STDF Standards and Trade Development Facility

STDF PROJECT GRANT APPLICATION FORM

The Standards and Trade Development Facility (STDF) offers grants for projects that promote compliance with international SPS requirements. Eligible organizations can apply for STDF project funding using this form. Applicants can request up to a maximum of US$1,000,000 for projects that have a duration of three years or less.

The STDF Working Group makes decisions on requests for STDF funding. The following types of projects are given favourable consideration:

- Projects relevant to the identification, development and dissemination of good practice in SPS-related technical cooperation, including projects that develop and apply innovative and replicable approaches;
- Projects linked to STDF work on cross-cutting topics of common interest;
- Projects that address SPS constraints through regional approaches; and
- Collaborative and inter-disciplinary projects focused on the interface / linkages between human, animal and plant health and trade, and benefiting from the involvement of two or more partners or other relevant organizations.

Complete details on eligibility criteria and other requirements are available in the *Guidance Note for Applicants* on the STDF website (www.standardsfacility.org). Please read the *Guidance Note* before completing this form. Completed applications should be sent by email (as Word documents) to STDFSecretariat@wto.org.

Project Title	**Improving the institutional capacity of Colombia and Ecuador to mitigate trade barriers due the high cadmium levels in cacao**
Objective	The aim of this project is to improve the institutional capacity of Colombia and Ecuador in managing cadmium concentrations in cacao to mitigate the trade barrier imposed by the new standards, using a regional approach. Specifically we will: (1) harmonize methods for cacao sampling and measurement of cadmium levels in cocoa and soils according to international standards; thereby preparing the countries for adequate inspection and potential certification/accreditation programs; (2) improve mapping baselines and mapping capacity for zoning of vulnerable areas in the two countries, based on harmonized methods and data on cadmium levels in cacao beans; (3) develop scientifically sound and context-relevant guidelines on good agricultural practices that lower cadmium levels in cacao.
Budget requested from STDF	USD 516,989
Total project budget	USD 617,999
Full name and contact details of the requesting	**Colombia** Marcela Urueña Gómez Viceministra de Asuntos Agropecuarios

organization(s)	Ministerio de Agricultura y Desarrollo Rural (MADR) de Colombia **Ecuador** Alexandra Peralta Viceministra de Desarrollo Productivo Agropecuario Ministerio de Agricultura y Ganaderia (MAG) de Ecuador **Project implementation entities** 1. Department of Earth and Environmental Sciences, Katholieke Universiteit Leuven (KU Leuven) Kasteelpark Arenberg 20, 3001 Heverlee, Belgium 2. International Center for Tropical Agriculture (CIAT) Recta Cali-Palmira, km 17, Valle del Cauca, Colombia 3. Escuela Politécnica del Litoral (ESPOL), Facultad de Ciencias de la Vida, Vía Perimetral, km 30.5, Campus Gustavo Galindo, Guayaquil, Ecuador 4. Department of Environmental Sciences Wageningen University & Research Droevendaalsesteeg 4, 6708PB, Wageningen 5. Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA) Vía Mosquera, km 14, Bogotá Colombia
Full name and contact details of contact person for follow-up	**Colombia** Dr. Oscar Mauricio Bernal Vargas Director de Cadenas Agricolas y Forestales (MADR) Email: Oscar.bernal@minagricultura.gov.co Tel: +571 2543300 **Ecuador** Sr. Luis Rueda Gerente del Proyecto de Reactivación del Café y Cacao Nacional Fino de Aroma Email: cafeycacao@mag.gob.ec Tel: +593 2 3960100 / 3960200 Ext. 1152 **Project implementation entities** Erik Smolders Full Professor of Environmental Chemistry, Department of Earth and Environmental Sciences, KU Leuven Email: erik.smolders@kuleuven.be Tel: +32 16329677

I. BACKGROUND & RATIONALE

1. Relevance for the STDF

This proposal is written on behalf of the requesting organizations of Colombia and Ecuador to help the cacao sector of the Andean region comply with new international standards on the concentration of cadmium (further abbreviated as Cd) in cocoa products; these regulations are very recent and will considerably affect the sector, particularly in Colombia and Ecuador. The implementing organizations of this project are involved in agronomic research on this issue in these countries and have been involved with the local institutions on food surveillance and with industry; it is felt that the local **institutions are not prepared to cope with the new standards, neither on surveillance nor on implementing**

good agricultural practices. This proposal addresses the issue, through a coordinated regional approach with participation of Colombia and Ecuador, and has relevance and potential implication in Peru.

The European Union (EU) has established limits on Cd in cacao-derived products (Commission Regulation EU No. 488/2014 of 12 May 2014 amending Regulation EC No. 1881/2006). The limits entered into force on January 1, 2019. The limits refer to Cd concentrations in the final product, not in the bean and the limits depend on the cocoa content of the product. On July 2 2018, the Codex Alimentarius Commission[†] has also defined, for the first time, limits for contamination of naturally occurring contaminants found in chocolate, the limits for Cd are 0.8 or 0.9 mg Cd/kg of chocolate, depending on the cocoa content. These Codex limits are very close to the EU (EU: 0.8 mg Cd/kg for chocolate >50% cocoa; Codex: 0.8 mg Cd/kg for chocolate with cocoa between ≥50-<70% and 0.9 mg Cd/kg for those with cocoa ≥70%.). The state of California has agreed in February 2018 on even stricter Cd limits for chocolate products under Proposition 65, above which consumers will be warned through product labelling. With the recent Codex adoption, it is foreseeable that several other countries will follow soon.

The **limits mainly affect the cacao sector in the Andean Region**, the reason being that the soils are naturally more enriched in Cd compared to that in other cacao producing regions, an aspect also acknowledged in the new Codex Alimentarius by referring to the Cd issue in cacao as **a naturally occurring contaminant**. Multi-elemental fingerprinting analysis of a global collection of cacao beans of different origin showed that the concentration of Cd in beans from South America were nearly three times higher than those from Central America and East Africa and ten-fold above those of West Africa[1].

The socio-economic impact of these new and upcoming regulations in Colombia and Ecuador cannot yet be calculated precisely; however, surveys of the extent of Cd concentrations in the beans are indicative that 30-50% of the beans may not be accepted unless blending of high Cd with low Cd bean is made. The new EU regulation and the Codex limits the concentration of Cd in the final product, not in the beans. There is no unique conversion from a chocolate limit to a bean limit but a maximum concentration of 0.6 mg Cd/kg bean, with or without peeling, is often informally used among buyers. Indeed, assuming that beans contain about 50% butter (an average value), then the concentration of Cd in the cocoa powder would be 1.2 mg Cd/kg for peeled beans (nibs) with 0.6 mg Cd/kg. Thus, if chocolate with 70% cocoa solid is produced from this cocoa mass the final concentration of Cd will be 0.8 mg Cd/kg, which is within the allowable limits. National surveys show that the average concentration in peeled beans of Ecuador is 0.90 mg Cd/kg (n=560; data of 2017 by KU Leuven group, Argüello et al., 2019[2]). In other surveys the averages are 0.94 mg Cd/kg[3] and 1.0 mg Cd/kg[4] (Ecuador), 1.1 mg Cd/kg[5] (Honduras) and 1.0 mg Cd/kg[6] (Peru). No nationwide surveys are publically available for Colombia but information from two informal sampling campaigns (n=638) indicate that about 80% of the collected beans contain Cd concentrations above 0.5 mg Cd/kg with 52% surpassing the 1 mg Cd/kg bean. Without doubt, **the average bean Cd concentrations exceed the limit and illustrate the extent of the issue, a significant trade barrier that is already felt by the countries and expected to impact even more strongly after January 1st 2019**.

The particular flavour and aroma of cacao beans from South America, especially those from the Andean region, have given a strong reputation of high-quality to the cacao from the region. The implementation of the new EU regulation on Cd is seen as a major threat for the cacao sector of these countries, where 90% of the production is in the hands of resource-poor small-scale farmers. Moreover, in Colombia cacao is widely promoted to replace the production of illicit crops in post-conflict areas and **the cacao production is expanding rapidly**. As such, the Cd issue is highly sensitive from a socio-political perspective. It is imperative that this problem requires **urgent and coordinated action** to search for solutions based on a strong regional collaboration.

The objective of this project is to improve the institutional capacity of Colombia and Ecuador in managing Cd concentrations in cacao **to mitigate the negative impacts of the trade barrier imposed by the new Cd standards.** The implementing organizations of this project have been working on this topic and have experienced several technical and organizational issues, including (1) lack of harmonization and quality control in the surveillance programs and laboratory procedures; (2) incomplete zoning of the vulnerable areas and recommendation domains, either because of lack of data or because of concerns about sharing data; (3) lack of knowledge on Cd risks for identification of suitable land for cacao expansions and (4) lack of coherent scientifically demonstrated and context-relevant agricultural practices to lower Cd in cacao. These priorities were confirmed during the International Workshop on Cadmium Reduction in the Andean Zone "CacaoCdFREE" (12-14 March 2018) organized by CIAT and CIRAD in

[†] http://www.fao.org/news/story/en/item/1143286/icode/

Colombia, and at meetings discussing national actions, e.g. as organized in Bogota (29 June 2018 by the Swiss cooperation and in Lima 18 July 2018 by the Ministry of Agriculture of Peru) with the participation of multiple stakeholders from Colombia, Ecuador and Peru, including research, government institutions and private sector. The project will use **a regional approach** and is a collaborative effort between European (KU Leuven, Wageningen University), South American (ESPOL, AGROSAVIA) and international (CIAT) organizations who are committed to share their expertise and knowledge to address on this sanitary food standard (i.e. high Cd in cacao beans). The project has a strong relevance and interest from Peruvian actors and will seek to align with their ongoing national action plan on Cd mitigation in cacao.

One of the main gaps encountered in the mentioned countries to address the Cd issue is the **lack of quality control** on the data of Cd concentrations in beans and associated soils. From the published scientific literature of Cd in cacao conducted in the region (i.e. Ecuador, Peru and Colombia), the **majority of the studies did not include quality control programs** with certified reference materials that are indispensable to assure the quality of the measurements of Cd. Many of the studies have not used the modern, but more expensive ICP-MS instrument, for Cd measurement which is preferable for the detection of low concentrations. The lack of standardization and harmonization of laboratory procedures for the bean and soil analyses was also highlighted in the previous above mentioned meetings. There is a clear need to develop and disseminate, regional guidelines and protocols for sampling, conservation and analysis of soil and plant samples, following international standards. Reliable soil and bean Cd data is needed not only for research purposes but also for government planning and commercialization. For that reason, a harmonization program on sampling, sample treatment and sample analysis will be set up that meets international standards, including informing the government institutions and training of the inspectors. This part hence addresses the **development and dissemination of good practice in SPS-related technical cooperation.**

The EU regulation on Cd in cacao was announced in 2014, and since then efforts have intensified in Colombia, Ecuador and Peru to map the areas (zoning) where Cd concentrations are high. It has been confirmed that the contamination is not random but that there is significant spatial association, i.e. hot spot regions stretching >100 km^2 [2]. However, this **zoning is incomplete**, as most of the data collection conducted until now have been scattered across several private and public sector entities which has restricted the sharing of information within and between the affected countries. To ensure that research funding is more effectively invested and to ensure collaboration, this project will take a regional approach by including public and private research organizations in Colombia and Ecuador (i.e. AGROSAVIA, ESPOL). Data will be harmonized with gap filling surveillance of some regions and the maps will be made with a scientifically validated state-of-the art approach through involvement of GIS experts in each country. Such an undertaking illustrates the **use of regional approaches to address SPS constraints.**

Finally, the International Workshop CacaoCdFREE (12-14 March 2018) in Colombia has revealed that there is ongoing research at the regional and at the broader international level on the effects of agronomic factors on Cd concentration in cacao beans by different actors, e.g. evaluation of effects of different cacao varieties, effects of soil amendments including fertilization, effects of cropping systems, among others. The applicants of this project experience that single field observation are often generalised without validation leading to conflicting and confusing messages, i.e. there is a strong need to identify coherent trends in available data and develop recommendations for good agricultural practices that can be demonstrated and evaluated involving end users. The applicants represent a strong scientific expertise, access to field trials across different cacao growing areas as well as an excellent network of relevant actors and institutions in the beneficiary countries and internationally. We propose to coordinate and facilitate the collating of information from field trials followed by a synthesis of trends and lessons, and dissemination of recommended practices to extension workers. This data gathering and training, combined with the translation of the information into context-relevant recommendations for Cd mitigation practices, **illustrate collaborative and inter-disciplinary approaches focused on the research/technologies for mitigation and remediation.**

Since the implementing organizations of this proposal are aware that other regional projects will also address the issue of high Cd in cacao beans in Colombia and Ecuador (e.g. ICCO future application project to STDF, ClimaLoCa project application to DeSIRA) the present proposal will focus mainly on improving (1) surveillance programs and laboratory procedures, (2) improving the mapping capacity for zoning of vulnerable areas and (3) development of guidelines on good agricultural practices to lower bean Cd levels. In this way this work will complement/support future work that is being planned in the region.

2. SPS context and specific issue/problem to be addressed

i) Sustainability and future trends of cacao production in Colombia and Ecuador due to Cd constrains.

Latin America currently produces about 18% of the world cacao[7], a share that is expected to continue growing. The major producers of cacao in the region are Ecuador (290,000 MT), Brazil (180,000 MT), Peru (107,000 MT) and Colombia (61,000 MT). Latin America is currently responsible for about 80% of all fine flavour cacao production in the world. Ecuador is the main producer, but other Latin American countries, such as Peru, also play an important role. For Ecuador, cacao is an important agricultural product for its economy representing about 4% of the total export (excluding oil). The EU and the USA are the main export markets. About 560,000 ha are planted with cacao in nearly all provinces of the country. It is estimated that the cacao sector **generates 600,000 jobs**; its market chain represents 4% of the economically active population and 12.5% of the agriculture economically active population of the country.

In Colombia, it is estimated that more than 54,000 families are involved in cacao cultivation, with plots dispersed across the country in the Caribbean region, passing through the Andean mountain ranges to the northern Amazon and the south-western Pacific coast. Cacao exports currently play a small role in the national economy and cacao production is mostly targeting the national market, with relatively low production levels of about 400 kg/ha on average[8]. This scenario is expected to change in the coming years. Since the initiation of the peace agreement between the Colombian government and the FARC there is increased **support, both from the national government and through international cooperation, to expand cacao cultivation** and replace illicit crops in post-conflict areas[8]. Moreover in some regions in Colombia cacao is partly replacing coffee as a commodity due to the negative impacts of climate change on coffee production. Many traders, sector representatives and producer organizations are considering the international market as the target outlet for the future production of recently planted and projected new areas across Colombia, with a focus on value addition, targeting the growing international market for fine and flavour and **deforestation-free cacao.**

Cadmium is a toxic trace metal that occurs in agricultural soils either by natural (geogenic) or anthropogenic (industrial and agricultural) sources. It can be readily taken up by plant roots and accumulate in edible parts of the plant. Bioavailability of Cd does get affected by soil factors such as: soil pH, organic matter content, and total soil Cd. Exposure pathway for non-smoking population is generally the consumption of contaminated food. Chronic exposure can cause adverse effects on the kidneys and the respiratory system and may lead to osteomalacia (softening of the bones). Due to these health-related issues, food regulations on permissible concentrations of Cd in foodstuff are very stringent and often close to the natural background since the margin of safety between actual and allowable dietary intake is very small. Since the announcement of the new EU regulation on Cd, concerns have raised among cacao growers in Colombia and Ecuador. Because of the widespread contamination of Cd in cacao beans reported in western South America, the problem has been attributed to geogenic origin (young soils formed from parent material rich in Cd).

ii) Institution framework for SPS management in Colombia and Ecuador

Ecuador

The Agency for Regulatory and Control of Plant and Animal Health (AGROCALIDAD) is a governmental institution adjoined to the Ministry of Agriculture (MAG) that controls, promotes and regulates agricultural health and food safety by following national and international standards. The Agency is responsible for the development and implementation of food safety and environmental sound agricultural practices and works together with the private sector for the execution of plans, programs and projects. AGROCALIDAD is the agency that has represented the country in the various meetings held by the Codex Committee on Contaminants in Foods (CCCF, Joint FAO/WHO Food Standards Program) taking an opinion on the proposed draft for maximum levels for Cd in chocolate and cocoa products in order to protect the health of consumers and ensure fair practices in food trade.

The government agency has also made efforts for promoting agricultural health in the Ecuadorian cacao sector. For example, in 2012, AGROCALIDAD released a technical report No. 0183 "Guidelines for good agricultural practices in cacao" in which the agency recommends conducting soil chemical analysis to evaluate soil fertility, organic residues and pesticides, and, heavy metals prior the establishment of new cacao plantations[9]. Despite being a good initiative, the norm gives no further information on sensitive topics such as levels of contaminants (i.e. Cd) in the soil, which can affect the safety, quality and market access of the produce.

For SPS management in the cacao chain in Ecuador private organizations play an important role. For example, the National Association of Cacao Exporters (ANECACAO) supports and campaigns through their associates on the implementation of good agricultural practices for cacao production. The association also works together with local authorities, universities and other private institutions to carry out training programs for cacao producers on SPS measures. This includes providing technical assistance on pest and disease management, and the implementation of mitigation strategies. This association, as many others, has shown much concern about the new Cd regulation since it is expected that other countries will soon also follow the EU in adopting stricter levels for Cd in chocolate.

Colombia

The Colombian cacao chain differs from the Ecuadorian in that global multi-nationals play a limited role. Two Colombia-based companies, Nutresa and Casa Luker, purchase nearly 80% of Colombian cacao bean production, with the remaining volumes flowing to small chocolate manufacturers and international markets[8]. These firms play an active role in increasing cacao production through commercial alliances with farmers, research, technical and social support. The national federation of cacao producers (FEDECACAO) represents 38,000 smallholder farmers in 22 departments of Colombia, and is focused on research, technology transfer and commercialization[8]. They are the primary provider of technical assistance, mainly present in the high production areas of the country.

The National Cacao Council (Consejo Nacional de Cacaoteros) is a sector-wide body comprised of producers, associations, private industry and governmental organizations formalized by the Colombian Ministry of Agriculture and Rural Development (MADR) with a specific mandate to develop the cacao sector. Five regional councils (Santander, Antioquia, Tumaco, Arauca, and Huila) constitute an important space to adapt production systems and extension materials based on producer industries and local needs, and to flag regional research and investment needs. AGROSAVIA (formerly CORPOICA) is the national agricultural research institute of Colombia responsible for setting and implementing the National Cacao Research Agenda, mostly focused on genetic improvement, best management practices, disease management and cacao quality. Several Universities and CIAT are also conducting research within sections of the supply chain.

The National System of Training (SENA – Servicio Nacional de Aprendizaje) is part of MADR and is responsible for agricultural training and adjustment of curriculum designs of existing training programs[8]. Finally of key importance here is the Colombian Agriculture Institute (Instituto Colombiano Agropecuario – ICA) that advises in the formulation, preparation, and implementation of policies, measures and procedures to protect and verify plant health, breeders rights and production quality and the safe use of seeds and agricultural inputs. They are also responsible for laboratory accreditation.

So far, a strong national institutional leadership on the Cd problem is still lacking in Colombia, despite widespread concerns throughout the sector, as informal data gathering suggests that they might be the most affected country by the regulation. There is also great concern among the international community due to potential implications for the post-conflict strategy. Various actors have emphasized the need for national and regional coordination and international donors have supported a number of meetings, that have helped to set priorities including the need for knowledge sharing, mapping, technical support and field based research to mitigate high Cd levels in cacao beans.

In summary, the capacity for SPS management on the issue of Cd in cacao seems to be more developed and with a clear institutional leadership in Ecuador than in Colombia. The public agency AGROCALIDAD and the Reactivation of Coffee and Cacao Project (both under MAG's umbrella) are already interacting with the private sector and research universities (i.e. ESPOL) for the implementation of programs and activities. AGROCALIDAD has the available human talent but this actor needs to be updated with reliable, scientifically robust information and knowledge which is one of the purposes of this project. The lack of institutional leadership in Colombia has put the country behind its peers in addressing the Cd problem. It is important to note that the private sector has played a strong role in data collection, with the obvious disadvantage that data is not publicly available. Because the Colombian authorities strongly support this project the applicants foresee positive changes to build the SPS capacity of the country.

iii) SPS priorities or issues identified in SPS-related capacity evaluations

The SPS priority for the cacao sector in Colombia and Ecuador is the upcoming regulation on Cd by EU and the possible regulations by California in USA. Meetings and workshops at international, regional and country level have been organized in the last years to share experiences and identify research needs to overcome the problem. For example, in July 2016 the Inter-American Institute for Cooperation on

Agriculture (IICA) held a technical forum to discuss about possible solutions to this problem based on the experiences and research conducted at the National Research Institute of Ecuador (INIAP).

In November 2017, the International Cocoa Organization (ICCO) and the Government of Peru organized the first International Symposium on Cocoa Research (ISCR 2017) as a platform to present, at a regional scale, the latest findings on research in cacao and to identify priorities for action. This symposium included the topic "Cadmium contaminant and food safety" on which results of research work conducted in Ecuador, Colombia, Peru and Trinidad and Tobago were presented. In terms of mitigation studies for Cd most of the work has been done in greenhouses and laboratory experiments under controlled conditions this highlights the urgent need to test mitigation strategies under real field conditions.

In March 2018, an International Workshop CacaoCdFREE, on Cadmium in Cacao in Andean countries was held at CIAT in Colombia. In this workshop, researchers from the region, Europe, USA and relevant private and public sector actors gathered to discussed an interdisciplinary research plan to overcome Cd contamination in cacao beans. The objectives of this meeting were to update the outcomes from previous meetings in Peru, identify research gaps and the intention to formulate a regional research project involving public and private sector stakeholders.

In July 2018, the representatives of the cacao sector (public and private) from Colombia, Peru and Ecuador met in the workshop "Cadmium in Cocoa: how to mitigate its economic and commercial impact?" which was organized by the Swiss Embassy in Colombia and the Productive Transformation Program of the Ministry of Commerce, Industry and Tourism of Colombia. The main objective of this meeting was to discuss possible strategies at country and regional level to deal with the challenges and opportunities associated with the application of the coming Cd regulation. The participants of the meeting emphasized the need for more collaborative work within the countries and the necessity to standardize and homologate procedures in the national laboratories for sampling and chemical analysis. Furthermore, the lack of a coherent view on the selection and application of agronomic countermeasures indicates the need for technical cooperation.

The many ad hoc meetings held within the various actors of the cacao sector have been beneficial in that the new regulation on Cd is now a priority in the agenda of the governments of Colombia and Ecuador. Through this meetings it is evident that some work has been done regarding mitigation strategies and that defined and coordinated action plans are only recently being delineated by the respective authorities. Finally, in order to address the SPS priority for the cacao sector training and educational programs as well as technical assistance to farmers are outmost necessary but at the moment largely absent in the respective countries. Technical decisions and sanitary countermeasures taken based on scientific evidence should be properly transferred to the stakeholders to ensure impact and sustainability.

3. Links with national/regional development plans, policies, strategies, etc.

The Colombian and Ecuadorian governments are promoting the production of fine aroma cacao, a sector that is most affected by the risks associated with high Cd levels. The two countries share a strong concern about the new EU Cd regulation and the Cd limits adopted by Codex Alimentarius and for that reason national programs have been recently announced or are being implemented.

The Ministry of Agriculture in Ecuador launched in July 2018 the "National Mitigation Plan for Cadmium in Cacao" which is a national initiative to address the Cd problem. Four aspects are the backbone of the Ecuadorian program: 1) systematization of the information regarding the current situation of the presence of Cd in cacao; 2) coordination with public and private sector the planning, implementation and dissemination of the program; 3) consolidate and execute mitigation strategies for Cd in cacao and 4) evaluation and monitoring of the implemented countermeasures. The results of the agronomic studies that will be collated in this project to mitigate bean Cd will be shared with the competent government agencies to facilitate the dissemination of the results. ESPOL, one of the co-applicants in this project is in close collaboration with the Ministry of Agriculture in Ecuador by leading the scientific committee of the National Mitigation Plan. Moreover, ESPOL is also participating in the development of a regional platform for cacao research in collaboration with the National Research Institute for Agriculture in Ecuador (INIAP).

In contrast to Ecuador, there have been some preliminary initiatives in Colombia to address the Cd issue for the Colombian cacao sector. However, most of these have come from the industry like monitoring of Cd levels in the cacao coming from the main suppliers, but as this is seen a competitive commercial advantage the information is not shared.

This project responds to pressing and urgent issues affecting the cacao sectors by providing short and medium-term solutions to mitigate Cd in the beans. The implementing organizations have identified national plans and private initiatives in both countries. The importance of quality control on Cd measurements has been overlooked; this project is the first coherent and regional initiative on that direction. The proposed project will fill these information gaps thereby strengthening the countries' relevant programs.

4. Past, ongoing or planned programmes and projects

Ongoing projects in Ecuador

The implementing organizations KU Leuven and ESPOL are at the moment involved and leading two research projects in Ecuador in the topic of Cd in cacao which are funded by the Flemish government:

1. Managing Cd concentrations in cacao products: from farm to fork (Project led by partner KU Leuven and ESPOL; 2018-2021)[‡]

This project is a doctoral (PhD) strategic basic research grant awarded to a student at KU Leuven to investigate the influence of post-harvest practices such as fermentation on the distribution of Cd within the different cacao bean tissues. In this project it is proposed that the accurate information and understanding of the micro-scale Cd localization in the cacao beans will allow the development of post-harvest management strategies. Bean washing prior and after fermentation as well as bean polishing will be explored as possible alternatives to reduce Cd concentrations in the beans.

2. Food standards and sustainability in the cocoa supply chain in Ecuador (Project led by partner KU Leuven and ESPOL, 2017-2020)[§]

From 2017-2020, KU Leuven and ESPOL obtained a project with the Flemish overseas agency (VLIR-UOS) to estimate the impact of the EU regulation on the cacao supply chain in Ecuador and to identify possible solutions to mitigate that impact. The project includes agronomical studies to evaluate the geographical distribution of Cd in cacao areas and the application of soil amendments to remediate high Cd areas. Additionally, economic studies are planned to make a cost-benefit analysis of agronomic countermeasures.

During the first year of the VLIR-UOS project a soil-crop (cacao bean) survey was conducted from July-September 2017 to determine the frequency of the Cd limit exceedance in beans and to identify areas of concern (Cd hotspots). This survey was the largest one conducted in Ecuador with 560 paired soil-leaf-bean samples collected in 196 farms. During this survey also information regarding agronomic management practices were collected in a questionnaire to the farmers. All chemical analysis were done in Belgium at KU Leuven, following strict quality control protocols. Soil and plant samples were analysed by ICP-MS to allow high-quality low-level of detection for Cd. The results of the survey confirmed a widespread problem: 45% of the nib (peeled bean) samples exceeded the 0.6 mg Cd/kg limit (Argüello et. al. 2019). Prediction maps for bean Cd were developed from geostatistical analysis of the data as well as the identification of hotspots where mitigation strategies should be focused. The second part of the VLIR-UOS project envisages field studies to investigate soil-based mitigation (liming application) strategies to reduce the concentration of Cd in cacao bean from high risk areas (i.e. cacao grown in soil with acidic pH).

Past projects in Ecuador

The implementing organizations are aware that other projects have been developed in Ecuador in collaboration with public and private institutions but they were not involved in any way on these projects:

1. Strengthen fine flavour cocoa trade chain (Vredeseilanden-VVOB 2016-2017)

Rikolto (former VECO) worked with the Flemish Association for Development Cooperation and Technical Assistance (VVOB) to strengthen the trade chain of the "Nacional" cacao of fine aroma cultivar through the implementation of educational programs for its production and commercialization. The work of this project was only focused in the province of Esmeraldas in Ecuador.

[‡] www.kuleuven.be/onderzoek/portaal/#/projecten/3E170598?hl=en&lang=en
[§] www.vliruos.be/en/projects/project/22?pid=3399

2. Monitoring Cd levels in cacao beans, soil and water (GTZ, CORPEI, ANECACAO, INIAP, 2008-2012)

In Ecuador, the National Institute for Agricultural Research (INIAP) with support from the German Technical Cooperation Agency (GTZ), Agency for Promoting Export and Investment (CORPEI) and ANECACAO conducted a research to monitor the presence of Cd in cacao beans, soils and water, as well as the identification of potential control measures. Results of this study showed that about 80% of the samples (n=156) the concentration of Cd in the bean are above the 0.6 mg/kg threshold[10]. However, this results need to be interpreted with caution and cannot be fully trusted due to analytical issues (see Section II.9). Additionally, since soil-bean paired samples were not taken, the identification of the spatial distribution of bean Cd is not possible.

Ongoing and past projects in Colombia

The implementing organizations AGROSAVIA and CIAT are currently or have been involved in the below outlined projects:

1. Development of a bio-product based on Cd tolerant-bacteria (Project led by partner AGROSAVIA, P1000590 2018-2023)

The Colombian Research Centre for Agriculture (AGROSAVIA formerly CORPOICA) is starting a research project in order to obtain a bioproduct based on the immobilization activity of Cd tolerant bacteria (CdtB). Preliminary laboratory experiments have shown positive results in that the bioproduct can immobilize Cd[11]. Therefore, the first year of research in this project will be focused on the bioeconomic impact of such type of technology in the national market and validate the preliminary results in greenhouse studies comparing both chemical and microbiological treatments. The project will include developing an optimized a medium to deliver the microorganisms to soil substrates and plant tissues. In the second year of the project, several prototypes of excipients will be tested; and finally doses and frequencies of amendments of the final prototype will be assessed in field conditions in Colombian cacao model farms, where contrasting climatic conditions, soil types and Cd concentrations have been characterized.

2. AGROSAVIA Research Agenda on Cd from 2013-2017

In 2013-2017 the "Corporación Colombiana de Investigación Agropecuaria" (CORPOICA, now AGROSAVIA) studied the issue of Cd in cacao in the frame of two large-scale projects that were supported by the Colombian Ministry of Agriculture and Rural Development (MADR). The projects were: "Genetic yield improvement program in Cocoa as a strategy to strengthen Colombian Cocoa production" and "Technological strategies to strengthen Colombian Cocoa Production".

One of the activities in the first project was the selection of individuals of *Theobroma cacao* L. from the Colombian germplasm vegetable bank, with properties like i. genetic diversity, ii. crop quality, iii. disease resistance, iv. compatibility and v. Cd absorption interacting with Cd-tolerant endophytic bacteria. On the second project, the activity related to Cd was the assessment of soil management strategies to tackle Cd uptake in cacao crops where high Cd levels were reported. This project investigated the following: i. clonal tops and rootstock propagation under Cd stress, ii. use of arbuscular mycorrhizae forming fungi translocation to reduce Cd absorption in seedlings, iii. selection of cacao farms with several soil/grain Cd concentrations to isolate and characterize soil oxalotrophic, potassium solubilizing–Cd tolerant bacteria (KSM–CdtB). From those, the most promising strategy found was the use of microorganisms as a bioremediation process to tackle the bioavailability of the metal in seedlings.

3. Geographical information system mapping for optimized cacao production in Colombia (Project implemented by partner CIAT in collaboration with Pennsylvania State University and USDA/Natural Resources Conservation Service (NRCS) 2018-2019)

This project is part of the Cacao for Peace initiative (USAID/USDA) and seeks to define suitable areas for optimal and sustainable cacao production and to identify high-yielding and high quality cacao varieties in a pilot area in the Sierra Nevada de Santa Martha, Colombia. This pilot will improve the national suitability map of cacao developed at scale of 1:100,000[**] by generating new soil information at high resolution (30m) and scale of 1:25,000. Cadmium concentration in soils will be mapped and added as a limiting factor for defining suitable areas for expanding cacao production and low Cd cacao varieties mapped.

[**] http://www.upra.gov.co/uso-y-adecuacion-de-tierras/evaluacion-de-tierras/zonificacion

Available information such as geology, land use and soil maps, digital elevation models combined with new soil data will be used for mapping soil properties (incl. Cd) using a digital soil mapping approach based on soil geomorphology and fuzzy logic.

Other past and ongoing projects in Colombia

The implementing organizations are aware of other projects in Colombia but they are not or were involved in any way on these projects:

1. Projects funded by the National Cocoa Fund (FNC) are outlined below, resources for this projects are obtained from the Cocoa Development Fee. This is a contribution from the cacao producers in accordance with law 67 of 1983, equivalent to 3% on the sale price for each kg of cacao that is sold to the processors and exporters. These resources are used to support research, technology transfer and commercialization programs; in harmony with the political goals set for the rural sector and agricultural activity within the National Development Plan. Beneficiaries of such project are producers and national consumers. The projects executed with resources of the FNC are:

2017
- Evaluation of strategies to decrease the content of Cd in tissues of the cacao plant, in Santander

-Determination of polluting sources that affect the content of Cd in the cacao bean

-Determination of Cd levels in cacao beans in some municipalities of the departments of Santander and Arauca

2018
-Evaluation of strategies to decrease the content of Cd in tissues of the cocoa plant

-Evaluation of pH and zinc in the accumulation of Cd in tissues of the cacao plant during the production phase, Santander

-Evaluation of the management of crop and crop residues as a strategy for the mitigation of Cd in cacao beans, Arauca

Future regional projects that include Colombia and Ecuador

1. STDF/PPG/577 "Mitigation and Remediation of Cadmium Contamination in Cocoa Beans in Latin America & the Caribbean": this is a regional project that will be implemented by the International Cocoa Organization (ICCO) and the beneficiary countries are Colombia, Ecuador, Peru and Trinidad and Tobago. The aim of the project is to develop a regional strategy for establishing mitigation and remediation measures for Cd in cacao beans[††]. The proposal is still under development so no further information is available.

2. CLIMA-LOCA "Low cadmium and climate-relevant innovation to promote sustainable cacao production in Colombia, Ecuador, and Peru": another regional initiative that aims to support the growing cacao sector in Colombia, Ecuador, and Peru by developing context-specific, low cadmium and climate-smart cacao production systems. To that end the project will improve the availability of site specific information, technology development and knowledge transfer. A concept note of this proposal was presented to the EU (DeSIRA program) and selected for further development of a full proposal. The project will be led by CIAT in collaboration with CIRAD, KU Leuven, Wageningen University, as well as local universities and research institutes in the three target countries.

3. COCOAndina is a Wageningen University-led research proposal focussing on the same three countries. The objectives are twofold: (i) to develop an interdisciplinary understanding of the factors that determine system responses and adaptation to critical disturbances (including new food safety regulation) affecting the cocoa sector in the Andean countries, and (ii) to use this understanding to co-design innovations for resilient and socially inclusive cocoa farms and landscapes. CIAT, AgroSavia and ESPOL are full partners in the project and collaboration with KU-Leuven is foreseen. This initiative has been selected based on a pre-proposal and the full proposal will be submitted on Feb 1.

[††] http://www.standardsfacility.org/PPG-577

In summary, the past projects and initiatives that were described above have been developed only at (sub) country levels in Ecuador and Colombia; whereas this STDF project proposal is a regional one with the advantage of sharing of data, knowledge, human resources and enhanced collaboration for the mutual benefit of the cacao sectors of Colombia and Ecuador. Finally, a strong component of this project will be the development of analytical quality control capacities as well as laboratory training to assure an efficient transfer of the technology and aid in building the institutional capacity for SPS management.

5. Public-public or public-private cooperation

Public and private stakeholders in Colombia and Ecuador are already addressing the Cd issue in cacao, though this initiatives lack of scientific support which limits the implementation into a larger scale. In order to ensure alignment with national programmes and actions and ownership by the country, we have interacted with many of the relevant institutions over the past 2 years and their demand for regional technical support was expressed in the before mentioned meetings (i.e. CacaoCdFREE), and is expressed in the support letters included in this application.

Our project considers farmers as the main beneficiaries, as well as government officials and researchers from local and national universities and research institutes and major extension agencies. The activities of this project will be developed in close collaboration with the government entities responsible for promoting the cacao sector, i.e. AGROCALIDAD in Ecuador, and ICA in Colombia under the respective Ministries of Agriculture. The involvement and collaboration of the Governments will facilitate the uptake of recommendations and dissemination of the results, and will aid in the development of a sustainable strategy at country and regional level.

The cooperation and input from top European research institutions like KU Leuven and Wageningen University will be key for accomplishing the technical objectives of this project. The participation of Wageningen is also instrumental due to the involvement of WEPAL, a Wageningen-based and world-leading organiser of proficiency testing (PT) programs in the fields plants, soil, sediments and organic waste. This will allow laboratories in the two countries to participate in a global ring test program that will be equipped with specific reference samples for Cd in cacao and soils, thus facilitating sustained quality control and possibilities for laboratory certification.

This project will also take advantage of the strong network and the experience from the International Center for Tropical Agriculture (CIAT) in the region. CIAT has a 50 years presence in the region, with its headquarters in Colombia and regional offices in Asia, Africa and Latin America (Peru and Nicaragua). CIAT has recently signed MOU's with the Ministries of Agriculture in Ecuador and Peru. CIAT, through its long presence and strong networks in the region is in a good position to ensure alignment and complementarity of the project with national initiatives. In fact, CIAT is already co-leading a regional initiative on Cadmium in Cacao in which many of the relevant actors of public and private sector are participating and which followed from the March 2018 regional meeting CacaoCdFREE[‡‡]. Since then, the group has worked on a concept note for a regional research project focused on finding solutions to mitigate Cd levels in cacao, and participated actively in various meetings on the issue at national levels in the region. In the project proposed here we will build on this existing network as a platform for coordination, training and dissemination; and expand it further. The project will facilitate the organization of regional workshops and sharing of knowledge and information among the two countries, and beyond. Moreover, CIAT has validated soil mapping models and developed high resolution soil information across the tropics (e.g., Kenya, India, Colombia, El Salvador, Brazil, among others) as well as developing capacity on digital soil mapping in partner organizations.

Two local research partners will take part in this project: ESPOL in Ecuador and AGROSAVIA in Colombia. They will collaborate in data collection, synthesis of existing data, technology transfer and student exchanges. The entities can build on a strong presence and reputation in their respective countries and an active research program supporting the cacao sector, including research on Cd in cacao. The proposed project partners have experience working with each other (i.e. KU Leuven and ESPOL led VLIR-OUS project in Ecuador, The Cacao for Peace project in Colombia).

The cacao private sector through its main associations ANECACAO in Ecuador and FEDECACAO in Colombia will be continuously updated with advances and results of the project, this will enhance collaboration and trust in the project. FEDECACAO in Colombia and ANECACAO in Ecuador are important dissemination

[‡‡]https://blog.ciat.cgiar.org/es/peru-ecuador-y-colombia-se-movilizan-para-enfrentar-el-problema-de-cadmio-en-cacao/

entities with access to ten thousands of farmers through their extension systems for that reason it is important to seek their cooperation.

6. Ownership and stakeholder commitment

This project proposal is an initiative of the Governments of Colombia and Ecuador through their respective Ministries of Agriculture and have proposed that this project will be implemented by the consortium of research organizations led by **KU Leuven** (Belgium). For the implementation of this project, **KU Leuven** (Belgium) is strongly supported (through grant contract) by the following national and international subcontractor organizations: **Wageningen University** (Netherlands), **International Center for Tropical Agriculture** (CIAT), **Escuela Superior Politecnica del Litoral** (ESPOL, Ecuador) and **AGROSAVIA** (Colombia). This proposal was developed to address the priorities of main public/private entities for SPS management in the Colombian and Ecuadorian cacao sector and that were expressed in the last regional meetings (i.e. CacaCdFREE). This proposal was endorsed by the Ministries of Agriculture in Colombia and Ecuador, private cacao producer federations such as FEDECACAO who have expressed their support for its implementation (see letters of support, Appendix 4).

Government Entities in Colombia and Ecuador that strongly support this project

The Ministry of Agriculture (**MAG**) in Ecuador is currently collaborating with the projects conducted jointly by KU Leuven and ESPOL mainly in the collection of data to map areas with high Cd content. In Ecuador, there will be two governmental institutions that this project will collaborate with and has the support, both under the umbrella of MAG**.** The first one is the Rehabilitation of Coffee and Cacao Project, which has about 300 field technicians in different provinces and their principal activity is providing technical assistance to small cacao growers. This project will work closely with the field technicians who will be instructed in interpreting the maps of spatial distribution of bean Cd that will be produced in this project for sample collection and identification of cacao farms in Cd risk areas. The field technicians from the MAG are key in this project for securing a higher impact and outreach of the results. Field technicians will be the appropriate link for transfer of technology to cacao farmers. The second institution in Ecuador, adjourn to MAG, that will support this project is AGROCALIDAD. This government agency will incorporate in their inspection to cacao export containers the guidelines that will be developed by this project based scientific, easy-to-use, information on number of samples per container, sample treatment and analysis, etc.

In Colombia, the Ministry of Agriculture and Rural Development (**MADR**) and the Ministry of Commerce, Industry and Tourism have recently started efforts to include the Cd in cacao issue in their agenda. Local meetings involving some actors from EU Regulation Commission in Brussels and Colombian researcher institutions (i.e. AGROSAVIA) have taken place in order to share the advances made in Cd studies. The Consejo Nacional de Cacaoteros, part of MADR, was also represented in the meeting CacaoCdFREE held at CIAT earlier this year, and in the meeting organized by the public-private Alliance led by IDH[§§], the sustainable trade initiative, on the 26th of June in Bogota. In both meetings it was highlighted the need for technical support to farmers.

Private organizations in Colombia and Ecuador that support this project

Cacao associations **FEDECACAO** in Colombia and **ANECACAO** in Ecuador are also key to this project as they are in direct contact with cacao producers and exporters through technical assistance and/or commercial ties. As exporters get benefits by enhancing the quality of their products, some of them offer technical assistance and training to their suppliers, including assistance to obtain certification such as: fair-trade, organic and sustainability labels. Therefore, this project will consider to use the exporters networking and training capabilities to educate the producers on this topic.

Partnership with local institutions that support this project

Two local partners will take the lead in each of the participating countries to strengthen local capacity on this project: ESPOL in Ecuador and AGROSAVIA in Colombia. They will oversee the sample collection and analysis, laboratory tests, technology transfer and educational programs and trainings, which in turn will secure the sustainability of this project afterwards.

Escuela Superior Politécnica del Litoral, **ESPOL**, is an Ecuadorian public university specialized in scientific and technical education. The Faculty of Life Sciences counts with a scientific group and a specialized

[§§] https://www.idhsustainabletrade.com/resource/nva-colombia-wgcocoa/

laboratory to conduct soil and water analysis. Currently this research group has a close collaboration with KU Leuven university in applied research projects related to Cd in cacao beans. The Soil Research Group from the ESPOL university has developed an important network in the cacao sector of Ecuador; for instance, associations of cacao producers, cacao exporters and the Ecuadorian entities in charge of policy development. ESPOL also implemented a soil/plant test laboratory with the capacity to measure Cd in cacao samples.

AGROSAVIA (formerly CORPOICA) is a joint public-private, decentralized, not-for-profit institution of scientific and technical nature. The corporation´s purpose is generating scientific knowledge and developing agricultural technologies through research, technology adaptation and transfer, and technical assistance for improving production competitiveness, equitable distribution of the benefits of technology, and sustainable use of natural resources in Colombia. One of the major crop networks in the research centre is cacao, where a multidisciplinary group of scientific researchers is focused on improve the cacao crop for small farmers in Colombia. AGROSAVIA has been working since 2008 in Cd detection in cacao soils and grains in Colombia. Recently has started a mitigation strategy based on bioremediation processes.

II. PROJECT GOAL, OBJECTIVE, OUTPUTS & ACTIVITIES (LOGICAL FRAMEWORK)

7. Project Goal / Impact

The expected impact of this project is that the cacao sector in Colombia and Ecuador can remain competitive, maintain its current area of production and even expand it. It is hoped that the growth of the cacao sector will translate in an increase of employment rate in the sector and a reduction of poverty particularly in rural areas.

Currently, the total cultivated area of cacao in Ecuador is 560,000 hectares[***]. Due to the importance of this crop in the country's economy, the Ecuadorian Government launched the program "Reactivation of Fine Cacao Aroma 2012-2021". Through this program the government plans to renovate about 284,000 hectares of fine aroma cacao and to establish 70,000 hectares of new plantations. With this increment of cultivated area the government seeks to increase the fine cacao aroma exports from 170,000 metric tons per year to about 300,000 metric tons per year starting from 2021, generating about US $ 700 million per year[†††]. Compared to Ecuador, the cacao sector in Colombia is rather small with 153,000 hectares. However, it is expected that the production of cacao will grow by 30% in the coming years as the government wants to boost the development of agricultural post-conflict areas with the expansion of this crop.

The ambitious programs of both countries can be threatened if no specific action is taken to address the issue of high Cd levels in cacao beans, particularly if the expansion of new cultivated area is done without adequate planning (i.e. considering low Cd risk areas). This project is a response to the concerns expressed by cacao stakeholders in the Andean region as outlined in section I.1. The limits are set on the final product and not on the cacao beans which gives an advantage for short-term solutions i.e. blending of cacao beans with high and low Cd concentration. However, such countermeasures can only be achieved if reliable site-specific information are available. For example, digital maps on spatial distribution of soil and bean Cd are accessible for Ecuador but are still needed in Colombia; this will be partly accomplished through this project. Longer term solutions are needed to decrease the Cd in the beans which, at the same time, will increase consumer acceptance and avoid that the demand for cacao produced in the Andean region decreases.

8. Target Beneficiaries

1. Participating national soil chemical laboratories in Ecuador and Colombia (i.e. AGROCALIDAD and ICA) will benefit from this project as the recipients of internal cocoa reference samples (at no charge) that will be encouraged to be used as an internal standard for the quality control of the cacao Cd measurements. In addition, the laboratories participating in this project will receive the QA/QC guidelines and information in the form of manuals about best laboratory practices for cacao sample

[***]http://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_agropecuarias/espac/espac-2016/Indice%20de%20publicacion%20ESPAC%202016.xlsx.

[†††] https://www.agricultura.gob.ec/magap-impulsa-proyecto-de-reactivacion-del-cacao-fino-y-de-aroma/

treatment and measurement that will be developed in this project. International quality control procedures (e.g. through participation in WEPAL ring tests, including for Cd assessments) will be promoted as well.

2. Ministries of Agriculture of Ecuador and Colombia will benefit from this project as they will receive maps of the countries with information regarding vulnerable areas i.e. risk of high bean Cd. Such information will allow the governments strategic planning and technological development of the cacao sectors. In addition, the technical staff from the government institutions will benefit as they will be invited to join the training sessions on map interpretation and usage and will receive technical information.

3. Cacao farmers are the main beneficiaries of this project whose produce is at risk of losing market if not meeting food safety standards on Cd. The production of cacao is done mainly with family labour, and most of them have none or few technical support to enhance the quality of its products. In Ecuador, only 15% of the farmers are estimated to be member of an association and only 2% are active participants. The reason for this low participation is the insufficient capacity of the associations to bring services. This can be an area where this project could help by adding value to this organizations through meaningful training. A good agricultural practice manual will be developed with the main technical results and practical recommendations of the project, targeted at extension workers and advanced farmers. A more basic, practical manual in language that is relevant for the reality of the farmers and helps to better understand the Cd issue in cacao will be disseminated. Hardcopies will be given to farmer associations and private companies for distribution among their producers, and E-versions will be available in local institutions for free downloads.

4. Cacao exporters, cacao national and international industry are also beneficiaries of this project. Specific benefits include: precise information of areas that produce high and low bean Cd for sourcing; increased international and domestic supply security by offering cacao-derived products that complies with international standards also in the national market; increase economic input by securing the market of fine aroma cacao which is a product sold with a higher price.

5. Chocolate manufactures and consumers will also benefit from this project. Securing the source of high-quality low-Cd beans from South America is key to maintain good product reputation (in case of chocolate makers) and chocolate brands with no price increase, particularly those sold as "origin chocolate" (in case of consumers).

(a) Gender-related issues

To prevent that the adoption of mitigation measures is biased by gender, we will strive at a strong gender balance at the various stages of this project and target and monitor female and male beneficiaries of different capacity building and dissemination efforts. Awareness of possible gender biases is also important when dealing with the government institutes and decision makers.

9. Project objective, outputs and activities (including logical framework and work plan)

The immediate objective of this project is to improve the institutional capacity of Colombia and Ecuador in managing Cd concentrations in cacao to mitigate the negative impacts of the trade barrier imposed by the new standard.

Specifically, the project will have three outputs:

(1) harmonize methods for cacao sampling and measurement of Cd levels in cocoa and soils according to international standards; thereby preparing the countries for adequate inspection and potential certification/accreditation programs;

(2) improve mapping baselines and mapping capacity for zoning of vulnerable areas in the two countries, based on harmonized methods and data on Cd levels in cacao beans;

(3) develop scientifically sound and context-relevant guidelines on good agricultural practices that lower Cd levels in cacao.

Output 1: Harmonize methods for cacao sampling and measurement of Cd levels in cocoa and soils according to international standards; thereby preparing the countries for adequate inspection and potential certification/accreditation programs.

Background

One of the main gaps encountered in the mentioned countries to address the Cd issue is the **lack of standardized protocols and quality control** on the data of Cd concentrations in beans and associated soils.

The first problem is the analytical one. Cadmium is a trace element present in the sub-ppm range, i.e. lower than one in a million by weight (=less than 1 mg/kg). To detect Cd, four different instruments are used, ordered from most recent to most old and from most expensive to least expensive: ICP-MS, ICP-OES, GFAAS and AAS. The former can detect Cd in solid samples to about 0.001 mg/kg, the latter to about 1 mg/kg and ICP-OES to about 0.2 mg/kg.

There are some ICP-MS instruments in Colombia and Ecuador but there is a lack of trained personnel to use them and the costs are high, most laboratories use either ICP-OES (most advanced labs), GFAAS or AAS. In addition, there is a lack of tradition in adoption and reporting of QA/QC: the QA is the Quality Assurance and is the use of representative standard materials, the QC is the Quality Control is the repeated use of internal verification procedures for the analysis. At this stage, there is no transparency in the QA/QC procedures, this confuses discussions about data and leads to misunderstandings. Clearly, harmonization of the analytical methods is a priority and this is generally acknowledged.

There is no lack of certified reference materials (CRMs) for soils they have existed for over 20 years. In contrast, CRMs for cacao products were lacking until very recently, and they are:

- NIST 2384 (baking chocolate) of the National Institute of Standards and Technology since 02/2015 (addition of certified values for Cd), certified Cd concentration=0.0734 mg Cd/kg

- ERM-BD512 (dark chocolate) of the European Commission's Joint Research Centre since 03/2018, certified Cd concentration=0.302 mg Cd/kg

- ERM-BD513, ERM-BD514 and ERM-BD515 cocoa powder are new CRMs still under development for quantitative determination of Cd.

A barrier to the use of these CRMs is their rather high costs. They might be replaced by ring testing using homogenized cacao powders, specifically targeted to give a good coverage below and above the trading limits, e.g. covering 0.1-1.0 mg Cd/kg.

The second problem is the inconsistent sample treatments prior to analyses, i.e. the decision which fraction of the beans must be analysed. Since the EU and Codex limits are not on the bean but on the chocolate, choices must be made. Some surveys reported whole ground beans sampled after fermentation and drying, other reported peeled beans (nibs), while others had washed, dried and peeled beans as such. Conceptually, cacao solids should be analysed as they drive the limits. Isolating that requires even chemical fractionation and is too complex for surveillance. A few papers have reported the differences in Cd concentrations depending on the fractionation (Argüello et al., 2019, Mounicou et al., 2003, Yanus et al, 2014). What is needed for surveillance is a consistent choice, e.g. peeling beans or not, and that may also be affected by ring test results showing the differences in variability in the data depending on fractionation.

The third problem is the yet unknown sample heterogeneity in bean Cd concentrations. Surveillance of bean quality for price setting has a strategy that is known to the distributors. It is yet unknown (or not communicated) how that strategy affects the variability of the Cd concentrations.

Output 1 will yield **internal cocoa powder reference samples** with consensus Cd content that will be distributed **at no cost** to all actors that want to perform bean Cd analyses. This Output 1 will also yield **technical information** on (i) inter-laboratory variation in detected Cd concentrations in cacao powder and soils; (ii) the effects of bean sample treatment prior to chemical analysis, including information which choice should be made about the fractions analysed and (iii) on sample heterogeneity. **By collaborating with laboratories and with the Ministries** responsible for food and agriculture, we will write **guidelines for QA/QC adoption in the laboratories** and disseminate these. At the same time, we will give the technical information to the regulatory bodies to set up formal inspection and potential accreditation programs. Inclusion of the relevant cacao standards in WEPAL proficiency testing programs which are offered at low cost is foreseen as a product of the project and will ensure sustainable solutions for laboratory quality control and accreditation after the project has ended. This work will contribute to the

future identification of risk management options aiming to reduce the concentration of Cd in cocoa beans and cocoa products.

Activities

Activity 1.1 Laboratory ring tests with cacao and soils

Five **cocoa powders** will be purchased from the main local processers in South America. The local samples are preferred to obtain a representative coverage below and above the trading limits, e.g. ranging from 0.1 to 1.0 mg Cd/kg. The KU Leuven group has identified local producers whose chocolate products cover that concentration range. The samples will be homogenised by sieving and mixing and will be bagged in 20 g quantities, the target is to obtain at least 50 bags of each powder. Laboratories will be contacted to participate; national laboratories (e.g. AGROCALIDAD) will take part in these tests. The KU Leuven group will analyse the cocoa powders (using ICP-MS) with reference to all certified chocolate standards (see above), previous tests showed adequate recoveries of the certified values (100±7% and 95±4%). With that, the KU Leuven group can benchmark the ring test samples. ESPOL partner will contact local laboratories in Ecuador and Colombia (i.e. AGROSAVIA and ICA laboratories, in Colombia, using ICP-OES and GF-AAS, respectively) willing to participate in the ring test. The samples will be distributed along with a questionnaire on the methodology. The data will be analysed with traditional inter-laboratory statistical techniques to exclude outliers, and to find consensus values. All laboratories will receive their results relative to anonymised group results and to the expected concentration based on the value benchmarked with the certified standard. In a second round, laboratories willing to improve will be helped to identify sources of errors.

Three **soil samples** with contrasting soil Cd concentrations, known from existing surveys, will be shipped to the WEPAL group at Wageningen, an existing soil ring testing group that is well established. The WEPAL group will ensure homogenisation and distribution. Soil laboratories from the two countries will be encouraged to specifically analyse these samples for the three main parameters controlling Cd uptake in cacao, i.e. total soil Cd, soil pH and soil organic carbon content. These data will be submitted to WEPAL and, specifically for this project, also to ESPOL who will analyse the data. All laboratories will receive their results relative to anonymised group results.

Activity 1.2 Evaluating bean sample treatments methods

Five bags of fermented, dried beans will be purchased from contrasting locations. The beans will be thoroughly mixed and distributed in 1 kg bag. The samples will be distributed to different laboratories willing to participate and asked to analyse the **beans as such or peeled beans**. A questionnaire will be given to identify their in house methods for sample homogenisation. All labs will be asked for triplicate analyses of each fraction. At ESPOL, a benchtop winnowing equipment (to peel beans at laboratory scale) will be purchased and used for peeling. All bean samples at ESPOL will be ground with a coffee blender and samples analysed at KU Leuven by ICP-MS. The data will be analysed with due attention to the variance among replicates, the difference between peeled and unpeeled bean data and the absolute value of the mean relative to the consensus values.

Activity 1.3 Evaluating sample heterogeneity in bagged beans ready for sales

The cacao distribution chain will be interviewed for the common sampling strategy to evaluate the quality of beans per selling lot. One of these strategies will be followed and applied to five different lot. The sampled aliquots of intact beans will be homogenised by blenders. The differences in Cd concentrations **between aliquots of the same** lot will be analysed.

Activity 1.4 Evaluation of data and developing guidelines for laboratories and accreditation schemes

The data analysis should reveal the three sources of variation, i.e. analytical among labs, sample heterogeneity within labs and sample heterogeneity among aliquots of the same lots. A meeting will be held with government employees responsible for the food and agricultural quality control programs. The data will be presented anonymously and discussed internally. Key points for discussion and agreements are a **consensus method for sample treatment** (peeling or not) and their choice for either or not adopting **accreditation programs** and their laboratory selection criteria. **Guidelines for QA/QC** will be written and distributed, and the different actors will be encouraged to **use the free cocoa powder samples as an internal laboratory verification tool, for national laboratories, the group will insist in a mandatory use and report of this material.** Training sessions in each country will be planned for the participating laboratories to help ensure continuation and commitment to the developed quality programs.

Output 2: Improve mapping baselines and mapping capacity for zoning of vulnerable areas in the two countries, based on harmonized methods and data on Cd levels in cacao beans.

Background

Mapping the spatial distribution of bean Cd concentrations is an essential tool for **zoning** vulnerable areas. The maps are not only visually attractive to identify these areas, they also allow mapping areas that have not been sampled by applying interpolation methods such as kriging. Kriging is a powerful interpolator based on geostatistics that allows predicting complex spatial patterns by modelling the spatial dependence between neighbouring observations as a function of their distance[12]. The spatial distribution of bean Cd have recently been mapped for Ecuador and data are available to also map this in Colombia. There are different approaches to interpolate a variable using kriging but it is logical to **map the bean Cd concentrations in a harmonized way that also ensures comparability.**

Output 2 will result in a **harmonized map** for Colombia and Ecuador of vulnerable **areas of Cd** contamination in **cacao beans**. This map allows the government and industries to better manage the Cd contamination, that is, for example, on the short term mixing the beans of different areas to achieve Cd threshold values. Additionally, this will contribute to the development and implementation of Good Agricultural Practices in the zones where Cd levels in the soils are higher.

Activities

Activity 2.1 Gap filling sampling of cacao beans

In this project, gap-filling sampling is taken into account in the budget (~100 samples per country) for better identifying areas of concern (hotspots) and to develop a prediction map of the spatial variability of Cd concentration in the beans in the cacao areas. More than 60% of cacao cultivated area in Colombia are concentrated in the Departments of Santander (24%), Nariño (11%), Antioquia (10%), Norte de Santander (8%), Arauca (8%) and Tolima (6%). The number of hectares planted in each province will be the base as to determine the number of samples that will be collected in each Department. For Ecuador, less data is currently available from the Amazon Region (long distance driving from ESPOL and difficulties in accessing) therefore efforts will be put in place to fill that gap in this project.

Activity 2.2 Geostatistical analysis of data to produce map for Colombia and Ecuador

For Ecuador georeferenced data was already gathered during the development of the VLIR-UOS project as described in Section I.4. For Colombia, this data will be made available for this project with AGROSAVIA (see Letter of support); however, under a confidentiality agreement since these data were collected with the support of business-oriented chocolate companies. These data, together with data available from FEDECACAO, still need to be analysed for consistency of methodologies; new data will be generated in Colombia (Section I.4).

Activity 2.3 Strategic sampling for Colombia and Ecuador

Based on the uncertainties found during geostatistical analysis of data and gap-filling analysis a strategic sampling plan will be developed based on an overlap of production areas and data availability; a **complementary cacao bean samples will be taken (AGROSAVIA will lead this survey in Colombia and ESPOL in Ecuador)**. The number of about 100 samples will be allocated to the different regions based on the number of hectares planted in each of the departments/provinces. The new data will be combined with the gathered data to create the final bean Cd map for zoning the vulnerable areas. CIAT has all expertise in house for geostatistical data analysis and mapping and national research partners have sufficient capacity to carry out the additional sampling. At the outset, we have budgeted for about 500 additional samples (=trees) in the two countries, this number is an estimated based on our knowledge of data availability in the countries.

Output 3: Develop scientifically sound and context-relevant guidelines on good agricultural practices that lower Cd levels in cacao.

Background

Cadmium reducing mitigation measures have been discussed during the International Workshop CacaoCdFREE on Cadmium Reduction in the Andean Zone (12-14 March 2018) organized by CIAT and CIRAD in Colombia. They fall in four different categories:

1. **Blending** high and low Cd beans to ensure that the produce is below limits imposed by the buyers. Middlemen and industry are already adopting that method, the harmonized maps (Output 2) can

better inform the government the macro scale potential of this mitigation measure, this project will not go beyond the development of the maps and will not further expand this possibility. Note that the VLIR-UOS project of the KU Leuven applicant has some attention to it by mapping the distribution chain.

2. **Agricultural countermeasures**: soil liming or other soil amendments and sound micronutrient fertilisation. Our data from the survey in Ecuador indicated that bean Cd concentration can decrease by factor 1.6 for every unit increase in soil pH, while doubling the organic matter content of the soil can decrease bean Cd by a factor 1.5. Therefore, agronomic strategies to increase soil pH by liming and the addition of organic matter with compost application can effectively be used to reduce the concentration of Cd in the beans. Research on this direction (pot trials and field studies) is currently planned for the second stage of the VLIR-UOS project (2018-2021). Associated to this is the choice for agroforestry or monoculture and the choice of organic versus conventional farming (including mineral fertilizers). Current data (e.g. Gramlich et al. 2017) do not indicate a statistically significant effect on bean Cd concentrations and, therefore, these systems (requiring long-term shifts) will not be further investigated.

3. **Genetic strategy**: selecting suitable varieties that have lower bean Cd. This approach is under investigation and will be further expanded here by collating the existing information and additional measurements in Ecuador. A recent publication is the first convincing study showing that varieties differ over factor 10 in bean Cd concentrations when grown in a common garden in Trinidad (Lewis et al. 2018). This opens up the possibility that changing varieties is an option to address the issue. We are aware of longer-term research initiatives, including at CIAT, for breeding and gene editing but will not invest STDF funds on that given that such are very long-term options and will not be ready to be implemented through this project.

4. **Post-harvest and processing approach**. One of the applicants is currently involved in one such projects (see above) and industry has also taken initiatives. While informal contact suggest that this is promising, we will not expand on this here given that it involves high research costs with unclear direct effect.

At the workshops listed above (I.2.iii), data have been presented on potential agronomic mitigation strategies. The applicants of this project experience that single field observation are often generalised without robust validation, i.e. there is a strong need to identify coherent trends to define effective and context-relevant agricultural practices.

Output 3 will result in an easy-to-interpret handbook developed for Cd mitigation strategies. This work will contribute to the current work of the Codex Committee on Contaminants in Food (CCCF) towards the development of a code of practice for the prevention and reduction of Cd contamination in cocoa beans.

Activities

Activity 3.1/3.2 Data consolidation and guideline preparation on Cd mitigation strategies

The principal activity of Output 3 is the production of good agricultural practices to mitigate bean Cd, based on synthesis of published and non-published data available in the countries as well as international publications. Data from agronomic countermeasures currently being evaluated in Ecuador (ESPOL, KU Leuven) and Colombia (AGROSAVIA) will become also available for the preparation of the guidelines. The main beneficiaries of the guidelines will be farmers and extension workers who will receive the recent and scientific-sound information.

10. Environmental-related issues

The EU and Codex Alimentarius have added cacao-derived products as a target for future regulations to ensure food safety. By 2019, cacao beans should pass strict controls in order to enter the European market. Ecuador and Colombia are vulnerable to this type of non-tariff measure because of the lack of information and science-based alternatives in managing Cd contaminated soils, even though the majority of them may be due to geogenic (natural) causes. An important environmental implication of this project will come from the mapping of vulnerable areas (high bean Cd) which will aid in planning and establishing of new plantations. For example, in Ecuador the 10-year government program for reactivation of fine aroma cacao production will be also executed in the Amazonian provinces of Sucumbíos, Orellana, Napo,

Morona Santiago and Zamora Chinchipe. Thus, correct identification of Cd hotspots will prevent unnecessary disturbance of land.

11. Risks

This project has been conceived to help the cacao sector of Colombia and Ecuador produce cacao beans that would allow the manufacture of final products that comply with Cd limits. As indicated in section (I.1) the limit is on chocolate not on beans. However, when translating the Cd levels of chocolate into levels admitted in cacao beans, importers will in practice consider the level of 0.6 mg Cd/kg as the threshold. The countries will be prepared to address that limit. An external factor that would adversely affect the results of this project will be the introduction of even more tighten limits for cacao derived products. In such scenario, the strategies will need to be re-oriented. Fortunately, with this project the countries will have in hand the relevant information (i.e. digital maps) to take the appropriate decisions on time. Another external risk that could affect the cacao sector is the introduction of other SPS/safety constraints. For example, lead is the next trace element to be controlled under Proposition 65 from the state of California, USA.

Cooperation and support (in-kind contributions) from the governments and private organizations in the countries to carry out the activities of this project have been granted as shown in the Support letters (Appendix 4). Lack of engagement and interest is not foreseen since this project is an initiative of the governments of Colombia and Ecuador who acknowledge the potential socioeconomic impact of the new regulation on Cd and urgency to address this issue in the countries. The governments through its representatives will receive continuous communication of the advances of the project, invitation to participate in meetings and workshops that will be organized in the frame of this project.

In order to produce the digital maps the applicants count-in that the information will be available. Although possible, the actual risk of not having the data is very low because during the assemblage of this proposal the agencies that own the data have made the adequate arrangements (i.e. confidentiality agreements between AGROSAVIA and industry who own the survey data from Colombia).

Ultimately, another failing factor would be the high drop-out rate of the technical staff that are trained or that the guidelines developed in this project are not followed. To prevent this from happening the implementing organizations in the respective countries will continuously advocate and promote the importance of the activities developed in this project so that people at all levels are willing to continue working.

12. Sustainability

This project will strengthen the capacity of local laboratories toward the generation of high quality and reliable Cd data. This data can be comparable between the countries because of the standardization of methods and protocols for sample treatment and measurement. To ensure the sustainability of this output, the laboratories will be encouraged to implement in their routine work the QA/QC guidelines that will be developed in this project. Since the laboratories will be involved in all stages for the development of this guidelines, it is anticipated they will empower its adoption and farmers and private sector will seek for laboratories with such strict protocols. Furthermore, the laboratories will be informed of the advantages of adopting accreditation programs as this is the best way to sustain laboratory quality systems and ensure compliance with regulatory standards.

The maps of zoning of vulnerable areas that will be developed in this project will direct the expansion of cacao crop in areas of low Cd bioavailability. In the long term this is the most sustainable approach to reduce the average Cd content of the cacao that is traded by the countries.

The important outcomes of this project will be transferred through training sessions for capacity building of laboratories and practical guidelines ensuring that the technical staff, farmers and stakeholders of the cacao supply chain make better choices regarding the selection of countermeasures to mitigate Cd in the bean. It is foreseen that through the adoption of the measures described in this proposal the cacao sector of Colombia and Ecuador will comply with Cd regulations of the European countries allowing the sectors secure market access.

III. BUDGET

13. Estimated budget

See Appendix 3

14. Cost-effectiveness

Ecuador and Colombia are two of the major producers of cacao in Latin American. While the production and trade of this product for the two countries have been steadily growing during the last years, this **positive trend is threatened by the new international standards on the Cd** content in cocoa products. The local institutions of both countries are not yet prepared to cope with the new standards, neither on surveillance nor on implementing good agricultural practices. Therefore, if no effective actions are taken to reduce the level of Cd in cacao bean exports, it is expected that the **export losses due to this new Cd regulation** will be high.

The economic **impact will be principally for the farmers and their families**. In Ecuador, the cacao sector generates 600,000 jobs and represent 12.5% of the agriculture economically active population of the country. In Colombia, it is estimated that more than 54,000 families are involved in cacao cultivation.

This proposal is **a cost-effective solution to mitigate the negative impact** on trade for Ecuador and Colombia caused by the SPS measure related to Cd in cacao products. The cost of the implementation is modest compared to the value of safeguarding exports and the social impact for the countries. Additionally, by being a **regional project (Ecuador and Colombia)** it allows to use resources more efficiently that otherwise would have been duplicated. For instance, project coordination costs, research studies, trainers and training materials. It is also important to highlight that this project also saves resources by **using collated material and the experience from previous projects**. This information comes principally from the implementing organizations partners from this project, and helps to develop the laboratory standard methodologies, the map for zoning vulnerable Cd areas and guidelines for mitigation practices. It is also important to mention that the results of this project will be open for use and benefit of other Andean countries (Peru) where areas with high bean Cd have been also reported. As indicated in section 5, CIAT has strong networking connections and presence in the region so sharing of the information is guaranteed through this partner.

IV. PROJECT IMPLEMENTATION & MANAGEMENT

15. Implementing organization

KU Leuven will be the Principal Project Implementer and Coordinator with overall responsibility for the project. For the implementation of the project KU Leuven has sought support of the following subcontracting agencies: CIAT, ESPOL, Wageningen University and AGROSAVIA. In its capacity KU Leuven will ensure that the project is properly implemented by the subcontracted organizations. This includes accountability to the STDF and other in-kind donors regarding technical, administrative and financial management of the project. KU Leuven will receive regular progress reports from the CIAT, ESPOL, Wageningen University and AGROSAVIA and after review, will submit a consolidated report to STDF and other donors.

KU Leuven is the largest university in Belgium and, founded in 1425, one of the oldest and most renowned universities in Europe. As a leading European research university and co-founder of the League of European Research Universities (LERU), KU Leuven supports all kind of research projects, from fundamental to applied, and from individual to large-scale international research consortia. KU Leuven is devoted to put its expertise to the service of society, and as such does not hesitate to engage in partnerships with other universities and research institutions in developing countries to enhance their teaching and research capacity. KU Leuven currently manages 28 programs in Africa, 10 in Central and South America, and three in Asia and for which more than 11M€ is invested each year.

The **Group of Soil and Water Management** from the Department of Earth and Environmental Sciences at KU Leuven is very experienced in managing and executing research projects at national and international level. For instance, at the moment the group is leading two projects related to Cd in cacao in Ecuador, a project in Katanga, Congo to study the effects on public health from environmental

contamination with toxic metals, and agronomic field trials in Madagascar to improve the efficiency of upland rice on phosphorus acquisition. All of these projects are being implemented with strategic partnerships with local research institutions. This indicates the professional capacity of KU Leuven and the Group of Soil and Water Management to take part and lead to successful end initiatives like the one presented in this proposal.

Furthermore, the Group has a long-standing experience in studying the fate and chemical behaviour of nutrients and contaminants in the soil plant-system, risk assessment of pollutants and development of agricultural countermeasures to reduce the uptake of metal contaminants. Professor Smolders one of the experts in this Group and leader of this project has contributed greatly to the body of scientific work published on Cd and was also the author of the EU risk assessment on Cd in the environment.

The contact details of the project leader for KU Leuven are:

Prof. Erik Smolders[‡‡‡]

Department of Earth and Environmental Sciences, Division Soil and Water Management, KUL
Kasteelpark Arenberg 20, 3001 Leuven
Email: erik.smolders@kuleuven.be

Contact details of the scientists from KU Leuven that will be involved in this project:

Dr. Daniela Montalvo Grijalva

Department of Earth and Environmental Sciences, Division Soil and Water Management, KUL
Kasteelpark Arenberg 20, 3001 Leuven
Email: daniela.montalvogrijalva@kuleuven.be

Partnership with European and International institutions: subcontractors in this project

This project will take advantage of the network and the experience from the **International Center for Tropical Agriculture** (CIAT). This organization has its headquarters in Colombia and regional office in Africa, Asia and Latin America. CIAT collaborates with hundreds of partners around the globe from government partners, national research organizations and universities, non-governmental organizations, civil society, and farmer associations. During this project, CIAT will produce digital maps for Colombia and Ecuador of vulnerable areas, as well as will serve as a link to various stakeholders at national levels in the targeted countries including farmers associations and private sector as well as government institutes and food safety authorities, principally in Colombia. CIAT will play a key role in knowledge dissemination, training and research activities and embedding of project activities and results through regional institutional networks.

Wageningen University (Netherlands), Department of Soil Biology is also committed to support this project. The group has expertise on the relations between soil biota, soil chemical and physical characteristics, bioavailability of nutrients, trace metals soil structure and organic matter. The University has also strong partnership with WEPAL, the world-leading organizer of proficiency testing programs. Wageningen University and KU Leuven will contribute to training and mobility through staff exchanges from Ecuador, Colombia and Europe.

The contact details of CIAT and Wageningen University scientists that will collaborate in this project:

Prof. Mirjam Pulleman
Email: Mirjam.pulleman@wur.nl

Dr. Mayesse da Silva
Email: m.a.dasilva@cgiar.org

Local institutions that are subcontractors in this project

ESPOL in Ecuador and AGROSAVIA in Colombia are the local institutions that will be subcontracted for the implementation of this project in the respective countries. ESPOL and AGROSAVIA will participate in the laboratory quality evaluations (ring tests), will conduct gap-filling collection of beans for the production of

[‡‡‡] https://www.kuleuven.be/wieiswie/en/person/00019360

maps. Their collaboration is important in this project as they will be the actors that will assure the sustainability of this project as they represent local institutions.

The contact details of ESPOL and AGROSAVIA scientists that will collaborate in this project:

Prof. Eduardo Chavez
Email: fchavez@espol.edu.ec

Dr. Daniel Bravo
Email: dbravo@agrosavia.co

16. Project management

KU Leuven is the principal implementer and coordinator of the project. The staff that will be involved in the project are Prof. Erik Smolders and Dr. Daniela Montalvo Grijalva, who will provide expert knowledge, technical advice and strategic guidance at the different stages during the implementation of the project. A steering committee will be established to monitor, supervise and evaluate the project. Members that will conform this Committee are: the Project Leader, and representatives from institutions/organizations key to the cacao sector and beneficiaries of this project: i.e. representative of Ministries of Agriculture in Ecuador and Colombia; national laboratories (AGROCALIDAD, ICA), and private cacao organizations ANECACAO and FEDECACAO.

Project implementing agencies sub-contracted by KU Leuven

- CIAT will be subcontracted as consultant for this project. The staff from CIAT Dr. Mayesse da Silva will be responsible for the conduction of the digital maps of bean Cd for Colombia and Ecuador. CIAT will support national partners in the development of training sessions and dissemination activities. Networking and alignment of this project with other on-going initiatives (i.e. work in Peru) are also the tasks committed by CIAT.
- Wageningen University will support the WEPAL ring tests and preparation of guidelines for mitigation strategies.
- The National institutions ESPOL and AGROSAVIA are key partners in this project as they will be involved in the surveys for gap filling collection of data, participate in laboratory evaluations, support data and expertise based on the research conducted in the countries, and capacity building through training and educational programs.

V. REPORTING, MONITORING & EVALUATION

17. Project reporting

The project will provide mandatory six-monthly reports on the progress of the activities in accordance with STDF reporting requirements. Additionally, interim reports will be produced by the responsible of the activities and these will be used to update STDF and relevant stakeholders on the status of the implementation of the project. The technical coordinator will collate the interim reports from the respective implementing agencies. KU Leuven will keep detailed financial records and will submit quarterly financial reports. Within 90 days of project completion, a complete final report of the project will be submitted to STDF and in-kind contributing agencies.

18. Monitoring and evaluation, including performance indicators

The overall success of the project will be measured by the sustain or increase of the export volume of bean cacao to Europe and USA markets. Cacao beans originating from Ecuador and Colombia will not be rejected or receive an alert notification due high Cd levels, as occurred in 2017 and reported in the EU RASFF portal for risks to public health in the food chain. The achievement of the immediate objective of the project will aid into keeping the cacao sector competitive, enhancing the countries' economy and helping in the reduction of poverty in rural areas which is the ambition of Colombia and Ecuador.

At the end of the first year of the project it is expected that the participating laboratories have enhanced their technical capacity on their ability to provide high quality reliable bean Cd data (Output 1). This enhanced capacity will be measured by the increase in the accuracy and repeatability of Cd measurements when results of the laboratories are compared with laboratories that follow international standards.

The progress of Output 2 will be evaluated by means of the production of digital maps about the distribution of the spatial variability of bean Cd with indication of areas with high Cd levels in the beans. These maps can be used by the local authorities to delineate future expansion cacao growing areas. The measure of success for this output is that the maps can predict with accuracy vulnerable zones and that can be used by the local authorities for decision making.

The progress of Output 3 will be evaluated through the production of scientific-based and context-relevant technical guidelines to mitigate Cd in the beans. These guidelines will be used for training sessions and will have impact on farmers, extension workers, researchers, etc.

It is important to indicate that at the initial stages of the project baseline data will need to be defined (i.e. current employment rate in the cacao sector, accuracy of laboratories for measuring Cd, etc) so that the achievement of the three outputs, objective and goal of the project can be verifiable and its impact properly assessed.

19. Dissemination of the projects results

Sharing of knowledge and technical information is an important aspect of this project and will be given high priority. To address the diversity of stakeholders that can benefit from the results of this project, different dissemination strategies will be used as presented in the table below. Upon completion of the project, the final report will be made available to the competent authorities and private cacao organizations in Ecuador and Colombia and a story case summary of it will be disseminated by STDF website. Finally, the results will be integrated online in a geographic information system (GIS) and made available for use of all stakeholders.

Audience	Dissemination strategy
Farmers and technicians	Guidelines on mitigation practices
Laboratories	Training materials on sampling and analysis of cacao beans and QA/QC guidelines
Authorities and industry	Policy briefs

ATTACHMENTS

Appendix 1: Logical framework (see attached template)

Appendix 2: Work Plan (see attached template)

Appendix 3: Project Budget (see attached template)

Appendix 4: Letters of support from organizations that support the project request

Appendix 5: Written consent from an STDF partner that agrees to implement the project ***OR*** evidence of the technical and professional capacity of another organization proposed to implement the project.

Appendix 6: Terms of Reference for key staff involved in project implementation

APPENDIX 1: Logical Framework[§§§]

	Project description	Measurable indicators / targets	Sources of verification	Assumptions and risks
Goal	The cacao sector in Ecuador and Colombia remains competitive and its area of production is maintained or even expanded	Increase in employment rates in the cacao sector Reduction of poverty levels in rural areas	National statistics	Donor's interest to support Government initiatives for the development of a sustainable cacao sector
Immediate objective	To improve the institutional capacity of Colombia and Ecuador in managing Cd concentrations in cacao to mitigate the trade barrier imposed by the new Cd standards, using a regional approach	Sustain or increase of the export volume of cacao beans in Ecuador and Colombia Cacao beans or derived products originating from Ecuador and Colombia are not rejected or received an alert notification at the European border due to high levels of Cd	Statistical data collected by government, exporters and farmers associations Data publicly available at the EU online database portal for risks to public health in the food chain - Rapid Alert System for Food and Feed (RASFF) https://webgate.ec.europa.eu/rasff-window/portal/	The Cd regulation will not change to even more tighten limits Other contaminants also regulated (i.e. lead)
Expected results	Output 1 Harmonize methods for cacao sampling and measurement of Cd levels in cocoa and soils according to international standards, thereby preparing the countries for adequate inspection and potential certification/accreditation programs	Cadmium measurements by participating laboratories are satisfactory in repeatability and reproducibility (determined by e.g. coefficient of variation not larger than 20%, or *z*-score <2, WEPAL methodology)	Reports from external control laboratories (WEPAL, KU Leuven)	Participating laboratories owned necessary analytical equipment to perform Cd measurements and are willing to adhere QA/QC protocols after appropriate training
	Activity 1.1 Laboratory ring tests Activity 1.2 Evaluate bean samples treatment methods Activity 1.3 Evaluate sample heterogeneity Activity 1.4	Milestones and budget assigned to each activity	Project report and deliverables	Active participation from key partners

[§§§] See the CIDT Handbook on Project Identification, Formulation and Design, available on the STDF website, for guidance on the preparation of logical frameworks.

	Develop QA/QC guidelines and training			
	Output 2 Improve mapping baselines and mapping capacity for zoning of vulnerable areas in the two countries, based on harmonized methods and data on Cd levels in cacao beans	Mapping accuracy to predict bean Cd and identify vulnerable areas is increased between 20-60%	Map accuracy for spatial distribution of bean Cd is verified by cross-validation methods	Number of budgeted samples provides sufficient information for developing accurate prediction maps
	Activity 2.1. Gap-filling of cacao bean sampling Activity 2.2. Geostatistical analysis of data Activity 2.3. Complimentary bean sampling	Milestones and budget assigned to each activity	Project report and deliverables	Active participation from key partners
	Output 3 Develop scientifically sound and context-relevant guidelines on good agricultural practices that lower Cd levels in cacao	Number of farmers/technicians that receive the guidelines	List of people that receive the guidelines	None of the agronomic countermeasures deliver a positive result in the field
	Activity 3.1. Collate available scientific data (published/unpublished) on mitigation strategies Activity 3.2 Preparation of guidelines/handbooks	Milestones and budget assigned to each activity	Project report and deliverables	Active participation from key partners

APPENDIX 2: Work Plan[12]

Activity	Responsibility	Year 1				Year 2				Year 3			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Output 1 Harmonize methods for cacao sampling and measurement of Cd levels in cocoa and soils according to international standards													
Activity 1.1 Laboratory ring tests with cacao and soils	KUL, ESPOL and Agrosavia												
Activity 1.2 Evaluating bean samples treatment methods	KUL, ESPOL and Agrosavia												
Activity 1.3 Evaluate sample heterogeneity in beans ready for sales	KUL, ESPOL												
Activity 1.4 Develop QA/QC guidelines and training	KUL, Wageningen, ESPOL and Agrosavia												
Output 2: Improve mapping baselines and mapping capacity for zoning of vulnerable areas in the two countries,													

[12] Please shade or otherwise indicate when the activity will take place.

based on harmonized methods and data on Cd levels in cacao beans													
Activity 2.1 Gap filling of cacao bean sampling	Agrosavia												
Activity 2.2 Perform geostatistical analysis of data to produce the digital maps	CIAT												
Activity 2.3 Complimentary bean samples taken for checking the quality of the map	ESPOL and Agrosavia												
Output 3: Develop scientifically sound and context-relevant guidelines on good agricultural practices that lower Cd levels in cacao													
Activity 3.1 Collate available scientific data (published/unpublished) on mitigation strategies from field experiments	KUL, CIAT, Wageningen, Agrosavia												
Activity 3.2 Preparation of guidelines	KUL, CIAT, Wageningen, Agrosavia												

APPENDIX 3: Budget (US$)[13]

[13] Use the headings in the budget table above as a basis to prepare a budget table, preferably as an Excel chart.

APPENDIX 4: Letters of support from organizations that support the project request

The letters of support from Ministry of Agriculture Ecuador, Ministry of Agriculture Colombia, FEDECACAO, CIAT, Wageningen University, ESPOL and AGROSAVIA are provided separately as supplementary documents.

APPENDIX 5: Written consent from an STDF partner that agrees to implement the project OR evidence of the technical and professional capacity of another organization proposed to implement the project.

Letter from KU Leuven indicating its technical capability to manage and implement such project is given in Appendix 5.

APPENDIX 6: Terms of Reference for key staff involved in the project implementation

Katholieke Universiteit Leuven (KU Leuven)

Specific responsibilities:

- To take lead in the implementation and overall coordination of the project
- To report the progress of the project to STDF and in-kind contributor agencies
- To manage funds according to the Project Budget Plan and coordinate with the subcontracted partners on the disbursement of funds
- To provide expertise and support on matters related to development of standard laboratory methods for Cd measurement (QA/QC), inter-laboratory comparisons, production of the internal cocoa powder reference standard and general strengthening the technical capacity of participating local laboratories
- To provide expertise in the analysis and synthesis of existing data for the development of guidelines for mitigation of Cd; this work will be done in collaboration with Wageningen University

Staff from KU Leuven involved in the project:

- Prof. Erik Smolders (Qualifications/Experience attached)
- Dr. Daniela Montalvo (Qualifications/Experience attached)

International Center for Tropical Agriculture (CIAT)

Specific responsibilities:

- To organize existing bean data to produce homogenized maps of bean Cd for Colombia and Ecuador
- To support on capacity building and dissemination activities in the region especially at institutional level
- To ensure alignment of project activities with national agendas and action plans related research and development projects initiatives in the region with special emphasis on Colombia, Ecuador and Peru

Staff from CIAT involved in the project:

- Dr. Mayesse da Silva (Qualifications/Experience attached)

Wageningen University

Specific responsibilities:

- To support the WEPAL ring tests
- To develop content for printed and on-line training materials including manuals, webinars and tailor made trainings for the different end users targeted in this project
- To collaborate with KU Leuven in the analysis and synthesis of existing data for the development of guidelines for mitigation of Cd

Staff from Wageningen University involved in the project:

- Dr. Mirjam Pulleman (Qualifications/Experience attached)

Escuela Politecnica del Litoral (ESPOL)

Specific responsibilities in Ecuador:

- To participate in the laboratory evaluations and improvement of quality control
- To coordinate any additional bean sampling needed
- To provide data and expertise based on their experiences/research in the country for the development of Cd maps and for the development of guidelines for Cd mitigation
- To support capacity building and dissemination of activities through educational programs and extension

Key staff from ESPOL involved in the project:

- Prof. Eduardo Chavez (Qualifications/Experience attached)

AGROSAVIA

Specific responsibilities in Colombia:

- To participate in the laboratory evaluations and improvement of quality control
- To coordinate any additional bean sampling needed
-
- To provide data and expertise based on their experiences/research in the country for the development of Cd maps and for the development of guidelines for Cd mitigation
- To support capacity building and dissemination of activities through educational programs and extension

Key Staff from AGROSAVIA involved in the project:

- Dr. Daniel Bravo (Qualifications/Experience attached)

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