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Final Report:

Project Sustainable Organic Waste Management in the Municipality of Perez Zeledon, Costa Rica

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1. Summary

At the national level, Costa Rica will promote composting as one of the alternatives to advance its national principles on sustainability, circular economy, and climate change mitigation. Therefore, the Perez Zeledon plant, the largest in the country, has become the most important case to support and multiply efforts from the different national authorities such as the Ministry of Agriculture (project partner), the Ministry of Environment, the Institute for Municipal Development and Advisory Services (Instituto de Fomento y Asesoría Municipal), and the Ministry of Health.

At the municipal level, the development of this project addressed the main need **to improve the composting processes implemented in the municipal composting plant**, which began operating in 2012. During the first mission in 2019, multiple points of potential improvement became evident, both in the previous phases such as separation at source and collection and transport of waste to the plant, as well as in the activities carried out at the plant itself. Additionally, the municipality expressed the need to improve the quality of the product obtained and position it as a beneficial option for organic farmers in the region.

Based on this, the team of Swiss experts provided specific technical advice based on direct observation during field visits and accompanied the implementation of the suggestions for improvement throughout the three years of project implementation. The advice included direct recommendations in the field, training, virtual follow-up meetings, documentation to transfer good practices based on the experience of the Swiss experts, design of protocols and guidelines, and support in the development of product application experiments. In addition, an on-site laboratory for measuring nitrites, nitrates and ammonium was implemented, including its set-up during the last mission and the corresponding training. As planned, activities were also developed **to strengthen environmental education** strategies to improve separation at source as a fundamental part of the system. In the same way, some spaces were created to **generate alliances** that enhance the sustainability and multiplication of the experience and results in the time after the project.

The project was initially planned for a period of two years, but due to the Covid-19 pandemic it was extended to three years. In this way and thanks to the virtual tools, it was possible to advance the activities overcoming difficult local conditions, thanks to the constant motivation of all partners. Similarly, despite the willingness of those responsible for the plant and the municipal waste system, the availability of financial resources was restricted due to the pandemic, so that there were delays in some of the infrastructure improvements. Thus, great improvements on the whole composting process (from the collection of organic waste to the use of the produced composts) have been achieved during the project, including the monitoring of product quality parameters both on site and in the laboratory.

In addition, the processes in the resulting plant have an important dynamic, including the need to adapt to unexpected situations. For example, since the end of 2021, the municipality had to temporarily locate the recycling of inorganics (plastics, glass, cardboard, etc.) in the same shed as the composting shed, so that some of the improvements in using a larger area, such as decreasing the size of the piles, were not fully implemented. A related fact is that in June 2021 the suggested improvement of cementing the floor of the composting shed was initiated, which required the removal of all piles. However, this offered the opportunity to restart the process under the suggestions offered by FiBL throughout the project, which will be facilitated by the documentation of all good practices suggested in the "manual for achieving excellent quality compost" as one of the tangible products of the project; and by additional consultancies that can be offered.

One of the main remaining challenges is to improve the structure of the piles to allow for optimal air circulation, thus reducing the generation of unwanted gases in the process. The municipality is still looking for additional alternatives to the coconut shells it already receives, such as pruning material, in order to receive it regularly, shred it, store it and incorporate it into the initial waste mixture in the indicated proportion. It is also expected that the regular recording of key parameters such as temperature, pH and humidity will continue, as well as the (at least annual) evaluation of quality parameters in the laboratory (heavy metals, nutrients, etc.). In this sense, it is expected that the appropriate and regular use of the laboratory set up at the plant can be monitored at a later stage.

2. Abstract in local language (Spanish)

A nivel nacional, Costa Rica fomentará el compostaje como una de las alternativas para avanzar en sus principios nacionales de sostenibilidad, economía circular y mitigación del cambio climático. Por ello, la planta de Perez Zeledon, la más grande del país, se ha convertido en el caso más importante a apoyar y multiplicar desde las diferentes autoridades nacionales como el Ministerio de Agricultura y Ganadería (socio del proyecto), el Ministerio de Ambiente y Energía, el Instituto de Fomento y Asesoría Municipal IFAM, y el Ministerio de Salud.

A nivel municipal, el desarrollo de este proyecto atendió la necesidad principal de mejorar los procesos implementados en la planta de compostaje municipal, cuya operación inició en 2012. Durante la primera misión en el 2019 se pudieron evidenciar múltiples puntos de potencial mejora tanto en las fases previas como la separación en la fuente, recolección y transporte de los residuos orgánicos a la planta, como en las actividades ejecutadas en la planta. Adicionalmente, el municipio expresó la necesidad de mejorar la calidad de producto obtenido y posicionarlo como una alternativa beneficiosa para agricultores orgánicos de la región.

Con base en ello, el equipo de expertos suizos proveyó una asesoría técnica específica a partir de la observación directa en visitas de campo, y acompañó a lo largo de los 3 años la implementación de las sugerencias de mejora brindadas. La asesoría incluyó recomendaciones directas en campo, capacitaciones, reuniones de seguimiento, documentación para transferir buenas prácticas con base en la experiencia de los expertos suizos, diseño de protocolos y guías y acompañamiento en el desarrollo de experimentos de aplicación del producto. Adicionalmente, se implementó un laboratorio en el sitio para medir nitritos, nitratos y amonio, incluyendo su montaje durante la última misión y el entrenamiento correspondiente.

De acuerdo con lo planeado, se desarrollaron también actividades para fortalecer las estrategias de educación ambiental, para mejorar la separación en la fuente como parte fundamental del sistema, y se facilitaron espacios para generar alianzas que potencien la sostenibilidad y multiplicación de la experiencia y resultados en el tiempo posterior al proyecto.

El Proyecto estaba inicialmente planeado para un periodo de dos años, pero debido a la pandemia de Covid-19 fue ampliado a tres. De este modo y gracias a las herramientas virtuales, fue posible adelantar las actividades superando condiciones locales difíciles, gracias a la motivación constante de todos los socios. De igual forma, a pesar de la voluntad de los responsables de la planta y del sistema de residuos municipales, la disponibilidad de recursos económicos fue restringida debido a la pandemia, de modo que hubo retrasos en algunas de las mejoras de infraestructura. Así, durante el proyecto se han conseguido grandes mejoras en todo el proceso de compostaje (desde la recogida de residuos orgánicos hasta el uso de los compost producidos), incluyendo el control de los parámetros de calidad del producto tanto in situ como en el laboratorio.

Adicionalmente, los procesos en la planta tienen una importante dinámica, incluyendo el tener que adaptarse a situaciones inesperadas. Por ejemplo, desde finales del 2021, la municipalidad tuvo que ubicar de manera temporal el reciclaje de inorgánicos (plásticos, vidrio, cartón, etc.) en el mismo galpón del compostaje, de modo que parte de las mejoras que resultan en utilizar una mayor área como el disminuir el tamaño de las pilas, no fueron implementadas por completo. Un hecho relevante relacionado es que el pasado mes de junio se inició la mejora sugerida de cementar el piso del galpón de compostaje, lo cual requirió remover todas las pilas. Sin embargo, esto ofrece la oportunidad de reiniciar el proceso bajo las sugerencias ofrecidas por FiBL durante todo el proyecto, lo cual facilitará gracias a la documentación de todas las buenas prácticas sugeridas en el “manual para lograr un compost de excelente calidad” como uno de los productos tangibles del proyecto; y también a asesorías adicionales que puedan ofrecerse.

Uno de los principales retos que aún persisten es la mejora de la estructura de las pilas que permita que la circulación de aire sea óptima, disminuyendo así la generación de gases no deseados en el proceso. La municipalidad busca aún alternativas adicionales a las cáscaras de coco que ya recibe, como, por ejemplo, material de poda, para incorporarlo a la mezcla inicial de los residuos en la proporción indicada. Se espera también que se continúe con el registro regular de parámetros fundamentales como temperatura, pH y humedad, y con la evaluación (al menos anual) de los parámetros de calidad en laboratorio (metales pesados, nutrientes, etc.). En este sentido, se esperaría poder acompañar posteriormente el uso adecuado y periódico del laboratorio implementado en la planta.

3. Starting Point

Based on secondary information and the observations during the first mission of the Swiss team in Costa Rica (October 2019), there was a lack of good quality data on solid waste generation and composition, collection of organics, characterization and precise amounts of organic waste treated in the plant, and costs of the collection system and the plant operation. There was no documentation neither about the composting processes nor about the quality of the product. It was also observed that compost heaps were not formed but were incorporated into a very large mountain of waste, generating anaerobic processes with strong odours, a significant amount of leachate and compacted blocks that were difficult to handle. The technology for the final screening was also very poor and, additionally, there was no monitoring of processes and quality parameters.

Figure 3.1. Images of the starting point at the composting plant of Perez Zeledon (August 2019)

There was also a lack of detailed data on the operational costs of the plant and the product value. According to the information given by the administration before starting the project, the full costs of the operation of the plant were estimated at CHF 92'000 per year. At that time, up to 100 t of compost could be produced monthly and sold at 0.17 CHF/kg to small farmers, but due the poor quality of the product, its price decreased by 50% (to 0.08 CHF/kg).

Finally, there was no structured communication and environmental education plan. Some punctual campaigns for the general population were carried out but are poorly documented.

4. Objectives

The project's **main objective** was to develop a sustainable compost plant operation at Pérez Zeledón and through that establish a socio-technical showcase, which has a high potential for replication and scaling up of similar plants in Costa Rica.

This includes the following key objectives:

- The **improvement of the value chain of organic waste and products** obtained in the plant of Pérez Zeledón.
- The **strengthening of stakeholder empowerment**, such as government agencies, operational staff, representatives of service users and farmers from the region and the users of the waste collection and treatment service

5. Project Review

a. Project Implementation

The objectives of the project remained unchanged. The activity's journey was mainly based on training through direct technical advice (face-to-face and virtual), generation of protocols (**Annex D**) and guidelines, and documentation. The system was conceived in three parts (figure 5.1), for each of one, different methodological strategies were developed.

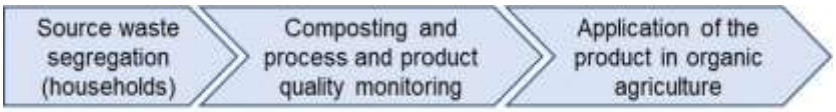

Figure 5.1. *Stages of the organics management system as a project development approach*

The following table presents the different strategies used in each part of the system:

Table 5.1. *Implementation strategies during the three project stages.*

Source segregation	Meetings with the Municipal Office of Communication and Environmental Education, webinars on environmental education and good practices with other municipalities in the country, design of a game as an education tool.
Composting process and monitoring	Experts' missions (3), trainings (in person and online), virtual meetings, design of protocols (**Annex D**), design and implementation of a field laboratory, guidelines
Product application	Fields experiments, organic farmers engagement, meetings, guidelines and compost quality monitoring.

b. Achievements of Objectives and Results

Overall, it is considered that 80% of the initially set objectives have been met. The first changes, thanks to the investment of resources by the municipality to address some of the suggestions made during the first mission (October 2019), were the replacement of the collection truck with a new one with leachate storage, and the extension of the covered composting area:

Figure 5.2. *Initial changes in the system after the first mission of the swiss experts*

Then, the main obstacles that the project team had to overcome were the Covid pandemic, and administrative processes for municipal budget allocation and procurement. The pandemic forced the postponement of the missions, replacing them with face-to-face consultancy. This also affected the dynamics of the operation of the waste system and the prioritisation of budget allocations by the municipality. Despite this, the municipality invested a larger amount of counterpart funds than initially promised, which is still active today (as with the current paving of the composting area) despite the formal completion (by dates) of the project; this demonstrates the commitment of the partners and the sustainability of the actions over time.

There is now a clear implementation of compost piles or windrows, in contrast to the accumulation of poorly separated and unstructured waste found in the first mission (figure 5.3). Additionally, a significant decrease in the presence of plastics in the windrows is evident. This is mainly due to the important efforts to improve the initial mixing phase of the waste when it is received at the plant; and to the effects that the environmental education and communication actions by the office in charge (figure 5.4), which has been part of the accompaniment of the project, are gradually having.

Figure 5.3. *Difference in material organisation and presence of plastics (2019 and 2022)*

Figure 5.4. *Verification of improvements in the presentation of waste for delivery to the collection service (2022)*

In the final phase of the composting plant's processes, a significant improvement was also achieved, thanks to the municipality's acquisition of a rotary sifter suggested by Dr. Fuchs (figure 5.5). Thanks to this, the final product can be more easily sorted and packed.

Figure 5.5. *Improvements at the final product screening stage*

The current product (figure 5.6) is of good quality and is being distributed through different channels. After packaging, approximately 30% is given to campaigns promoting organic agriculture and better separation at source. About 50% is sold to farmers and the remaining 20% is stored for a short time.

Figure 5.6. *Compost generated in the composting plant under revision (2022).*

Dr. Fuchs recommended in 2020 the implementation of an on-site laboratory to measure nitrite, nitrate, and ammonium, among other parameters such as salinity, as a strategy to support the improvement of plant processes, product quality and marketing. During the September 2021 mission, Dr. Fuchs took part of the equipment with him to demonstrate how the laboratory works. Finally, during the April 2022 mission, it was installed (figure 5.7), after a process of procurement of equipment and materials that had stumbles and delays due to the unavailability of equipment in the country, complicated import processes and the pandemic situation. To facilitate the further use of the laboratory and the interpretation of test results, a detailed guide was provided in Spanish (**Annex H**).

Figure 5.7. *On-site laboratory: Demonstration in September 2021, and installation and training in April 2022*

To help the local collaborators to apply the recommendation of the Swiss experts, a dissemination tool was created: “The guidelines for the composting of organic waste from municipal waste collection” (**Annex F**). This was complemented by a video titled “Composting procedures" (**Annex L**). Those materials could be helpful also for collaborators of the composting plant independent of their instruction level.

Throughout the project, and especially during the final mission, the interest and motivation of the local partners and different relevant actors identified in the system to continue the improvement processes in the plant and the multiplication of the experience were verified. In addition to the empowerment of the municipality itself (figure 5.8, left), the Ministry of Agriculture (figure 5.8, centre) and its branch in Perez Zeledón participated in the field activities, constantly reinforcing the advice with their local knowledge. Similarly, ACEPESA (figure 5.8, right), as the national coordinator of the project and a highly recognised organisation in the country and the region, is committed to continue monitoring the subsequent results

and to promote their multiplication by motivating actions from the different national authorities, enabling alliances, and disseminating the learning and advice provided through the different multiplication tools generated (see section c below).

Figure 5.8. *Left: Eng. Alvaro Murillo, responsible for the waste system in the municipality Perez Zeledón and the composting plant. Centre: Swiss experts, technicians of the municipal waste system, and the representative of the Ministry of Agriculture. Right: Director of ACEPESA*

The dissemination of the project also involved the agricultural sector, in order to promote the use of the compost obtained. For this purpose, different demonstration experiments were carried out (figure 5.9) with fast-growing foods such as coriander, broccoli, tomato, and sweet pepper. In addition, between September 2021 and April 2022, a short-term experiment was conducted with coffee crops, monitored directly by the Coopeasa Coffee Cooperative. In general, the product demonstrated significant contributions to the initial growth of the plants, compared to conventional and chemical fertilisers. In order to boost the sale of the product, it was recommended that the municipality conduct such experiments on a regular basis. However, to obtain robust and more complete results, it was also suggested to implement scientific experiments together with universities or technical institutes in the region (see also **Annex G**).

Figure 5.9. *Experiments demonstrating the benefits of composting with different foods from the region*

c. Multiplication / Replication Preparation

At the first instant, relevant actors were identified to enhance the multiplication of learning in order to initiate or strengthen other systems of integrated management of organics and composting in the country. In the face of actors other than the project partners, as strategies for disseminating results to motivate the multiplication of the experience, activities were developed during the execution of the project itself, and documents and materials were generated that will be disseminated in the future.

During the development of the project, 3 virtual seminars were held to share the processes and improvements implemented in Perez Zeledon. In addition, this facilitated the exchange of municipal experiences developed at the national level. These addressed aspects of environmental education and technical aspects of the operation of composting plants. As a result, a series of 3 documents were produced that compile all this information (figure 5.10).

Figure 5.10. *Guidelines as project outcomes to facilitate the dissemination and the multiplication (See **Annexe E, F and G**)*

The municipal good practice guide (Figure 5.10. left; **Annex E**) was delivered during the last mission in April 2022, to the main actors at national level, members of the National Intersectoral Committee Nama - Waste, composed of government institutions, municipalities, private sector, and NGOs, linked to the issue of climate change. This document was also sent to other relevant actors and disseminated through social networks, giving it a national and Latin American scope.

The second document (figure 5.10, centre; **Annex F**), is aimed at technical staff of municipalities that decide to implement similar projects; while the guide for compost application has as its target audience farmers who wish to use the compost produced in the plant, whether they are organic or conventional farmers (figure 5.10, right; **Annex G**).

In addition, a board game, and a “selective collection reminder” poster (figure 5.11.) are tangible tools for the multiplication of the project. Both products were handed over to the Environmental Education and Communication Office of Perez Zeledon to be distributed to different institutions. On the one hand, the game is aimed at educational institutions and community organisations that promote environmental education with school children and youth. On the other hand, the poster will be placed in shops and markets that must register there the days and hours of selective waste collection.

Figure 5.11. *Environmental education and information tools (see **Annexe I and J**)*

In addition, during the missions, the Swiss experts, in addition to training the technicians in Perez Zeledon, held exchange sessions with students and professors from the University of Costa Rica and the Technological Institute of Costa Rica, as well as with the Nama Committee (Figure 5.12).

Figure 5.12. *Expert conferences (2019-2022) and presentation of results to the Nama Committee - Waste (2022)*

The multiplication of the experience during the development of the project was also done through conferences, dissemination in social networks and through the media (figure 5.13).

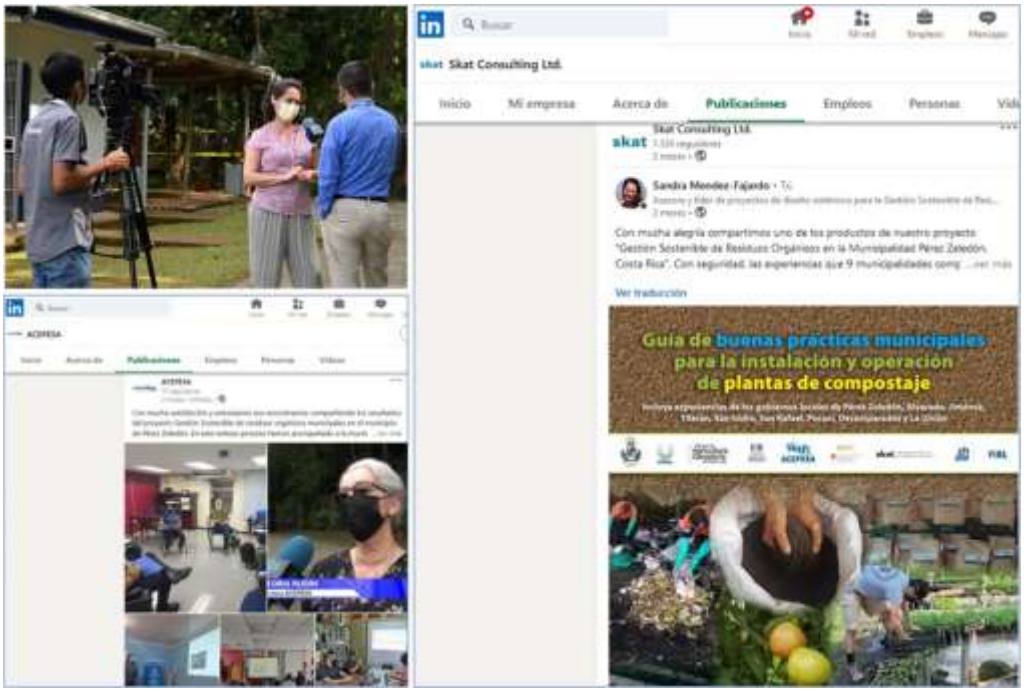

Figure 5.13. *Examples of dissemination of project results, in different media*

d. Impact / Sustainability

The project indicators were planned along the two lines demarcated by the two main objectives of the project: Improvement of the technical aspects of the system (outcome 1), and environmental education, multiplication, and empowerment of actors (outcome 2).

The following table shows the indicators related to the technical aspects assigned to outcome 1:

Table 5.2. *Project indicators for Outcome 1.*

Project impact		
A socio-technical case established for a regional composting system that will have national reach and impact.		
Outcome 1:	**Impact**	
Improving the value chain of organic waste and products obtained at the Pérez Zeledon plant.	To achieve a more efficient composting process to obtain good quality products competitive in the organic fertiliser market.	
Indicators Output 1.1: The elements of the current system are assessed (2019)	**Reported**	
Amount of organic waste collected [t/month] (avg)	274	
Amount of compost produced [t/month]	Up to 100	
Number of measured parameters for product characterisation [number]	0	
Indicators Output 1.2: The efficiency of the composting plant has improved.	**Reported**	**Increase %**
Greenhouse gas reduction [t CO2-eq/year]	270	*-45*
Amount of organic waste collected after project interventions [t/month]	298	8,8
Amount of compost produced after project interventions [t/month]	246	146,0
Number of staff trained [number]:	11	
Number of jobs created [number]:	2	
Indicators of Output 1.3: Marked opportunities for the organic product obtained have increased	**Reported**	**Increase %**
Quantity of marketable organic product(s) [t/month]	172	72,0
Revenue generated from the sale of the product [CHF/kg]	0,10	25,0

To quantify the environmental impact of the project, **GHG emissions** (kg CO2-eq/t FS input) from waste transport, from landfill of organic waste and from composting are used as efficiency indicators. According to the following table, 4 different scenarios are considered for comparison. To assess the direct impact of the project, scenarios 2 “Project Start” and 3 “Project End” are compared. All numbers given refer to the organic fraction of municipal waste only.

Table 5.3. *Baseline data for GHG Emission calculation.*

	Landfill		**Compost**		**GHG Emissions [kg CO2-eq./xx]**		
Scenario	Input [t FS/year]	Distance [km]	Input [t FS/year]	Distance [km]	Landfill [/t FS Input]	Compost [/t FS Input]	Transport [/t*km]
Landfill only (1)	8514	165	0	0	5000	0	0.12
Project Start (2)	5226	165	3288	15	5000	180	0.12
Project End (3)	4938	165	3576	15	5000	90	0.12
Full coverage (4)	0	0	8514	15	5000	60	0.12

(1) no collection and no composting of organic wastes, total amount sent to landfill.

(2) collection and on-site treatment 2019 at project start, baseline for impact reporting.

(3) collection and on-site treatment 2022 at project end, result line for impact reporting.

(4) full coverage of organic waste collection plus enhanced composting processes.

Comparing GHG emissions related to the transport of organic wastes and to the composting, an annual reduction of 270 t CO2-equivalents was achieved. GHG Emissions are largely connected to the composting process and only to a small amount to transport. This shows the importance of the project’s efficiency optimization measures. If a full coverage of a separate collection of organic wastes is implemented (scenario 4), overall GHG emissions from composting will rise due to the increased amount of organic wastes treated. Envisaging further efficiency measures, as outlined in sections 6 and 7, the specific GHG emission factor for composting can be cut to one third compared to the start of the project. This will result in an overall GHG emission reduction of about 4’800 t of CO2-equivalents per year compared to the actual landfilling procedure.

Table 5.4. *Compost GHG Emission calculation for 4 scenarios.*

	Emissions			
	Compost			
	from Waste	from Transport	**Total**	
Scenario	[t CO2-eq/year]			[t CO2-eq/t Input]
Landfill only (1)	-	-	-	-
Project Start (2)	592	6	**598**	**0.18**
Project End (3)	322	6	**328**	**0.09**
Full coverage (4)	511	15	**526**	**0.06**

(1) no collection and no composting of organic wastes, total amount sent to landfill.

(2) collection and on-site treatment 2019 at project start, baseline for impact reporting.

(3) collection and on-site treatment 2022 at project end, result line for impact reporting.

(4) full coverage of organic waste collection plus enhanced composting processes.

In addition to the beneficial effect of separate collection and composting on GHG reduction, the use of quality compost will lead to a significant humus build up in agricultural and horticultural soils. At a humus reconstitution ratio of 40-70 kg Humus-C/t Compost, at the end of the project some 120 - 210 t of Humus-C is added to soils.

At the beginning of the project, it was intended to achieve a 50% increase in the amount of **waste collected**. However, the conditions encountered during the development of the project only allowed for an **increase of 8.8%** (table 5.3). At present, the municipality is building the concrete floor, according to the suggestions given by FiBL, so that a restart of the processes with the desired efficiency is expected, which will allow a gradual increase in the number of inhabitants receiving the differentiated collection service.

As a positive contrast, thanks to the gradual implementation of process improvements and product quality monitoring, the increase in the **amount of compost produced increased by 146%**, from 100 tons per month (August 2019) to 246 tons per month reported in the last project mission (April 2022).

Of the total amount of compost produced, approximately 30% is donated through environmental education campaigns and the promotion of urban agriculture as part of the municipality's activities. Therefore, the **increase in the amount of compost potentially sold on the market is 72.2%**. A total of 133 bags of 25 kg were sold between January and June 2022, showing that the market for the product is growing.

A total of **11 employees** of the municipality were trained, including the 3 technicians working directly at the composting plant. This technical team was **reinforced with a new job**. As part of the technical capacity building activities, the municipality and the regional office of the MAG supported the four-month stay of **Nadia Frei, a student trainee of the *Berner Fachhochschule für Agrar-, Forst- und Lebensmittelwissenschaft***, who was directly advised by Dr. Fuchs. As part of her activities, Nadia helped to improve the use of protocols for process and quality monitoring and conducted a series of experiments to verify the properties of compost.

The indicators related to the second work stream are shown in the table below. As part of the output 2.1., a total of **104 people** participated in training activities, conferences with experts, and webinars to disseminate results and transfer local knowledge. During the project, **5 cooperation agreements** were concluded by the municipality, specifically with the regional office of the Ministry of Agriculture, IFAM, organic farmers through the Coopeasa cooperative, and Mr. Mora and Mr. Bolivar, with whom different compost demonstration experiments were developed. In addition, as described in section 6.1 below, the IFAM (Institute for Municipal Development and Advisory Services) plans to conduct at least **2 outreach activities annually**.

Table 5.5. *Project indicators for Outcome 2*

Project impact	
A socio-technical case established for a regional composting system that will have national reach and impact.	
Outcome 2:	**Impact**
Increased stakeholder engagement	Strengthening cooperation and stakeholder engagement
Indicators Output 2.1: The commitment of actors defining regional and local programmes and regulations has increased.	
Actors participating in the organic waste management workshops [number]	104
Number of new cooperation agreements [number]	5
Number of post-project actions planned [number/year]	2
Indicators Output 2.2: Strategies to multiply and expand the project have been defined.	
Number of official multiplication activities initiated through the project [number/year]	4
Expected number of beneficiaries of multiplication activities [number]	32
Number of visitors to the plant during the project [number/year]	N.A.

Regarding the output 2.2 during 2022 and thanks to the dissemination of the project through the Institute for Municipal Development and Advisory Services IFAM, the municipality of Perez Zeledón has received official requests from **4 municipalities** to receive technical assistance for their composting plants, which have gradually been started: The municipalities of Esparza, Golfito, Coto Brus and Pococí.

To date, **32 organisations** at the national level have received the document. *"Good practices in the implementation of composting plants"* (**Annex E**) both printed and in pdf. It is expected to start disseminating the two other documents generated by the project, *"Guidelines for the composting of organic waste from municipal waste collection"* and *"Guidelines for the correct application of the composting plant product"*, so that this indicator will be increasing. In the same vein, through the Ministry of Agriculture MAG and IFAM, the document *"Guide for the chemical analysis of compost in the field laboratory, Perez Zeledon Composting Plant"* will be shared to encourage the implementation and use of the in-situ laboratory to measure nitrites, nitrates, and ammonium, to the extent that the municipalities have their own resources to acquire the equipment and materials. **Annexes F** and **G** will be disseminated virtually through the partners' official websites and social media.

Finally, due to the pandemic, **technical visits** to the plant by groups from schools, universities or social organisations could not take place, as initially planned. However, some officials from other municipalities, in an isolated manner, were able to visit the facilities, and through virtual tours they have shared the operation of the plant. It is expected that in the medium term this activity will be developed as part of the environmental education and communication strategies.

6. Outlook / Further Actions

6.1 Multiplication / Replication

At the national level, the Institute for Municipal Development and Advisory Services (IFAM) has taken it upon itself to promote the multiplication of the project both nationally and internationally. For this purpose, as an example, a face-to-face meeting of municipalities will be held in which Perez Zeledón will present the results of the project, focusing on the best practices learned and the technical, administrative, and financial requirements needed to achieve excellent compost quality. The IFAM will continue to receive and manage requests for advice from other municipalities, for which it will assign technicians from Perez Zeledón.

The IFAM will also finance the travel of both the plant manager and direct project partner, engineer Alvaro Murillo, and the technician in charge of the operation, engineer Randall Varela, to present the project at the 9th Inter-American Congress on Solid Waste (DIRSA) in Medellin, Colombia (August 31 to September 2, 2022).

From the Ministry of Agriculture and the Ministry of Environment, the project will be disseminated through the resulting documents, meetings, and training at national level. The experience will also be promoted as a successful case in universities with related training programmes.

At the municipal level, the plant will regularly set up spaces for technical visits to schools and universities and will promote community meetings and visits to businesses to encourage good separation of organic waste at source.

Alliances will continue to be sought with organic farmers' associations and with the municipality's Agricultural Office to promote the use of the compost produced. This will be done through the continuation of environmental education campaigns to promote composting and recycling, and compost donations to incentivize urban vegetable gardens, as well as through the occasional implementation of demonstration experiments.

6.2 Impact / Sustainability

Those responsible for the composting plant will continue with the measurement of quality parameters both on site, following FiBL's suggestions in the technical guidelines provided. Similarly, the municipality will annually allocate the necessary resources to measure annually (as a minimum) the quality parameters in the laboratory.

The empowerment shown by IFAM to multiply the Perez Zeledón experience in the country and in the region (see 6.1.), together with the interest of other authorities at the national level to follow up on the case study, will become triggers for the continuity of good practices and improvements implemented at the plant.

In addition, the country is steadily advancing towards GHG reduction targets based on its decarbonisation and organic waste recovery plans at the national level. In this framework, thanks to the example shown by this project as a feasible emissions prevention strategy, both Perez Zeledón and other municipalities will continue their efforts to increase their waste collection coverage and to improve the efficiency of their composting plants. Similarly, organic agriculture will continue to be promoted and

the Ministry of Agriculture will continue to encourage the generation and use of organic fertilisers such as compost.

The integrated-sustainable management system for organics and the composting process in Perez Zeledon have improved substantially thanks to the advice and the implementation of the suggestions. From a sustainability point of view, however, one aspect is still at risk: the use of the laboratory installed to measure nitrite, nitrate, and ammonium on site. During the final mission last April, Dr. Jacques Fuchs installed the equipment purchased by the municipality with the support of project resources, and conducted the training required to perform the tests. In addition, to make it easier for the technicians to repeat these processes over time, we developed a manual in Spanish for the use of the laboratory and the interpretation of the results. As a complement to this guide, and with the images of the installation in the field during the April mission (2022), a video was produced in which the processes of use of the equipment and interpretation of the results are described, all with voice-over in Spanish **(Annex M)**. However, since these are completely new equipment and processes for the technicians of the composting plant, as a group of experts we believe that a single training has not been enough to achieve autonomous use of the laboratory. **This will be followed up sporadically with the support of Dr. Fuchs on a voluntary basis, but it would be ideal to have resources for an additional virtual meetings of reinforcement and follow-up of this technical aspect. In addition, due to the infrastructure arrangements still being made at the plant, a continuation of the consultancy would be an ideal complement to achieve full implementation and adoption of the technical suggestions offered in terms of process and product quality monitoring**.

7. Lessons Learned / Conclusions

The main lessons learned, and conclusions are:

- The improvement of processes and product quality control in municipal plants requires significant efforts in terms of human resources as well as investments. This in turn demands a significant level of empowerment of the responsible municipal officials.
- The correct separation of organic waste at source and delivery of organic waste with as few plastic bags as possible are fundamental aspects in improving the quality of compost. These cultural changes take time and require significant resources in environmental education campaigns and incentives. It was found that in Perez Zeledon this aspect is quite advanced, although there is still room for improvement.
- It is essential to incorporate structural material such as *defibrated* wood or coconut husk fibres (as is the case in Perez Zeledon) when receiving the waste at the plant and making the initial mixture. However, it is not easy to achieve a permanent availability of these materials in the plant, so there are still challenges in this aspect.
- The use of compost in agriculture requires important changes in the farmers' mentality and practices. This can be achieved by promoting visits to the composting plant to verify the processes properly carried out, verification of protocols that record temperature and pH dynamics, and implementation of demonstration experiments. These suggestions are detailed in the guidelines resulting from the project (in Spanish)
- In order to achieve dissemination and multiplication of the experience, it is necessary to involve and empower related authorities at both national and municipal levels. This is achieved by regular dissemination of progress in process improvements and by documentation and dissemination through meetings, conferences, and technical visits of these relevant actors.
- The project's implementation strategies, involving environmental education events, on-site meetings and training, user-oriented guidelines and showcase field experiments, showed to be very efficient in awareness rising throughout all stakeholder levels. Especially on-site training showed to have a highly sustainable effect in allowing trained personnel to act as future trainers and multiplicators.
- Great improvements on the whole composting process (from the collection of organic waste to the use of the produced composts) have been achieved during the project. However, in order to manage the process in the future and ensure its quality, a small amount of financial support for another one to two years follow-up would be desirable to allow the local collaborators to refine and consolidate their knowledge and experience.

- Similarly, expert support would also be desirable for the implementation of multiplication of the project in other municipalities, each situation being a little different. The contribution of the experts could allow a quick and efficient implementation of the concept of composting of organic waste.
- Finally, for a successful continuation of the activities, both on the technical level of the composting plant and on the organisational level in the municipality and beyond, a number of uncertainty factors have to be taken into account.

  Examples are:

  - Further efforts to develop the good practice and full coverage of separate collection of organic wastes free of plastics.
  - Guaranteed in-time supply of consumables for field laboratory
  - Sufficient financial means for acquisition and purchase of new equipment such as a compost turning machine or compost sieve.
  - Permit for the compost's phytosanitary quality to be applied in food production.
  - Further promotion of farmer support actions to promote cultivation specific use of compost.
  - Further awareness rising measures throughout the local population to use compost for private gardening.

8. Annexes

A. *First Intermediate report (February 29, 2020)*
B. *Second Intermediate report (January 27, 2021)*
C. *Third Intermediate Report (April 24, 2021)*
D. *Monitoring Protocols (field parameter)*
E. *Dissemination tool: Good practices in the implementation of composting plants*
F. *Dissemination tool: Guidelines for the composting of organic waste from municipal waste collection.*
G. *Dissemination tool: Guidelines for the correct application of the composting plant product*
H. *Dissemination tool: Guide for the chemical analysis of compost in the field laboratory, Perez Zeledon Composting Plant.*
I. *Dissemination tool: A playful-pedagogical tool to promote better separation at source*
J. *Dissemination tool: "Selective collection reminder" poster for businesses and markets*
K. *Laboratory results*
L. *Dissemination tool: video "Composting procedures"*

   Link (English version): https://youtu.be/Hum0Cx5CWs0

   Link (Spanish version): https://youtu.be/qEdXgq-sPFQ

M. *Dissemination tool: video "Field laboratory methods"*