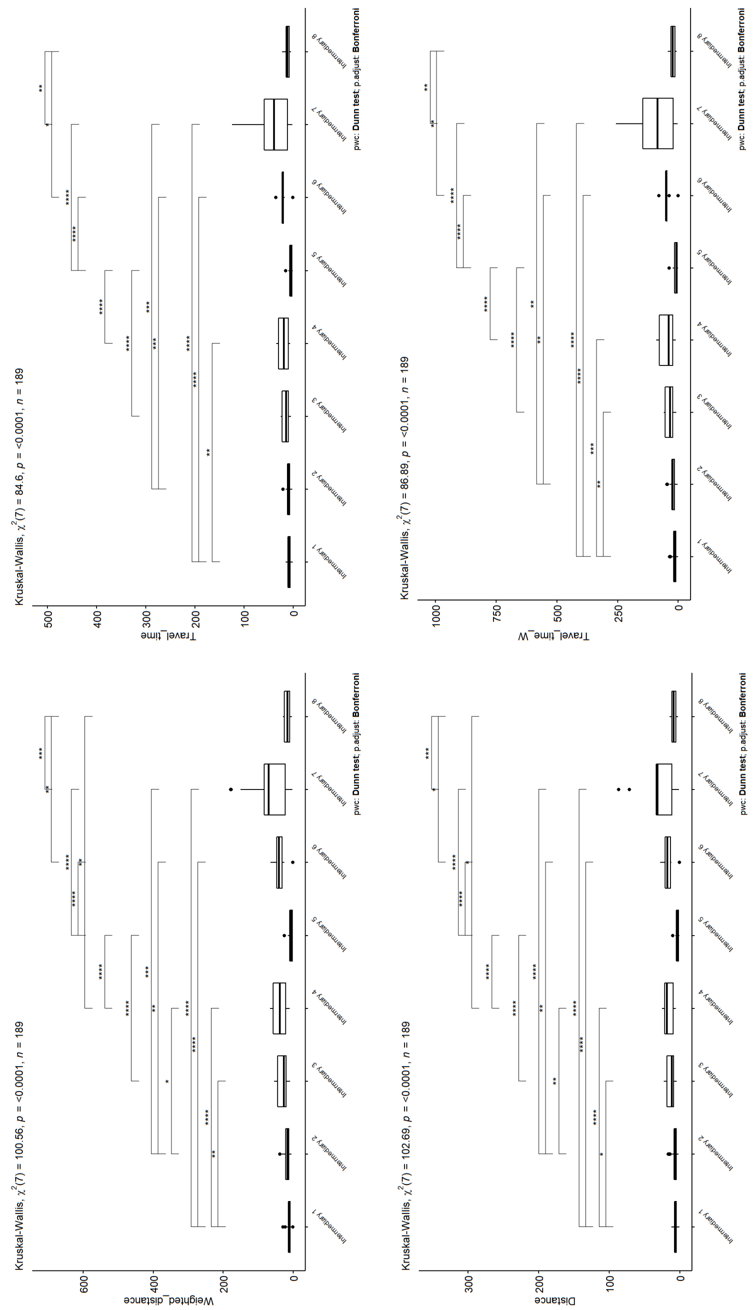



Figure 6.2: Visualization of the Kruskal-Wallis results: boxplots with p-values.

# Biography


**Piette Joséphine**

josephine.piette@hotmail.com

Rue Pierre Depoortere 67, 5020 Vedrin

0476.21.23.63


## Studies

- **Master in Geography, general orientation, in-depth (UCLouvain, 2020 - 2022)**:

  Title of the Master's thesis: *Remoteness as an inhibitor or a promotor for farm-level socio-economic and environmental sustainability in Ecuador*, Supervisors : Éric Lambin et Lina Tennhardt

- **Bachelor's degree in Geography (UNamur, 2017 - 2020)**:

  Title of the final work : *«Développement socioéconomique en Grèce : Mise en évidence du rôle des gradients géographiques dans les disparités régionales et influence de la récession»*, Graduated with Distinction.

**UNIVERSITÉ CATHOLIQUE DE LOUVAIN**
**Faculté des sciences**
Place des sciences, 2 bte L6.06.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/sc**