Cost-benefit analysis for RESADE promoted technologies and crops in Togo.

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October 2023

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Acronyms

ICBA	International Center for Biosaline Agriculture
ITRA	Institut Togolais de Recherche Agronomique
RESADE	Improving agricultural REsilience to SAlinity through DEvelopment and promotion of pro-poor technologies and management strategies in selected countries of Sub-Saharan Africa
BADEA	Arab Bank for Economic Development in Africa
IFAD	International Fund for Agricultural Development
NARES	National Agricultural Research and Extension Services
BPH	Best Practices Hub
BCR	Benefit-Cost ratio
NGO	Non-Governmental Organization
DSID	Directorate of Agricultural Statistics, IT and Documentation
PRSA/FSRP	West Africa Food System Resilience Program

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Summary

The RESADE project is implemented in seven countries, including Togo. The overall goal of the project is to improve food security for farming households by combating soil salinity and climate change. In Togo, the project is led by the Institute of Agricultural Research (ITRA), which conducts experiments at two hubs, one of which is in Atti Apédokoè, the focus of this study. The global project plan includes various studies, including a cost-benefit analysis, which is the subject of this report for the Atti Apedokoe site in Togo.

The study relied on two sources of data: the first from the project experiment level (documenting the various operations carried out at the hub and associated costs and focus group discussions), and the second from the farmers outside the experiment center who adopted the technologies disseminated within the project. Data from the farmers were collected from approximately thirty respondents, with a majority being women (57%), using a questionnaire.

All the collected data was used to construct the cost-benefit calculation model to generate profitability results. The obtained results show that the cost-benefit ratios at the hub level are less than one, which is not necessarily indicative of poor results, considering that it is a "research project." However, at the farmer level, the benefit-cost ratios are greater than one. This indicates a positive impact of the project, as its goal is to disseminate various technologies to farmers to reduce the effects of soil salinity, ultimately reducing food insecurity and improving the livelihoods of households. The varieties Jasmine 85, Arica 11, and IR841 should be further promoted by the project. The economic and social benefits of the project are already apparent, and it is strongly desired that the project provides equipment for primary processing, especially rice dehullers, to reduce the long distances traveled by producers for processing.

1. Introduction

The RESADE project is funded by the International Fund for Agricultural Development (IFAD) and the Arab Bank for Economic Development in Africa (BADEA). The project is implemented by the International Center for Biosaline Agriculture (ICBA) in partnership with national partners- the National Agricultural Research and Extension Services (NARES). RESADE targeted seven SSA countries in which the salinization of agricultural land is a growing problem. These are for Southern Africa Botswana, Mozambique and Namibia and for West Africa The Gambia, Liberia, Sierra Leone and Togo (**Error! Reference source not found.**). T he project is designed to support national agricultural development policies and strategies of the target countries by rehabilitating and increasing the productivity of salinity-affected lands, and will provide technical assistance in salinity management to other IFAD- and BADEA-funded projects being implemented in these countries.

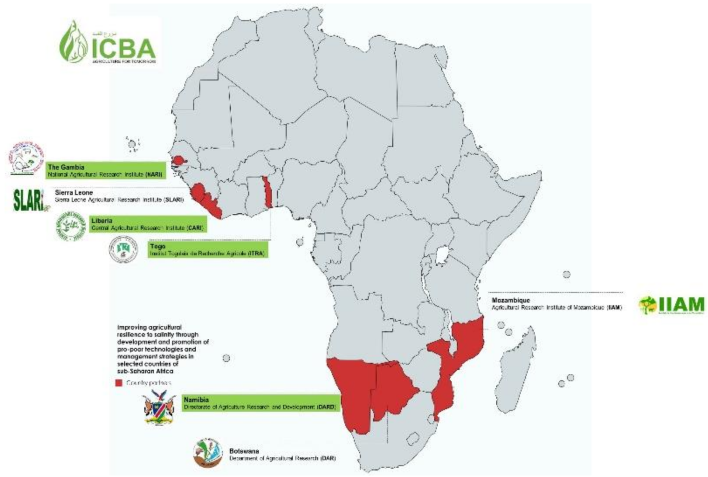


Figure 1. RESADE Project Countries

The goal of the project is to improve food security and reduce poverty of poor smallholder farmers, particularly women, in salinity-affected areas in Botswana, The Gambia, Liberia, Mozambique, Namibia, Sierra Leone, and Togo. The development objective of the project is to increase agricultural productivity and incomes in salinity-affected agricultural areas by:

- Introducing salt-tolerant crops and best agronomic management practices
- Developing value chains for introduced cropping systems
- Building the capacity of farmers and extension workers in salinity-resilient and climate-smart agriculture in collaboration with National Agricultural Research and Extension Services (NARES).
- Incorporating climate-smart and salinity-resilient agricultural models and approaches into national agricultural development policies and strategies in the seven target countries.

The project is expected to deliver the following outcomes:

- Around 11,550 smallholder farmers in targeted areas, at least half of them women, adopt new cropping systems that are resilient to salinity and climate change and utilize climate-smart innovative intensification technologies and practices that increase productivity and mitigate/prevent further salinization.
- In targeted areas, productivity of saline lands is increased by 30%, and economic returns to smallholder farmers are increased by 20%.
- Climate-smart and salinity-resilient agricultural models and approaches are incorporated into national agricultural development policies and strategies in the seven target countries.

The project activities in Togo were implemented in a Best Practices Hub (BPH) established in Atti-Apedokoe (Prefecture of Ave) and its surrounding villages (Kekekope, Betekpo, Attitekope). The project used the Farmer Field School approach to disseminate technologies, increase awareness, and to equip smallholder farmers with knowledge on technologies that help to overcome salinity issues and increase crop yields and revenue.

Explored technologies in the framework of the implementation of RESADE project in Togo include the introduction of new crops and varieties (salt-tolerant crop varieties), soil amendments, crop fertilization, crop management, irrigation methods such as drip irrigation systems (including leaching fraction method) to reduce the salinity effect via leaching and soil moisture conservation. Foods and recipes based on tested crops in the hub were made to develop crop value chains. In Togo, the experimentations in the framework of the project have been underway for three growing seasons (2020, 2021 and 2022 farm seasons). Beneficiary farmers have been involved in project activities from the beginning. The objective of this study is to provide a detailed analysis of the costs and associated benefits of the technologies introduced by the project.

The study’s main objective is to conduct an in-depth cost-benefit analysis of the small-scale technologies tested and other crop intensification options. Specifically, the study aims to explore the quantitative and qualitative variables that influence the cost of the evaluated technologies in the BPH. Using socio-economic data, the study will estimate the potential benefits of applying the tested technologies to smallholder farmers in Atti-Apedokoe and surrounding villages (Togo). The cost-benefit analysis results will guide the project team's future priorities.

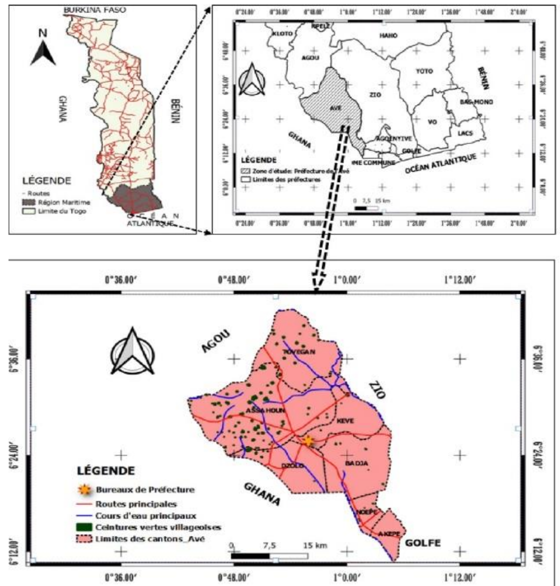
Apart from the general introduction, the document is structured in two (02) main parts: the first sets out the methodology used to carry out the study, and the second presents the main results obtained.

2. Methodology

The proposed methodological approach is based on an annualized participatory analysis, the objective of which is to retrospectively assess the economic benefits of the technologies promoted by the project.

2.1. Study site

The pilot site for the Best Practices Hub (BPH) in Togo, where the trials are conducted, covers an area of 1 hectare enclosed with wire fencing and guarded by a security agent. The hub is equipped with an irrigation system used for conducting the trials. Surrounding the hub, there is rice and vegetable cultivation over an area of approximately 9 hectares. The hub is located in Atti-Apedokoe, a village in the Assahoun canton (**Error! Reference source not found.**), situated in the Maritime region of the country. This locality is about three (3) kilometers away from the village of Assahoun, the capital of the canton from which it derives its name. Furthermore, Assahoun is a significant village located less than one (1) kilometer from Keve, the capital of the Avé prefecture, with which it shares administrative and banking services. Atti-Apedokoe shares its territory with other neighboring villages such as Ando, Kekekope, Attitekope, Betekope, Gasokope, and others. It is, therefore, a densely populated area.



Source: CBA Togo, 2023

Figure 2. Ave prefecture where the hub is located

The area is characterized by an economy primarily based on agriculture, which is still traditional, often in the form of family or small-scale farming. Productivity is limited due to low yields. Subsistence crops such as rice, maize, yam, cassava, sweet potato, taro, cowpea, and groundnut are grown in the area, with maize being the predominant crop. Additionally, the practice of horticulture by farmers is becoming more common, with crops like tomatoes, okra, spinach (Gboma), amaranth, peppers, lettuce, etc., being cultivated.

Land overexploitation leading to soil fertility decline and land salinization are some of the main challenges related to the quality of arable land. People of Atti-Apedokoe acknowledge that salinity is a real development issue in their area, but they only recently became aware of the phenomenon due to ignorance. "Yes, our lands are affected by salinity, and the phenomenon is spreading from low-lying areas to uplands," they say. "Almost all the lands in the region are affected by salinity. Signs of salinity in our lands include white crystals (**Error! Reference source not found.**), soil compactness, and poor water infiltration. Furthermore, there are specific weeds that used not to grow here, but now they are starting to invade our cultivated lands." The

Figure 3. Salt crystals on the ground in Atti-Apedokoe

local population considers the impact of salinity to be moderately severe, but they believe that it affects crop productivity to varying degrees. For example, maize yields have reportedly decreased by around 50%, while salinity-related yield losses for horticultural crops are estimated at 25%. The causes of salinity are more related to the original materials of the land than to the current farming practices or non-exceptional climatic conditions.

Although the phenomenon of salinization is relatively recent, it is rapidly progressing across all the lands in the area, and to date, no resilience intervention or solution approach has been proposed by technical services (including government, NGOs, etc.) or by the local population themselves. In fact, these communities seem to denounce a situation of neglect from which they believe they are suffering. They have never been alerted or assisted regarding the issue of salinity, neither by public services nor by non-governmental organizations (NGOs). They have also not received any training on managing soil salinity.

The local population has acknowledged that in recent years, they have experienced significant drought in their area. This drought has been characterized by a scarcity of rainfall and its uneven distribution over time. This has had an impact on crops, especially maize, groundnut, and cowpea, which have experienced unusual price hikes at certain times of the year. At the same time, the crops that typically generate income for them, such as horticultural products, have also seen drastic price reductions, leading to occasional selling at low prices. However, the locality has not experienced flooding or extreme weather conditions like earthquakes or landslides.

In terms of adaptation, the locality does not have an irrigation system to address the lack or irregularity of rainfall for many of its crops. Even the water reservoir that provides the community with drinking water is used to irrigate low-lying horticultural areas often dries up when the drought persists, leaving the population in distress.

2.2. BPH and farms firm school characteristics

The project started in 2019 with a baseline study including a face-to-face survey with farmers that concluded in 2020. Experiments on the hub experiments began in 2020 with rice variety trials. It was after a series of training sessions for farmers on good agricultural practices in 2021 that the technologies were disseminated in the farming community, leading to the appearance of the "Jasmine 85" and "Arica 11" rice varieties on farmers' fields in 2022. However, following the project's approach, during the three (03) years of experimentation on the hub, a small plot of 0.06 hectares was made available to farmers for them to grow rice according to their practices and the innovations they had learned.

On the Atti-Apedokoe site, which is the subject of this study, the technologies focus on salt-tolerant crop varieties and other climate-smart agricultural practices. Some of these technologies are in an experimental stage, while others are potentially being used in the farming community. The crops involved in these endeavors include rice, sorghum, millet, panicum, quinoa, barley, and cowpea.

The experiments are grouped into five (5) technological packages, namely:

- **Soil Amendments**: These experiments involve the use of organic materials such as *Leucaena leucocephala* leaves, biochar, chemical materials like natural phosphate, and dolomite lime for soil amendment. Soil amendment is considered an effective strategy for managing saline-affected soils. This technology was experimented with over three seasons: in 2021 (rainy and dry seasons) and in 2022, focusing on sorghum and millet crops.
- **Fertilization**: In addition to combating soil salinity with organic materials, it is important to support the development of plants that require immediate access to nutrients to grow. Fertilization experiments explore different fertilizer doses, including composts and foliar fertilizers, among others. This technology was tested over three seasons: in 2021 (rainy and dry seasons) and in 2022, with a focus on sorghum and millet crops.
- **New Crops and Varieties**: There are crop varieties that are resistant to soil salinity. These crop varieties are tested to evaluate their level of resistance/tolerance under the saline conditions of Atti-Apédokoe. This experiment aims to diversify crops in areas affected by salinity. Crops such as rice, sorghum, millet, barley, panicum, quinoa, and cowpea were experimented with over two seasons (2021 and 2022).
- **Crop Management**: This experiment assesses different sowing periods to minimize the impact of soil salinity on plant development. Its goal is to select appropriate planting dates for two introduced crops. Over two seasons (2021 and 2022), sorghum, millet, and quinoa were experimented with using this technology.
- **Screening varieties of rice**: Rice is one of the main crops grown in the area. It is essential to identify rice varieties that are tolerant to salinity while also exhibiting good agronomic performance. This experimentation was initiated on the hub with this technology over three seasons (2020, 2021, and 2022).

The table 1 gives details of the various technologies and their level of implementation.

***Table 1**: Technologies developed with the project.*

Crops	Technologies	Seasons	Level of implementation
Rice	Screening of varieties rice *around 09 varieties:* ▪ *ARICA-6* ▪ *ARICA-11* ▪ *Jasmine 85* ▪ *IR841* ▪ *BR-47* ▪ *BR-78* ▪ *BRRI* ▪ *dhan-61* ▪ *dhan-67*	2020 2021 2022	In the Hub Outside the Hub *(with 03 varieties: JASMINE 85, ARICA 11, and IR841)*
Sorghum	Soil amendments *around 05 treatments* ▪ *Control* ▪ *Rock phosphate* ▪ *Dololime*	2021 (a) 2021 (b) 2022	In the Hub

	▪ *Biochar* ▪ *Leucena leaf*		
	Fertilization *around 04 treatments* ▪ *Control* ▪ *Organics compost* ▪ *Formula calculated based on soil fertility.* ▪ *Foliar fertilizer*		In the Hub
	Crop management *around 01 Variety* ▪ *ICSV 700*	2021 2022	In the Hub
	New crop and varieties *around 02 varieties* ▪ *ICSV 700* ▪ *ICSR93034*	2021 2022	In the Hub
Millet	Soil amendments *around 05 treatments* ▪ *Contrôle* ▪ *Rock phosphate* ▪ *Dolomi* ▪ *Biochar* ▪ *Leucena leaf*	2021 (a) 2021 (b) 2022	In the Hub
	Fertilization *around 04 treatments* ▪ *Contrôle* ▪ *Organics compost* ▪ *Formula calculated based on soil fertility.* ▪ *Foliaire fertilizer*		In the Hub
	Crop management *around 01 variety* *IP 19586*	2021	In the Hub
	New crop and varieties *around 02 varieties* ▪ *IP 19586* ▪ *MC94C2*	2021 2022	In the Hub
Cowpea	New crop and varieties *around 02 varieties* ▪ *IRLI-9334* ▪ *IRLI -9643*	2021 2022	In the Hub
Barley	New crop and varieties *around 02 varieties* ▪ *CM72* ▪ *581/A*	2021 2022	In the Hub
Panicum	New crop and varieties *around 01 variety* ▪ *BP-1*	2021 2022	In the Hub
Quinoa	New crop and varieties *around 03 varieties* ▪ *ICBA-Q3* ▪ *ICBA -Q4* ▪ *ICBA -Q5*	2021 2022	In the Hub
	Crop management *around 01 variety*	2022	

	▪ *ICBA-Q5*		

Source: CBA Togo, 2023
(a)= Rainy season / (b)= Dry season

The learning of these new technologies takes place through a farmer field school approaches. In this approach, farmers are invited to training sessions on technical practices, best practices Hub, and more, with a focus on combining theory and practical application. These training sessions occur within the hub, and it is hoped that farmers, once back on their own farms, will replicate the practices they have learned. As a result, three rice varieties (JASMINE 85, ARICA 11, and IR841) are now being cultivated by farmers in the BPH and farmers in the village. Exploratory surveys conducted with some farmer leaders in the beneficiary villages. have confirmed the presence of these varieties in the farming community. It should be noted that the IR841 variety is a local variety that has been cultivated in the area for years. Therefore, it can be said that two new varieties have been introduced, with IR841 already being a locally existing variety produced for many years. Regarding taste after cooking, farmers have affirmed that these varieties have a good flavor appreciated by consumers. This has led to increased demand for these varieties in the market, presenting a good opportunity for farmers and other market participants.

The implementation of this learning approach has prompted producers to reconsider their organizational structure. As a result, six farmer cooperatives (3 in the BPH and 3 outside the BPH) were established and formalized and all of them were able to actively participate in the training sessions. The producers in the study area are small-scale farmers with small landholdings, typically less than 1 hectare for all the farmers encountered. They derive their primary income from agriculture. In addition to rice, they cultivate crops such as maize, cassava, and vegetables, among others.

As a reminder, the training of farmers was conducted using a cascade approach. Farmers trainers were initially trained by experts from the International Center for Biosaline Agriculture (ICBA) on good agricultural practices resilient to soil salinity, with the aim of equipping them with participatory diagnostic tools to identify and analyze production constraints at the village level. These technical skills enabled trainers to effectively apply knowledge in the field with farmers.

The training sessions were conducted both in theory and practice on site. In the theoretical aspect, interactive discussions focused on the best practices of the modules to be developed. The practical aspect involved applying the theoretical elements taught on a demonstration plot within the hub. While most of the practices and theory centered around rice cultivation (one of the main crops in the area), trainers also included good practices related to other crops. Overall, the training covered four major themes, which are:

- ***Soil Amendment and Management***: This theme encompassed practices related to soil improvement, including the use of organic materials and chemical inputs to manage soil salinity.
- ***Fertilization***: The training addressed various aspects of fertilization, emphasizing the use of composts, foliar fertilizers, and other nutrients to support plant growth.

- ***New Crops and Varieties***: This theme focused on introducing and experimenting with crop varieties that are resilient to soil salinity, including rice, sorghum, millet, barley, panicum, quinoa, and cowpea.
- ***Crop Management***: The training covered techniques to optimize crop management, including selecting appropriate planting dates to mitigate the effects of soil salinity on plant development.
- ***Processing of agricultural products***: This involved training producers on good hygiene practices and implementing new technologies for processing agricultural products (bread flours of sorghum, soy, cassava, yam and plantain, corn couscous, bakery, and pastry products, etc.).

Through this comprehensive training approach, farmers were equipped with the knowledge and necessary skills needed to adapt to and manage saline soil conditions, thereby improving their agricultural practices and potentially increasing crop yields.

2.3. Identification of practices, and the crops promoted.

As described earlier, various crops, including rice, sorghum, millet, cowpea, barley, quinoa, and panicum, were experimented with in the hub using different practices. The observed practices in the hub include:

- ❖ **Nursery Establishment**: One of the good practices taught to farmers in the hub is the use of seedling nurseries, especially for the rice varieties cultivation. This practice significantly reduces the quantity of rice seed required. In the study area, farmers are accustomed to direct seeding and broadcasting.
- ❖ **Seeding**: Seeding is done in two forms depending on the crops: transplanting for crops that go through the nursery phase, with one plant per hole, and direct seeding for crops that were not raised in nurseries. The seeding rate for these crops varies from 2 to 3 seeds per hole.
- ❖ **Fertilization**: Fertilization is carried out in two forms, organic and mineral, using recommended doses.
- ❖ **Biochar Production**: The production of biochar is an important practice within the project, as it is a scientifically proven method for combating soil salinity and improving soil fertility.
- ❖ **Irrigation**: Irrigation is facilitated through a system installed in the hub to ensure the availability of water throughout the year, particularly during dry periods.

Since the start of the project until the completion of this study, three varieties of rice including two ARICA 11 and JASMINE 85(introduced by ICBA) and IR841, which can be considered a local variety in this context, have been distributed and cultivated by farmers in the hub and surrounding.

2.4. Data collection and description

The preparation for the data collection mission involved a series of meetings and email exchanges between the ICBA team, ITRA team, and me as the Consultant in charge of this study.

The meeting with ICBA team took place on July 26, 2023, and served to clarify the scope of the study. During this meeting, ICBA team provided guidance and shared tools that were already available and standardized for all countries. It also involved sharing the data collection tool developed by ICBA team. The content of this tool was discussed in detail for a better understanding. It's worth noting that this tool was used for the rest of the mission.

Two meetings were organized with the project team at the Togolese Institute of Agronomic Research (ITRA). The first meeting focused on the various technologies developed at the hub (such as seed varieties, farm seasons, implementation approach, etc.), as well as the existing data related to trials and accounting. Based on the information obtained, two data collection tools were designed—one for researchers and another for financiers—modeled after the tool developed by ICBA team. The second meeting aimed to ensure a clear understanding of the content and usage of these two tools.

For the technologies tested in the experimental station, ICBA's developed Excel file, which contained elements corresponding to data collection on the costs and benefits of technologies, was initially considered. However, it was found to be too complex given the structure of technical and financial data management within the project. Consequently, two other more user-friendly tools were developed primarily for financial purposes based on the ICBA tool.

Collecting data with these tools required the presence of researchers involved in the project and accounting personnel. The two files were provided to researchers and financiers, and each group input their respective information. Continuous communication was maintained with these stakeholders during the data input period. Once the files were filled out, a working session was organized with the project team and individuals responsible for providing the data to better understand the information contained within the files and ensure that it was accurately recorded. Following this meeting, the data was structured and reported in the format required by ICBA.

For the technologies disseminated to farmers working outside of the BPH, a separate tool was developed by ICBA to collect data from these farmers. In accordance with ICBA's instructions, data was collected through a questionnaire from about thirty (18 women and 12 men) project beneficiaries who were farmers outside the BPH. The selection of these farmers was done through a random draw based on the list of the three cooperatives that had been structured and formalized with the project's support. To ensure gender representation in the selection of farmers, the list of farmers was divided into two smaller lists (men and women). A random draw was conducted using the Excel spreadsheet software from the Microsoft Office suite for each of these two smaller lists. In the end, 12 men and 18 women were surveyed.

The absence of knowledge or practice of standard units by farmers in their agricultural activities led to the development of workarounds for conversions. Here are some of the methods used:

- Calculation of yield in conventional units: Yield calculations were based on the finished product obtained and sold in the market, which is white or milled rice. The rice sold by the farmers is processed rice, meaning white rice. This rice is packaged in 50 kg bags for sale.

Therefore, the quantity of rice obtained from farmers is collected. This quantity is then multiplied by a factor of 65%[1] to convert it into conventional paddy rice units. For example, a farmer who ends up with 2 bags of white rice weighing 50 kg each, then the total weight is 100 kg, would have produced 154 kg (=100/65) of paddy rice;

- Price Calculation for Paddy Rice: The same method was used to calculate the price of paddy rice.

Given the difficulty of obtaining the costs of agricultural operations per treatment, mechanical and arithmetic calculations were performed to determine these costs. The total cost of the operation for the trial is divided by the number of treatments in the trial to obtain the cost of the operation per treatment.

The products from the experimental harvests were not sold. Therefore, to determine the selling price of the products to calculate income, secondary data from the National Directorate of Agricultural Statistics was used, taking into account the monthly selling price in the Maritime region for the month when the harvest took place.

The selling price of **barley**, **quinoa**, and **panicum** could not be determined. These are products that are not found in consumption markets in Togo or neighboring countries. Extensive searches on international statistical data websites such as FAOSTAT and Trade Map were unsuccessful. Therefore, the analysis did not include these crops.

The various economic operations performed were reported on a per-hectare basis.

For training, kits, equipment, and other costs related to training sessions, as well as machinery and equipment costs, salaries, and security expenses, these costs were not extrapolated per hectare. These expenses are considered fixed costs that do not depend on the cultivated area.

It should be noted that these costs and benefits are recorded according to the size of the cultivated areas, and extrapolations were made to bring the costs to a per-hectare basis.

The seeds used for experiments at the hub were provided to the project team by ICBA free of charge.

2.5. Analysis method

The different levels of collected data were verified, various calculations were performed and then synthesized.

Two levels of data processing and analysis are proposed for each technology, depending on the data source (experimental site, farmer level, or a combination of both sources):

- "Excel ICBA" file processed using formula programming: This programming generated a summary table of expenses (costs) and benefits, from which the cost-benefit analysis was conducted.

[1] A good mastery of processing must achieve a yield rate of 65% for white rice and 70% for parboiled rice, taken from: GIZ, 2013. Improving the quality of rice, Cahier n°2; Trainer's manual, Burkina Faso, July 2013.

- Data collected from farmers: Data from farmers were entered, processed, and synthesized (averages calculated) in a single file. The major lines of expenses (costs) and benefits were established, forming the basis for the cost-benefit analysis.

These various levels of analysis provide a comprehensive assessment of the costs and benefits associated with each technology, taking into account data from experimental sites and farmers.

***Table 2**: Outline of presentation of results*

Cost for a season	Technology 1	Technology 2	...	Technology n
Machines and equipment				
Inputs				
Operation				
Technical support learning costs				
Maintenance				
Harvest				
Cost (Cultivated area)	Technology 1	Technology 2	...	Technology n
Cost per ha				

Benefit for a season	Technology 1	Technology 2	...	Technology n
Yield (kg/ha)				
Price selling (f cfa/kg)				
Benefit per				

Benefit and cost actual	Technology 1	Technology 2	...	Technology n
Benefit				
Cost per ha				
Cash-flow				
Update factor				
Benefit actual				
Cost actual				
IRR				
NPV				
PP				

Benefit-Cost Ratio (BCR)
Benefit actual
Cost actual
Ratio

The economic and financial data, on the one hand, related to the expenses or costs associated with the implementation of a technology, and on the other hand, the benefits quantified in monetary terms, are used to calculate the benefit cost ratio (BCR). In general, a project with a benefit-cost ratio (benefit/cost) greater than 1 should be considered profitable and acceptable for implementation.

The study had its fair share of challenges, the most significant being the structuring of data at the project's accounting level, particularly concerning the payment of labor for agricultural operations. Many activities were paid for in a single payment statement without distinguishing between technologies. For example, a payment statement might encompass activities such as plowing, weeding, and fertilization, but it wouldn't specify which trials required these operations. Consequently, it was necessary to put in meticulous efforts to cross-reference accounting data with technical data to obtain apparent values. However, this method inherently created sources of errors, approximations, or omissions that could affect the results of the analysis. As such, this limitation of the study should be taken into account.

The lack of detailed accounting records tied to specific technologies makes it challenging to precisely allocate costs and benefits to individual trials or experiments. Therefore, the analysis may have some degree of imprecision due to the need for data reconciliation between financial and technical records.

2.6. Variables for CBA (cost, output, and life cycle and lands variables)

The analysis focuses on the treatments of the technologies. For each technology, experiments are conducted, and each experiment includes multiple treatments or crop varieties. These experiments were set up on elementary plots with salinity characteristics. Table 3 presents the various experiments conducted at the hub between 2020 and 2022. In total, 98 treatments are analyzed over the three (03) years of experimentation, in addition to field data, which, however, are processed for a single year (2022). Since soil fertility measurements (soil restoration) were not carried out in soil analysis, the study remains in the conditions of the initial implementation of the experiments.

The cost variables consist of current expenses directly involved in production and the depreciation of equipment and machinery (drilling, irrigation pipes, boots, scales, tarpaulins, etc.).

The variables falling under the assets category are yield and selling price, which allows for the calculation of revenue. On the hub, the harvested products from the experiments are not sold. They are used as seeds made available to the beneficiary farmers of the project for the adoption process. Sales prices are identified in the national statistical data from the DSID[2].

The figures used in the cost-benefit analysis model correspond to average investment, cost, and benefit amounts per producer and gross amounts for the treatments. The summaries are based on averages. Projections related to costs and benefits were calculated based on the current costs and benefits of the treatments. The cost-benefit analysis covers a three-year implementation period, and a discount factor was applied to convert costs and benefits to present value. Covering a three-year implementation period, a discount rate of 10%, calculated based on the prevailing interest rate at Orabank Togo and the overall risk associated with the agricultural sector, was

[2] DSID: Monthly bulletin of the market information system, SIM Togo (2021, 2022), PRSA

applied. The use of the discount factor converts costs and benefits generated during different years of the project to their present value.

For the calculation of the NPV (Net Present Value), the following were considered as investments at the hub (Table provided by ITRA): the cost of equipment and machinery ($4600 US), the cost of goods, services, and inputs ($189940 US). The total of these costs is estimated at $194,540, which is equivalent to 113,983,128.47 FCFA (we considered the exchange rate of 2019 for Senegal which is $1=585.911 Fcfa. We did not find for Togo and Togo and Senegal have the same currency)[3]. At the farmer level, the implementation of technologies by the farmers involves training in the use of these technologies. In this context, farmers are expected to invest in acquiring this knowledge. Therefore, the cost of farmer investments includes the cost of training provided by the project to farmers, which amounts to 1,716,600 FCFA in 2022.

***Table 3**: The different trials carried out in the hub between 2020 and 2022*

Technology	Essais	Crops
Soil amendments	Amendment 1 (No amendment)	Sorghum et Millet
	Amendment 2 (Leucena)	Sorghum et Millet
	Amendment 3 (Biochar)	Sorghum et Millet
	Amendment 4 (Phosphate rock)	Sorghum et Millet
	Amendment 5 (Dololime)	Sorghum et Millet
Fertilisation	F1 (No fertilization)	Sorghum et Millet
	F2 (NPK 140g + Urée 62 g)	Sorghum et Millet
	F3 (NPK 140g + Urea 62 g) + Foliar fertiliser 5ml solution for 5l water	Sorghum et Millet
	F4 (Compost)	Sorghum et Millet
New crops and varieties	Millet IP 19586	Millet
	Millet MC94C2	Millet
	Sorghum ICSR 93034	Sorghum
	Sorghum ICSV 700	Sorghum
	Panicum BP-1	Panicum
	Quinoa ICBA Q3	Quinoa
	Quinoa ICBA Q4	Quinoa
	Quinoa ICBA Q5	Quinoa
	Cowpea ILRI 9334	Cowpea
	Cowpea ILRI 9643	Cowpea
	Barley CM 72	Barley
	Barley 581/A	Barley
Screening of Rice varieties	ARICA 6	Rice
	ARICA 11	
	IR 841	
	JASMINE 85	
Crop management	Sorghum ICSV 700 - Date 1	Sorghum
	Sorghum ICSV 700 - Date 2	Sorghum
	Millet IP 19586 - Date 1	Millet
	Millet IP 19586 - Date 2	Millet

Source: CBA Togo, 2023

[3] OECD (2023), Exchange rates (indicator). doi: 10.1787/037ed317-en (Accessed on 17 October 2023)

3. Results and discussion

All the collected data (from the hub and outside the hub) were processed, and various cost components, in addition to benefits, were calculated. Trend analysis of the results shows that the cash flows for all technologies are negative, with the least negative results observed for the "Screening varieties of rice" technology. This technology has allowed the introduction of new varieties into farmers' fields to date. To align with the existing situation at the farmer level and considering the hub's results, it is appropriate to focus the cost-benefit analysis solely on the "Screening varieties of rice" technology and specifically on the three varieties disseminated to farmers. Therefore, the various results presented in the upcoming subsections pertain exclusively to the "Screening varieties of rice" technology both in the hub and outside over three seasons.

3.1. An elaborate list of costs

The cost elements are based on the various operations carried out in the establishment of crops. Thus, regardless of the treatment or variety being experimented with in the field or among farmers, the main cost components remain the same. The costs are structured into three major categories:

- ***Machinery and Equipment***: This includes machines and equipment purchased for experimental needs. Items such as scales, boots, irrigation systems, etc., fall under this category. The cost of equipment or machinery depreciation is considered in the calculations. When the same equipment or machinery is used for multiple technologies, the fixed cost (depreciation) of the equipment/machinery is used for all the technologies involved.
- ***Inputs***: This category encompasses seeds, chemical fertilizers (NPK, urea, foliar fertilizers), and organic manure (compost, biochar, etc.).
- ***Operations***: This cost category takes into account inputs and agricultural operations for the establishment and maintenance of crops (clearing, plowing, sowing, weeding, purchase and application of fertilizers, insecticides, and herbicides, etc.).
- ***Training***: In the technology transfer process, a series of training sessions were provided to farmers to teach them the best agricultural practices developed at the hub. These training sessions were conducted at the hub and included practical and theoretical components.
- ***Maintenance***: This category includes expenses related to equipment maintenance and employee salaries
- ***Harvesting***: This part of the costs covers expenses related to harvesting and post-harvest operations (harvesting, threshing, winnowing, sorting, husking, etc.).

3.2. A list of economic benefits and social benefits

The benefits identified both with and without project intervention can be divided into those that are quantifiable in monetary terms and those that are qualitative and/or very difficult to quantify or monetize. While only quantifiable and monetizable benefits will be considered for the calculation of the benefit-cost ratio, it is also important to consider the more qualitative benefits to have a more comprehensive understanding of all the project's advantages. Table 4 classifies the project's benefits.

Table 4: Economic and social benefits for farmers

	Benefits	Quantifiable
Economic	Adoption and resumption of rice production by some farmers	Yes
	Adoption of new agricultural technologies	Yes
	Access to more productive and salinity-tolerant seed varieties	Yes
	Restoration of soil fertility	Yes
	Increase of Arab land	Yes
	Recovery of degraded land and its cultivation	Yes
	Increase in agricultural productivity and income	Yes
	Increase in food security	Yes
	Group purchase and sale of inputs and agricultural products	Yes
	Access to credit loans and agricultural financing	Yes
	Development of new agribusiness	Yes
Social	Social Strengthening of social cohesion	No
	Women empowerment	No
	Ease of access to basic social services	No
	Better perception of agricultural activity	No
	Vitalization of community work	No

Source: CBA Togo, 2023

However, only productivity has been quantified for the cost-benefit analysis (CBA). The other parameters require soil analyses or are simply projected into the future.

3.3. Monetary value of costs

As previously mentioned, the study focused on rice variety tests. Expenses at the hub level (**Table 5**) vary from one year to another year but are consistent within the same year for all three varieties. This can be explained by the fact that cultivation operations, although they remain the same from one year to another, are not carried out with the same intensity. This variation in intensity affects the duration of implementation.

Table 5: Monetary value of costs in the hub

Rubric	Screening varieties of rice 2020			Screening varieties of rice 2021			Screening varieties of rice 2022	
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11	Jasmine 85	IR841
Machines and equipment	-	-	-	93 300	93 300	93 300	77 750	77 750
Inputs	2 278	2 278	2 278	2 278	2 278	2 278	2 278	2 278
Operation	57 241	57 241	57 241	68 340	68 340	68 340	41 640	41 640
Technical support learning costs	-	-	-	1 242 850	1 242 850	1 242 850	1 716 600	1 716 600
Maintenance	-	-	-	114 000	114 000	114 000	276 000	276 000
Harvest	5 400	5 400	5 400	8 160	8 160	8 160	5 520	5 520
Cost (Cultivated area)	64 919	64 919	64 919	1 528 928	1 528 928	1 528 928	2 119 788	2 119 788
Cost per ha	**4 839 733**	**4 839 733**	**4 839 733**	**5 059 333**	**5 059 333**	**5 059 333**	**4 079 333**	**4 079 333**

Source: CBA Togo, 2023

At the producer level outside the BPH (**Table 6**), costs are higher for the Jasmine 85 and Arica 11 varieties, which are the main varieties introduced by the project. These results can be explained by the fact that these new varieties are more demanding and require more maintenance. The same trend is observed among men, but among women, expenses were higher with IR841 and Arica 11. In all cases, these newly introduced varieties would require additional labor.

***Table 6**: Monetary value of costs for farmers outside the BPH*

Rubric	**Screening varieties of rice All**			**Screening varieties of rice Male**			**Screening varieties of rice Female**		
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11
Machines and equipment	4 604	3 515	4 456	5 463	3 488	3 680	6 397	3 529	4 113
Inputs	43 579	37 201	43 600	81 640	58 025	48 680	21 830	26 788	30 900
Operation	19 091	25 225	23 571	30 500	45 250	25 800	12 571	15 213	18 000
Harvest	18 200	22 504	22 793	30 025	36 700	22 160	11 443	15 406	24 375
Cost (Cultivated area)	85 474	88 445	94 420	147 628	143 463	100 320	52 241	60 936	77 388
Cultivated area (Average)	*0,19*	*0,23*	*0,21*	*0,24*	*0,45*	*0,23*	*0,17*	*0,12*	*0,16*
Cost per ha	**442 453**	**385 940**	**459 786**	**609 561**	**316 608**	**445 867**	**316 270**	**519 987**	**495 283**

Source: CBA Togo, 2023

3.4. Quantify and determine benefits.

In the experimental setting (**Table 7**), the yields of the introduced varieties are very promising. Jasmine 85 ranks first with yields ranging between 9 and 10 tonnes per hectare, followed by Arica 11 with yields averaging around 9 tonnes per hectare, and IR841 closes with yields averaging around 7 tonnes per hectare. The choice of these varieties by the producers is therefore justified considering their agronomic performance.

It should be noted that at the hub level, the crops grown are not sold but are sometimes used as seed material for dissemination among the producers. For calculation purposes, the project's potential profits from selling the harvested products are obtained by multiplying the quantity of the product obtained by the market selling price. These prices vary from year to year.

***Table 7**: Quantification of the benefit in the hub*

Rubric	**Screening varieties of rice 2020**			**Screening varieties of rice 2021**			**Screening varieties of rice 2022**	
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11	Jasmine 85	IR841
Yield (kg/ha)	10 660	7 500	10 140	10 430	7 050	9 650	6 910	6 640
Price selling (fcfa/kg)	181	181	181	215	215	215	252	252
Benefit	**1 929 460**	**1 357 500**	**1 835 340**	**2 242 450**	**1 515 750**	**2 074 750**	**1 741 320**	**1 673 280**

Source: CBA Togo, 2023

At the farm level outside the BPH (**Table 8**), it is clear that the Jasmine 85 variety has stood out with a yield of 3.38 tonnes per hectare, followed by IR841 with a yield of 3.2 tonnes per hectare, and Arica 11, which yielded 2.6 tonnes per hectare. Based on gender, it is observed that men are more inclined to cultivate the Jasmine 85 variety, whereas women tend to prefer Arica 11. However, it remains the case that the introduced varieties are more likely to meet the productivity needs of the producers compared to traditional local varieties.

According to the information gathered from the field, rice is sold in its processed form (white rice). It is sold either at the market to retailers or to wholesalers, mainly from Ghana, or to the rice milling plant. Prices vary depending on the season, and rice is typically packaged in 50 kg bags. Producers make profits ranging from 700,000 FCFA to around 1,000,000 FCFA per hectare.

***Table 8**: Quantifying the benefit for farmers outside the BPH*

Rubric	**Screening varieties of rice All**			**Screening varieties of rice Male**			**Screening varieties of rice Female**		
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11
Yield (kg/ha)	3 380,89	3 217,93	2 612,93	4 143,60	2 423,05	2 427,34	2 945,06	3 615,36	3 076,90
Price selling (fcfa/kg)	268	276	273	280	283	265	262	273	293
Benefit	**906 079**	**888 952**	**713 330**	**1 158 136**	**685 117**	**643 731**	**771 184**	**986 994**	**899 993**

Source: CBA Togo, 2023

3.5. Profitability, IRR, NPV, and payback period

The analysis of **Table 9** shows that the cash flows are negative, meaning that the expenses incurred are greater than the revenues. These results do not allow for the calculation of the Net Present Value (NPV), Internal Rate of Return (IRR), or the payback period (PP). However, these results do not seem disastrous. Indeed, since these are research activities, all the cultivation operations that need to be carried out require labor and therefore incur expenses.

***Table 9:** Profitability in the Hub*

Rubric	**Screening varieties of rice 2020**			**Screening varieties of rice 2021**			**Screening varieties of rice 2022**	
	Jasmine 85	IR841	ARICA11	Jasmine 85	IR841	ARICA11	Jasmine 85	IR841
Benefit per	1 929 460	1 357 500	1 835 340	2 242 450	1 515 750	2 074 750	1 741 320	1 673 280
Cost per ha	4 839 733	4 839 733	4 839 733	5 059 333	5 059 333	5 059 333	4 079 333	4 079 333
Cash-flow	- 2 910 273	-3 482 233	-3 004 393	-2 816 883	-3 543 583	-2 984 583	-2 338 013	-2 406 053
Update factor	0,91	0,91	0,91	0,83	0,83	0,83	0,75	0,75
Benefit actual	1 754 055	1 234 091	1 668 491	1 853 264	1 252 686	1 714 669	1 308 279	1 257 160
Cost actual	4 399 758	4 399 758	4 399 758	4 181 267	4 181 267	4 181 267	3 064 864	3 064 864
Cash-flow actual	-2 645 703	- 3 165 667	- 2 731 267	-2 328 003	-2 928 581	-2 466 598	-1 756 584	-1 807 703
NVP								
IRR								
PP								

Source: CBA Togo, 2023

The analyses show positive cash flows for the producers surrounding the hub (**Table 10**), indicating that the producers were able to generate positive cash flows for their activities. These cash flows were discounted using a discount factor estimated at 10% to calculate the Net Present Value (NPV), which yielded a negative result. This result can be explained, firstly, by the fact that the generated revenues are not sufficient to cover the cost of investment, and secondly, it is the very first year of production for these introduced varieties, and it will take at least two (2) years before being able to cover the investments.

***Table 10**: Profitability for farmers outside the BPH*

Rubric	Screening varieties of rice All			Screening varieties of rice Male			Screening varieties of rice Female		
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	ARICA11	Jasmine 85	IR841	ARICA11
Benefit per	906 079	888 952	713 330	1 158 136	685 117	643 731	771 184	986 994	899 993
Total cost per ha	442 453	385 940	459 786	609 561	316 608	445 867	316 270	519 987	495 283
Cash-flow	463 626	503 011	253 544	548 575	368 509	197 864	454 914	467 007	404 710
Update factor	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91
Benefit actual	823 708	808 138	648 481	1 052 851	622 834	585 210	701 077	897 267	818 176
Cost actual	402 230	350 855	417 987	554 146	287 825	405 333	287 518	472 716	450 257
Cash-flow actual	421 478	457 283	230 494	498 705	335 009	179 876	413 559	424 552	367 918
NVP	-607 344			-703 010			-510 572		
IRR	-21%			-26%			-16%		
PP									

Source: CBA Togo, 2023

3.6. Benefit-to-cost ratios

The benefit-cost ratio has been calculated based on the discounted benefits and costs, as presented in the **Table 11**, and the ratios are all less than one. This is not surprising considering the previous results and the nature of the project, which is a research project. In research projects, it is common to have benefit-cost ratios less than one because the long-term benefits and impacts often outweigh the initial investment and costs, especially when considering the broader implications and knowledge gained from the research.

***Table 11**: Benefit-cost ratio in the hub*

Rubric	Screening varieties of rice 2020			Screening varieties of rice 2021			Screening varieties of rice 2022	
	Jasmine 85	IR841	Arica11	Jasmine 85	IR841	Arica11	Jasmine 85	IR841
Benefit actual	1 754 055	1 234 091	1 668 491	1 853 264	1 252 686	1 714 669	1 308 279	1 257 160
Cost actual	4 399 758	4 399 758	4 399 758	4 181 267	4 181 267	4 181 267	3 064 864	3 064 864
Ratio BC	**0.40**	**0.28**	**0.38**	**0.44**	**0.30**	**0.41**	**0.43**	**0.41**

Source: CBA Togo, 2023

The real impacts of this research project are observed at the producer level outside the BPH. Therefore, when the indicators in the analysis are favorable, the project has achieved its objectives. Table 12 shows that benefit-cost ratios are above one. Overall, the IR841 variety has the best ratio (2.30), followed by Jasmine 85 (2.05) and Arica 11 (1.55). The same ranking is observed among men. However, among women, Jasmine 85 has the best ratio (2.44), followed by IR841 (1.90) and Arica 11 (1.82). These ratios suggest that the project's benefits may not fully outweigh the costs for each variety, but they still provide valuable insights into the performance and economic viability of the different rice varieties.

Table 12: *Benefit-cost ratio for farmers outside the BPH.*

CB	**Screening varieties of rice All**			**Screening varieties of rice Male**			**Screening varieties of rice Female**		
	Jasmine 85	IR841	ARICA11	Jasmine 85	IR841	ARICA11	Jasmine 85	IR841	ARICA11
Benefit actual	823 708	808 138	648 481	1 052 851	622 834	585 210	701 077	897 267	818 176
Cost actual	402 230	350 855	417 987	554 146	287 825	405 333	287 518	472 716	450 257
Ratio BC	**2.05**	**2.30**	**1.55**	**1.90**	**2.16**	**1.44**	**2.44**	**1.90**	**1.82**

Source: CBA Togo, 2023

3.7. Finalized cost-benefit analysis of technologies.

Over the three years of implementing the Rice Variety Screening technology at the hub level, the average ratio is 0.39. At the producer level, this ratio averages 1.97 (1.84 for men and 2.05 for women). These ratios provide insights into the overall cost-benefit performance of the technology over the specified time frame, with higher ratios at the hub level and slightly lower ratios among agricultural producers, but still indicating positive benefits relative to costs.

Table 13*: Summary of benefit-cost ratios in and outside the hub*

Hub	**BCR (Technology per year)**
Screening varieties of rice 2020	0.35
Screening varieties of rice 2021	0.38
Screening varieties of rice 2022	0.42
Screening varieties of rice (2020-2022)	0.39
Farmers	**BCR (Technology per category)**
Screening varieties of rice (All)	1.97
Screening varieties of rice (Male)	1.84
Screening varieties of rice (Female)	2.05

Source: CBA Togo, 2023

4. Conclusion

The purpose of this study was to conduct a cost-benefit analysis of the RESADE project, launched in 2019 at the Atti-Apedokoè site in Togo, in the western part of the Maritime Region. This project primarily aims to transfer technologies to farmers to overcome the soil salinity they are facing.

The results of the cost-benefit analysis show that at the hub level, all benefit-cost ratios are less than one, indicating unfavorable outcomes. However, at the producer level, the calculations are promising results for each of the three introduced rice varieties with the benefit-cost rations greater than one. At this stage, the project appears to have generated technologies that are well-suited to the agroecological conditions of the region and, at the same time, contribute to improving the living conditions of farmers by increasing their income. This renewed hope in the rice sector in the area has allowed some farmers who had abandoned rice cultivation due to soil salinity issues to resume rice farming. Nevertheless, the revival of rice production in the area faces two major challenges. First, the lack of nearby processing units (rice mills) forces farmers to transport paddy rice over long distances for milling, which increases their production costs. Second, there is a lack of financial resources to meet the expenses related to agricultural inputs and labor for expanding cultivated areas.

To conduct this study, we collected data from two sources: the project experiments center (BPH) and farmers outside the BPH. We faced some difficulties while collecting data at the project experiment level, particularly with financial data. For instance, payment records for labor at the hub do not distinguish between different technologies and cultivation operations. Therefore, expenses related to different cultivation operations and technologies can be grouped together on the same payment record. Additionally, sometimes the payment of expenses is delayed, which makes it difficult to accurately allocate expenses.

It is worth noting that besides the cost-benefit analysis, which evaluates the financial profitability of the RESADE project at the producer level, particularly for the technologies that have already been disseminated among them, such as the salt-tolerant rice varieties, the project has also generated significant economic and social benefits for the beneficiary farmers and the wider community. Given the enthusiasm of the population and the interest shown in the implementation of activities, it is important for the RESADE project to further support these farmers, especially in providing necessary equipment, strengthening value chains, marketing products, and capacity building for more long-term impact.

Furthermore, considering the above, the study suggests that for future projects and those with an impact evaluation focus, expense records should be clearly dedicated to each technology, and these records should be updated as expenses occur.

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Annexe

See attached Excel files.