Supply chain climate change risk assessment

Jalisco Mexico

June 2017

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About PROADAPT

PROADAPT was launched in 2013 by the Inter-American Development Bank in partnership with the Nordic Development Fund to improve climate resilience among small and medium enterprises and to foster business opportunities to provide climate resilience solutions, or products and services that help buyers to reduce or transfer their vulnerability to climate risk.

About the Multilateral Investment Fund

The Multilateral Investment Fund is the innovation lab for the Inter-American Development Bank Group. It conducts high-risk experiments to test new models for engaging and inspiring the private sector to solve economic development problems in Latin America and the Caribbean. The MIF addresses poverty and vulnerability by focusing on emerging businesses and smallholder farmers with the capacity to grow and create economic opportunities.

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Contents

List of figures

List of tables

1. A climate risk assessment for Danone's Margarita Project

According to the Intergovernmental Panel on Climate Change (IPCC, 2014[1]), the internationally accepted authority on the subject, climate change is a scientific reality. If anthropogenic greenhouse gas emissions were to stop today, the world would still be 'locked-in' to an inevitable amount of warming, and impacts associated with climate change would continue to manifest for centuries to come. All economic sectors, and particularly those that are natural resource dependent, are vulnerable to the impacts of climate change. Therefore, it is imperative that actions are taken to adapt to the negative impacts, and seize the potential opportunities that arise from a changing climate. The agricultural sector, whose greenhouse gas (GHG) emissions have nearly doubled in the past fifty years (FAO, 2014[2]), is both a major contributor to climate change and most at risk of climate change impacts, as the sector's economic output is strongly correlated to existing climate conditions.

Mexico is already experiencing the impacts of climate change. Since the 1960s, national average temperatures have increased by 0.85°C, while winter temperatures have increased by 1.3°C. Average annual precipitation has decreased in the southern regions over the past fifty years (Instituto Nacional de Ecología y Cambio Climático, 2016[3]) and heavy rains and droughts have become more frequent and intense (Secretaría de Medio Ambiente y Recursos Naturales, 2016[4]).

These climate changes are affecting Mexico's dairy sector. The drought that the nation is currently facing is driving up the price of production inputs (Portal lechero, 2017[5]). In Jalisco, extremely high temperatures have been observed over recent years, resulting in decreased milk productivity, more frequent dairy cattle miscarriages and decreased water supply.

In light of the aforementioned impacts, increasing the dairy sector's climate resilience can be highly beneficial to its future growth prospects, while having substantial environmental co-benefits.

Danone Mexico, Danone Ecosystem Fund and Technoserve set out in 2010 to create a sustainable milk sourcing strategy while improving the livelihoods of small-scale milk

[1] IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf [Accessed on 19 April 2017]

[2] Food and Agriculture Organization of the United Nations – FAO. (2014) México: el sector agropecuario ante el desafío del Cambio Climático, p.10-14. Available at: http://www.fao.org/3/a-i4093s.pdf [Accessed on 20 April 2017]

[3] Instituto Nacional de Ecología y Cambio Climático. (2016). Online article. Efectos del cambio climático. Available at: http://www.gob.mx/inecc/acciones-y-programas/efectos-del-cambio-climatico [Accessed on 19 April 2017]

[4] Secretaría de Medio Ambiente y Recursos Naturales. (2016). Online article. *Cómo afecta el cambio climático a México*. Available at: http://www.gob.mx/semarnat/articulos/como-afecta-el-cambio-climatico-a-mexico [Accessed on 19 April 2017

[5] Portal lechero. (2017). Online article. México: Se disparan costos de productos lácteos por temporada de sequía. Available at: https://www.portalechero.com/innovaportal/v/11307/1/innova.front/mexico:-se-disparan-costos-de-productos-lacteos-por-temporada-de-sequia.html [Accessed on 19 April 2017]

producers, within the framework of the Margarita Project[6]. This project brings together public and private sector partners to provide a full suite of services that enable participating farmers to increase productivity and quality as well as their incomes. The project has already achieved considerable success doubling incomes of over 300 small-scale dairy farmers and supplying 12% of Danone Mexico's milk procurement volumes. Danone intends to expand this programme to reach 3 000 farmers, enhancing the sustainability of milk production and further increasing farmer incomes.

Analysing to what extent climate change threatens the Margarita project is an essential step to strengthen milk producers' resilience and to ensure long-term economic sustainability.

Danone, working with the IDB/MIF as part of the PROADAPT programme funded by IDB, MIF and the Nordic Development Fund, seeks to examine the practical steps to build climate resilience in its milk/dairy supply chain in Jalisco, Mexico. The Margarita Project provides a well-defined case study to develop a supply chain climate change risk assessment.

Danone has very precise business targets for its business model and its dairy suppliers. The objective of this supply chain climate risk assessment is to understand how a changing climate will impact these targets, and to understand any fragility within the supply chain and the actions required to manage the risks and build resilience. A secondary objective of this project is to provide the foundations for developing an assessment process that could be replicated across Danone's Latin and Central American operations. Finally, the mission aims to identify adaptation options that deliver against and make a positive contribution towards Danone's business and sustainability targets, including future carbon neutrality.

This study is based on a literature review and interviews conducted with technical experts, to identify the current state of knowledge of climate change impacts on dairy farming. This was followed by an analysis of near-time and longer-time scale climatic changes, based on the best available published information.

Working with Danone, Technoserve and dairy farmers, Acclimatise has drawn on the literature review and the results from the climate change analysis to identify and assess potential impacts for key elements of the supply chain to inform the climate risk assessment. This first assessment has been completed through a five-day in-country mission where interviews were undertaken, together with site visits to farms. The in-country mission included face-to-face meetings with Danone and Technoserve's technicians, two workshops, and individual meetings with farmers and other stakeholders to analyse the main climate risks to dairy production and to discuss and identify the most relevant options to manage negative impacts and take advantage of opportunities. The options have been screened using a qualitative analysis to assess the implications for GHG production and the wider sustainability targets set by Danone.

[6] More information about the Margarita project is available at: http://ecosysteme.danone.com/project/margarita-milk-club/

This report sets out the results of the analysis, the assessments and the final list of proposed management options, and provides a template for replicating this process at other Danone locations.

Climate risk analysis of a supply chain

From large multinational corporations to small and medium enterprises (SMEs), **economic entities are connected to each other via supply chains** which create links between people, activities, information, and resources to produce and distribute a specific product or service. The level of climate change risk may vary along the supply chain and climate change impacts can take various forms:

- Climate change can entail **physical risks** (Carbon Trust, 2017[7]; BSR, 2015[8]; Adams and Khosa, 2013[9]; GIZ 2013[10]) as it increases the probability of occurrence of extreme weather events which may have significant repercussions on assets and operations: disruption of transport, halt of operations, yield lost, etc. Such events also impinge on businesses' facilities as warehouses and storage buildings can be negatively affected by extreme weather, resulting in damages or loss of stored goods.

- Climate changes can also **reduce the availability and/or increase the price of certain inputs** (Ibid). Agrifood industries are particularly concerned, as agricultural production is strongly correlated to existing climate conditions, therefore highly vulnerable to climate variability and change.

- It can also cause disruptions in communities that impact **supplier workforce availability and productivity** (BSR, 2015).

- There are also **regulatory risks** (Carbon Trust, 2017; BSR, 2015; Adams and Khosa, 2013), like the risk of new energy taxes and regulations, reporting requirements, etc., that can have an impact on businesses.

- Some **reputational risks** (Ibid) may also exist for companies who misuse certain natural resources (for instance water) whose availability could be reduced in a climate change context.

[7] Carbon Trust, (2017), Missing link: Harnessing the power of purchasing for a sustainable future, Carbon Disclosure Project.
[8] BSR (2015), Business Action for Climate-Resilient Supply Chains. A Practical Framework from Identifying Priorities to Evaluating Impact. May 2015. Available at: https://www.bsr.org/reports/BSR_Report_Climate_Resilient_Supply_Chains.pdf
[9] Adams P., Khosa B., (2013), Assessing and managing climate change risks in supply chains, UK Environment Agency. Available at: http://climateuk.net/sites/default/files/Supply%20Chains.pdf
[10] GIZ, 2013. Guía para integrar adaptación al cambio climático en cadenas de valor (en base a experiencias de Ecuador). Available at: http://api.ning.com/files/dzJVcnA3Xm1s-*Z8vH3m-pNfO2A*2R4i0xJyX262ZXXOO1CKYUThp2CZmBLOL3SCG94v4u7qR4iLqp3EzERtI3MQh7B3UZrP/GIZGESORENPub_CadenasdeValorFINALBaja.pdf

Climate change can also **lead to new opportunities** (Adams and Khosa, 2013). Companies who are **aware of climate change risks and adapt their strategies, become more resilient and increase their competitiveness** compared to a business-as-usual scenario. Introducing new products and technologies to enhance resilience and reduce GHG emissions, for example, may result in **more efficient production and logistical processes, and cost reductions**, while contributing to the development of technologies and services that **help other stakeholders gain resilience and reduce their emissions at a lower price**. The emergence of these new products and technologies can bring **new market opportunities and provide an edge over competitors**. Those actions can also have a **positive impact in terms of corporate reputation**. Finally, more favourable climate conditions allow the production of new commodities (e.g. new crops) and diversification of supply.

In conclusion, **gaining resilience will lead to a competitive advantage in a climate change context**. This assumes that the cost of inaction is greater than the cost of building resilience.

How to address climate change impacts on a supply chain?

Being aware of climate change impacts and its consequences on the supply chain (understanding whether a changing climate could disrupt the supply chain or some of its components) is the first step towards building climate resilience. Mapping the supply chain in detail – including geographic locations, helps identify the most vulnerable parts of the chain and therefore target the most appropriate adaptation measures.

According to Gledhill et al[11]. (2013), **two main parameters** should be considered in a climate risk analysis of a supply chain:

- The **nature and magnitude of climate change impacts on the supply chain and supplier's ability to cope with these effects**: Analysing commodity's susceptibility to climate change effects and potential multiplier effects; climate change long-term effects on investment plans; market demand for commodities that are likely to be affected by climate change, etc.
- The **flexibility and concentration of the supply**: if a commodity is sourced from a diversified pool of suppliers situated in different locations, the company is less likely to be vulnerable to disruptions. On the contrary, a small number of suppliers located in the same geographic area (and therefore submitted to similar climate change impacts) reduces the alternative options, if the commodity becomes scarce.

[11] Gledhill R., Hamza-Goodacre D., Ping Low L., (2013), Business-not-as-usual: Tackling the impact of climate change on supply chain risk, PricewaterhouseCoopers (PwC). Available at:
https://www.pwc.com/gx/en/services/advisory/consulting/risk/resilience/publications/business-not-as-usual.html

Considering the supply chain model, i.e. whether the company is structured on a just-in-time (JIT) or stockpiling model, and understanding how it can adjust to the business necessities, is also part of the study.

- Once the analysis and detailed mapping of the supply chain has been undertaken to identify the most relevant climate risks and their effects, adaptation measures can be identified and prioritized (Adams and Khosa, 2013), such as:
- Concrete adaptation measures to **address climate change impacts**: Focus should be placed on no-regret and low regret measures with the potential to provide benefits under a range of future climate change scenarios; mainstream climate change into decision making processes and setting risk management procedures according to the identified vulnerabilities, etc.
- Adaptation **options to diversify sand deconcentrate the supply**: Fine-tune the company's supply strategy based on the analysis of the relative climate exposure of key commodities and suppliers; expand the supply to other possible suppliers and/or locations; switch to domestic suppliers to reduce risk inherent to long-distance transport logistics, etc.
- Measures **favouring an enabling environment for the implementation of the selected adaptation measures** and having a **leverage effect** to boost their impacts towards a more resilient supply chain: institutional, commercial and financial arrangements, capacity building activities, awareness-raising and communication options, actions to support community development, social, economic and environmental sustainability, etc.

2. The current state of knowledge of climate change impacts on dairy supply chain

The dairy sector is likely to face the adverse consequences of climate change, both through direct impact on livestock's wellbeing, as well as through indirect impacts on the availability and quality of food and water, logistical problems or physical damages provoked by extreme climate events. This situation is likely to constitute an economic burden for both farmers and suppliers who must work together to avoid acute disruptions to the dairy supply chain. As the dairy farming system is already experiencing the consequences of climate change, it is necessary to implement solutions to adapt to its current impacts and to anticipate negative repercussions on the milk supply chain.

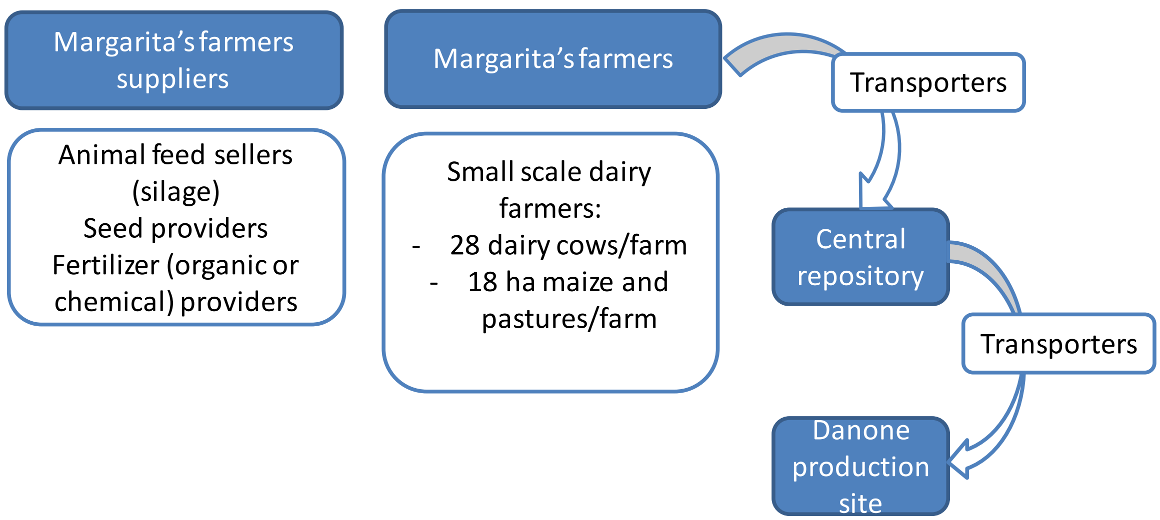
2.1. The Margarita project's supply chain

The Margarita project aims at establishing a **sustainable milk sourcing strategy** while improving the livelihoods of small scale milk producers. Margarita is a "sourcing" project from Danone Ecosystem Fund, therefore emphasis is given to supporting farmers in sustainable milk production while improving their social and economic conditions, and managerial skills.

The **supply chain** associated to Margarita is a **very concentrated, homogeneous supply chain, located in a very small geographic area (and therefore submitted to very similar climate change impacts)**. Except for chemical fertilizers providers and transporters, all the parties involved in the supply chain are agricultural producers.

The Margarita supply chain is represented below:

Figure 1: Margarita project - Supply chain



Agricultural producers (and namely dairy farmers) form the main component of Margarita's supply chain, and the project is based on the explicit recognition that enabling farmers to increase productivity and quality as well as their incomes, increases the sustainability of the supply chain as a whole.

Since Margarita's supply chain involves cattle, feeding crops, storage and transportation activities, climate variability and change have a multiple-pronged impact on the project: direct consequences on animals and milk production, indirect impacts on pastures and fodder crops (Zhao et al., 2005[12]), direct consequences on roads, storage facilities and operations.

[12] Zhao Y., Wang C., Wang S., Tibig L., (2005) Impacts of Present and Future Climate Variability On Agriculture and Forestry in the Humid and Sub-Humid Tropics in Climatic Change, Volume 70, Issue 1, p. 73–116. Available at: http://link.springer.com/article/10.1007/s10584-005-5938-8 [Accessed on 19 April 2017]

This report assesses these effects and includes a special focus on the Mexican state of Jalisco, where the Margarita project is located.

2.2. Direct consequences on animals

2.2.1. Heat stress

Dairy cattle are extremely vulnerable to hot temperatures because of their high metabolic rate and poor water retention (Chase, 2006[13]). Their thermoneutral zone (TNZ), that is, the range of temperature where the animal doesn't have to expend energy to maintain its normal body temperature (Extension, 2010[14]), is between 6°C and 16°C, the lowest average of all livestock species (Alonso-Spilsbury et al., 2012[15]). Heat stress, triggered by high temperatures, high humidity and radiant energy, carries a high-energy cost for affected dairy cows and leads to altered metabolism, hormone and feed intake rates. **This may lead to a 10% to 25%-reduction in milk production** (Nidumolu et al., 2010[16] and Chase, 2006) which would represent a loss of 17 USD to 42 USD per day for a typical Margarita farm with 28 productive cows. This would also mean a step backwards for the Margarita project which enabled to increase by more than 85% the daily milk production of a typical Margarita farm, from an average of 22 productive cows to 28 productive cows per farm and from 13 litres per cow and day to 19 litres, according to Danone's technicians.

Heat stress also affects the cows' reproductive performance, even after giving birth. The length and intensity of the oestrus period decreases, along with the fertility rate and growth, size and development of ovarian follicles, as well as foetal growth. The risk of early embryonic deaths increases too (Chase, 2006).

2.2.2. Diseases and pest distribution

Higher temperatures combined with increased soil moisture create a breeding ground for the development of pathogens or parasites. Vector-borne diseases transmitted through midges, flies, ticks and mosquitoes may increase as they benefit from higher temperatures and wetter conditions. In addition, cattle are also vulnerable to new diseases that may result from climate change, as new weather patterns are likely to bring about shifts in disease distribution and location of outbreaks. As a result, previously unexposed animals will lack the genetic resistance to protect themselves from new forms of illnesses (Ibid).

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[13] Chase, L.E., (2006). Climate change impacts on dairy cattle. Fact Sheet, Climate Change and Agriculture: Promoting Practical and Profitable Responses. http://climateandfarming.org/pdfs/FactSheets/III.3Cattle.pdf [Accessed on 19 April 2017]

[14] Extension, (2010). Online article. Explain the concepts of thermoneutral zone, lower critical temperature, and upper critical temperature, and how they relate to metabolic rate. Available at: http://articles.extension.org/pages/44454/explain-the-concepts-of-thermoneutral-zone-lower-critical-temperature-and-upper-critical-temperature [Accessed on 19 April 2017]

[15] Extension, (2010). Online article. Explain the concepts of thermoneutral zone, lower critical temperature, and upper critical temperature, and how they relate to metabolic rate. Available at: http://articles.extension.org/pages/44454/explain-the-concepts-of-thermoneutral-zone-lower-critical-temperature-and-upper-critical-temperature [Accessed on 19 April 2017]

[16] Nidumolu, U., Crimp, S., Gobbett, D., Laing, A., Howden, M. and Little, S. (2010). Heat stress in dairy cattle in northern Victoria: responses to a changing climate. CSIRO Climate Adaptation Flagship Working Paper No. 10. Available at: http://www.csiro.au/resources/CAF-working-papers.html [Accessed on 19 April 2017]

Heat stress may also trigger diseases that reduce milk production. A recent study in the state of Jalisco demonstrated that **higher temperatures and humidity can increase the risk of mastitis**, the inflammation of the udder through which milk is extracted. According to the study, excessive heat leads cows to drink more water and eat less, while remaining stationary to cool down. This increases their internal body temperature, which contributes to mastitis' development. This disease **causes cow's milk production to fall by 10%-15% daily** (Bedolla, 2018[17]), that is, a loss of 17 USD to 25 USD per day for a typical Margarita farm. According to Danone's veterinarians on the Margarita project, mastitis is the most consequential disease that farmers are facing nowadays.

It is therefore clear that climate change has a direct impact on cattle by triggering heat stress on the animals, reducing their wellbeing, and productivity. In addition, new weather patterns are likely to create the conditions that can trigger epidemics and affect cattle's health. Beyond the direct impacts, a changing climate is also likely to impinge on livestock's sustenance, as described below.

2.3. Indirect consequences on cattle's feeding system: pastures, feed crops and water

2.3.1. Grazing systems and feed crops

Droughts constitute a powerful threat to the animals' grazing systems. Prolonged periods of combined hot temperatures and lack of water are likely to reduce the amount of quality forage available to grazing livestock (United States Environmental Protection Agency (EPA), 2017[18]).

Estimates show that by 2030, the State of Jalisco will experience strong hydric stress (Velasco, 2012[19]). Therefore, the preservation of fodder crops and pastures must be carefully planned to ensure the sustainability of milk production. In 2011, a strong drought in Mexico led 20 states to experience a lack of fodder that provoked significant weight losses in the cattle population. Almost 35% of the national livestock was affected and the milk production substantially dropped as compared to 2010 levels (Rodríguez et al., 2011[20]).

Rising temperatures and both a lack of precipitation and/or extreme precipitation will create lower quantity and quality of crops and grains, impacting on the amount and diversity of fodder available for livestock. If temperatures exceed crop's optimum temperatures, yields will decline (EPA, 2017), causing feed crops' prices to surge and impacting farmer's production costs and net revenues.

[17] Bedolla, CC (2008), Pérdidas económicas ocasionadas por la mastitis bovina en la industria lechera. REDVET. Revista electrónica de Veterinaria 1695-7504 2008 Volumen IX Número 4. Available at: http://www.veterinaria.org/revistas/redvet/n040408/040805.pdf [Accessed on 20 April 2017]

[18] United States Environmental Protection Agency – EPA (2017). Online article. Climate Impacts on Agriculture and Food Supply. Available at: https://www.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply#livestock [Accessed on 20 April 2017]

[19] Velasco I. (2012). Instituto Mexicano de Tecnología del Agua. Sequía y cambio climático en México, pp. 48. Available at: http://repositorio.imta.mx:8080/cenca-repositorio/handle/123456789/1100 [Accessed on 20 April 2017]

[20] Rodríguez Licea G., Juárez Carrillo C. (2011). Impacto de la Sequía sobre los Mercados Agropecuarios en México (2011) in Economía Actual, pp. 27-28. Available at: http://web.uaemex.mx/feconomia/Publicaciones/e404/ea-15_Gabriela.pdf [Accessed on 20 April 2017]

2.3.2. Water

The agricultural sector is highly dependent on water and is one of the largest consumers of fresh water resources. Water is used in the livestock sector at the farm level (for animal consumption, cleaning and other farm uses) and for the growing of feed crops and other servicing and product processing purposes (Thornton, van de Steeg, Notenbaert and Herrero, 2009[21]). As climate change is likely to negatively affect fresh water supplies, by increasing precipitation variability and poorer water quality (Ibid), water resources should be conservatively managed by the dairy industry. Not only will climate change likely lead to less water availability and disruptions, temperature increase may also lead to increased water demand. For instance, temperature variations modify cattle's water intake from 3kg/kg of dry matter at 10°C, to 8kg at 30°C and 14kg at 35°C (Ibid).

2.4. Direct consequences on transportation, storing and transformation activities

Some extreme climate events like high winds or heavy rains have already provoked important impacts on transportation and storing activities in Los Altos de Jalisco. Strong winds caused falling of trees and posts, impeding the passage of trucks transporting milk and provoking power failures that caused milk refrigeration problems. Heavy rains made secondary roads and paths impassable, causing delays and disruptions on milk supply[22].

Damage to productive infrastructure can also be provoked by these extreme climate events.

2.5. Economic consequences

Climate change impacts are likely to affect the production of milk as changing weather patterns disrupt the agricultural planning cycle, increasing instability and impairing the industry's income.

One of the main risks brought about by climate change to the dairy industry is the inability of farmers to produce sufficient fodder for their livestock. For example, if grass and fodder crop levels do not cover the livestock's nutritional needs, because of damaging weather events, farmers will need to purchase more from suppliers (Hennessy et al., 2017[23]). It is likely that the increase in production costs will be passed on to the consumer, reducing the product's competitiveness in the market.

Changing and less predictable weather events contribute to the volatility of food prices and negatively affect the country's food supply. In Mexico, it is expected that reduced food supply will be accompanied by a rise in domestic demand, as the population is growing and consumption patterns are evolving (Ibid). This is an important challenge for the country's

[21] Thornton P.K., van de Steeg J., Notenbaert A., Herrero M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know in Agricultural Systems, pp.117-119. Available at: http://www.sciencedirect.com/science/article/pii/S0308521X09000584 [Accessed on 19 April 2017]

[22] Stakeholder's workshops in Tepatitlán de Morelos and San Juan de los Lagos, May 2017.

[23] Hennessy T. and al. (2017). The impact of climate change on dairy production, safe food, p.71-73. Available at: http://www.climatenorthernireland.org.uk/cmsfiles/M10039-SAFEFOOD_Climate-Change-on-the-Dairy-Production-Report-24-02-2017.pdf [Accessed on 20 April 2017]

farming sector. The 2005 drought is illustrative of the cost of weather events on Mexico's agricultural sector. It is estimated that the drought led to a 13%-reduction of the total milk production and cost around 779 million pesos (42 million USD).

It should also be noted that the provision of dairy products flows into a larger supply chain of the food processing industry. Food retailers need consistent supply from farmers, whose production is at risk of being disrupted by climate change. From slow onset weather events to natural disasters, climate change-related phenomena can have both short and long-term impacts on supply chains. Beyond reductions in production, the dairy sector may also have to deal with damage to assets such as farm buildings and machinery (Hennessy T. et al, 2017). As these meteorological events are likely to increase, it is essential for food companies to actively engage with their suppliers in order to mitigate potential negative consequences to their business.

Climate data for the Margarita project area: observed climate and mid-to long-term future projections

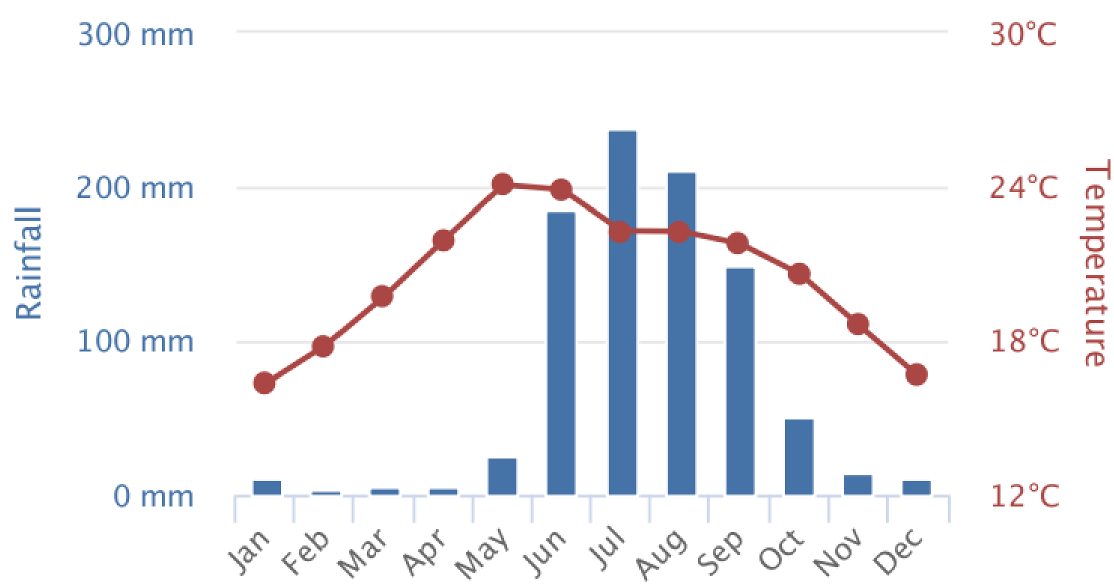
The geographical area of the Margarita project, Los Altos de Jalisco, in the Mexican State of Jalisco, has a sub-humid warm climate with average temperatures varying from 14°C to 18°C in the autumn and winter, and from 20°C to 22°C in spring and summer. The days are usually warm, with temperatures reaching 30°C in May or June, and nights are mild, with average temperatures around 11°C.

The average annual rainfall is 900 mm and the majority of precipitation events (80%) occur in the months of June, July, August and September often in the form of heavy rain.

The following figure shows the average monthly temperature and rainfall for the Altos de Jalisco region from 1901 to 2015 obtained from the World Bank's Climate Change Knowledge Portal[24].

[24] Available at: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Latin America&ThisCCode=MEX

Figure 2: Average monthly temperature and rainfall for Altos de Jalisco from 1901 to 2015



Source: World Bank Climate Change Knowledge Portal

The latest CMIP5[25] climate change projections for the region were analysed using data from multi-General Circulation Models (GCMs). The GCMs are run using a range of Representative Concentration Pathways (RCPs), which are greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. The four RCPs include:

- RCP 2.6 scenario: estimates that GHG concentrations will reach a peak between 2010 and 2020 and decrease thereafter.
- RCP 4.5 scenario: estimates that a peak in GHG concentrations will occur by 2040 and decrease thereafter
- RCP 6 scenario: estimates that the maximum concentrations will be reached by 2080 and decrease thereafter
- RCP 8.5 scenario, the most pessimistic scenario, estimates that GHG emission concentrations will continue to rise throughout the 21st century.

- Climate change data for the Altos de Jalisco region was obtained for these four scenarios using 16 models[26].
- The following figures and tables illustrate the projected temperature and rainfall changes according to RCP 2.6, 4.5, 6 and 8.5 scenarios:

[25] Coupled Model Intercomparison Project 5

[26] The Models used were: BCC_CSM1_1, BCC_CSM1_1_M, CCSM4, CESM1_CAM5, CSIRO_MK3_6_0, FIO_ESM, GFDL_CM3, GFDL_ESM2M, GISS_E2_H, GISS_E2_R, IPSL_CM5A_MR, MIROC_ESM, MIROC_ESM_CHEM, MIROC5, MRI_CGCM3 and NORESM1_M

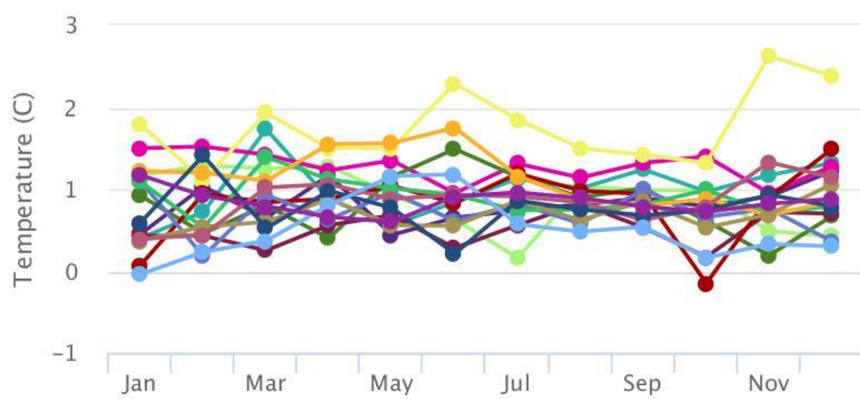
- Increase of average annual temperature
- (see Table 1, Figure 3 and Figure 4)
- + 0.5 °C to + 2 °C from 2017 to 2039, and
- + 0.2 °C to + 6 °C from 2040 to 2099.
- Changes in total annual rainfall (see Table 2, Figure 5 and Figure 6)
- Maximum projected decrease[27] - 23.32 % and
- maximum projected increase + 7.74% from 2017 to 2039, and,
- Maximum projected decrease - 40.42 % and
- maximum projected increase + 4.23% from 2040 to 2099.

Additionally, according to the World Bank's Climate Change Knowledge Portal, the region is prone to droughts and presents a mean annual irrigation deficit between -5% and -15% for 2030. Floods may occur in lowlands and valleys, and there is a medium risk of precipitation-triggered landslides due to regional topography.

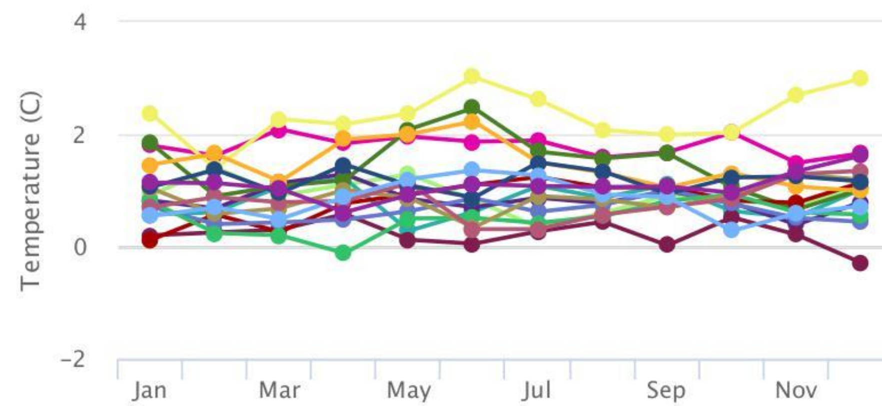
[27] Depending on scenarios.

Figure 3: Projected temperature changes: RCP 2.6 and RCP 4.5 scenarios

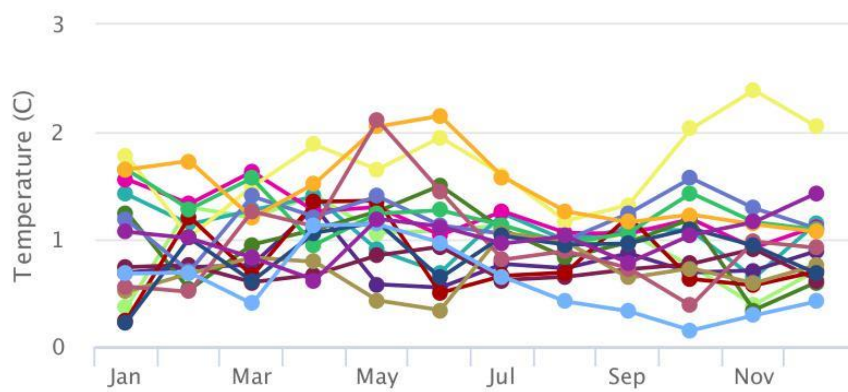
Projected change in Temperature for Tepatitlan 2040 RCP 2.6:



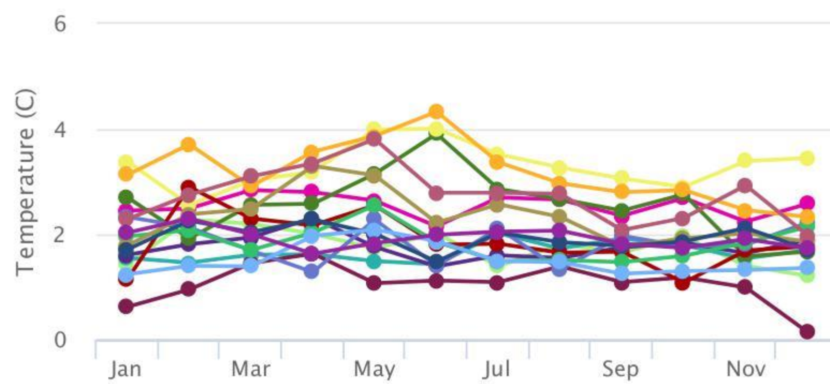
Projected change in Temperature for Tepatitlan 2099 RCP 2.6:



Projected change in Temperature for Tepatitlan 2040 RCP 4.5:



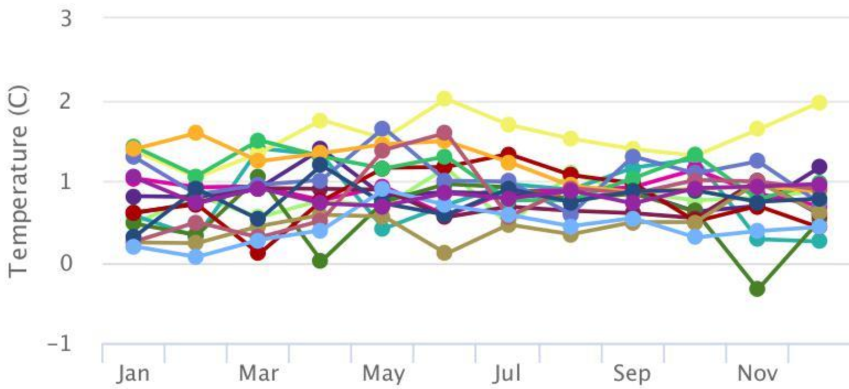
Projected change in Temperature for Tepatitlan 2099 RCP 4.5:



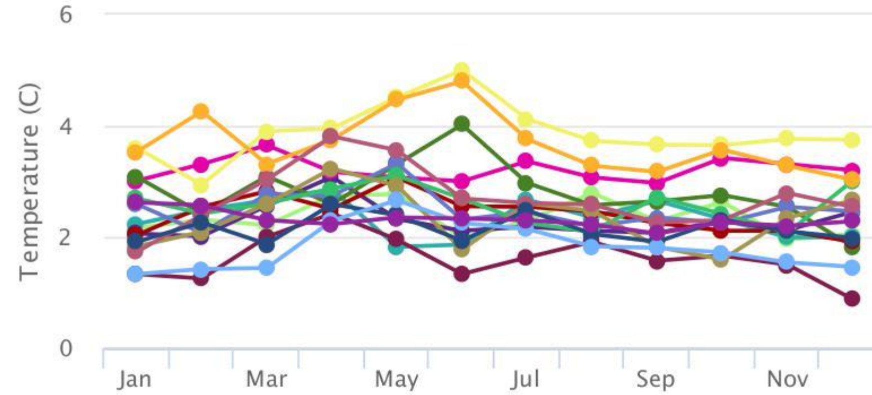
Source: World Bank Climate Change Knowledge Portal

Figure 4: Projected temperature changes: RCP 6 and RCP 8.5 scenarios

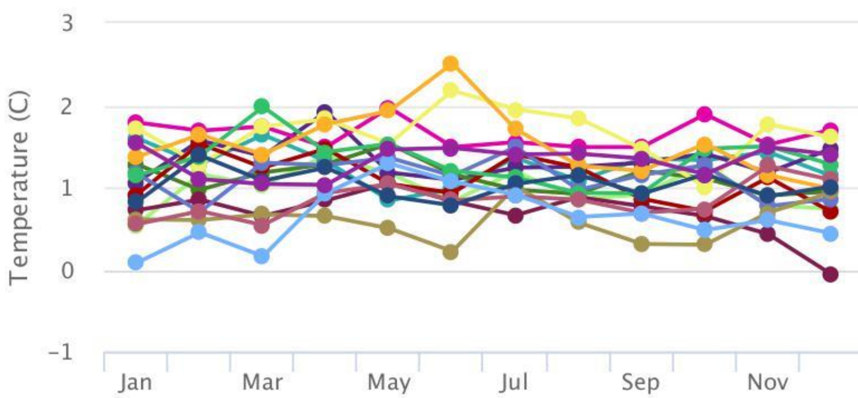
Projected change in Temperature for Tepatitlan 2040 RCP 6:



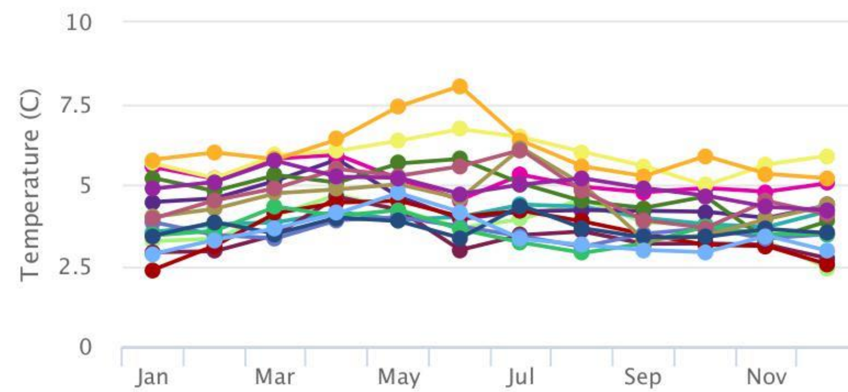
Projected change in Temperature for Tepatitlan 2099 RCP 6:



Projected change in Temperature for Tepatitlan 2040 RCP 8.5:



Projected change in Temperature for Tepatitlan 2099 RCP 8.5:



Source: World Bank Climate Change Knowledge Portal

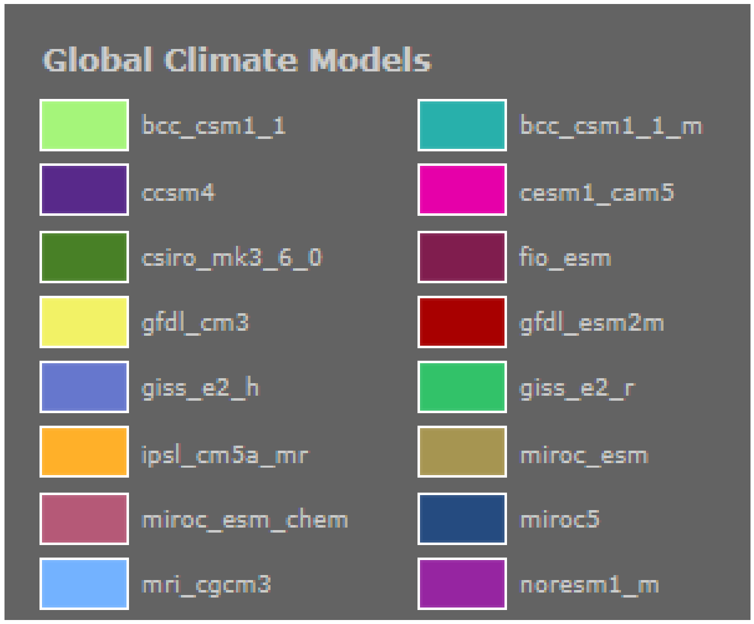


Table 1: Projected temperature changes 2017 -2039 and 2040 – 2099

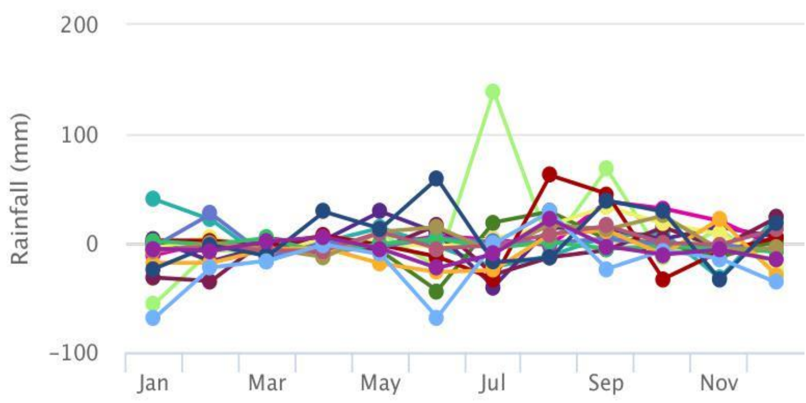
Projected Temperature changes 2017 – 2039 (°C)	Mean	Min	Max
RCP 2.6	0.9123	0.4877	1.7962
RCP 4.5	1.0255	0.5314	1.743
RCP 6	0.8936	0.4412	1.5944
RCP 8.5	1.1696	0.5693	1.7279
Projected Temperature changes 2040 - 2099 (°C)	**Mean**	**Min**	**Max**
RCP 2.6	1.0096	0.2316	2.3463
RCP 4.5	2.1133	1.0706	3.3102
RCP 6	2.632	1.6257	3.8853
RCP 8.5	3.3079	3.3221	6.1893

Source: Climate Explorer. European Climate Assessment and Data[28]

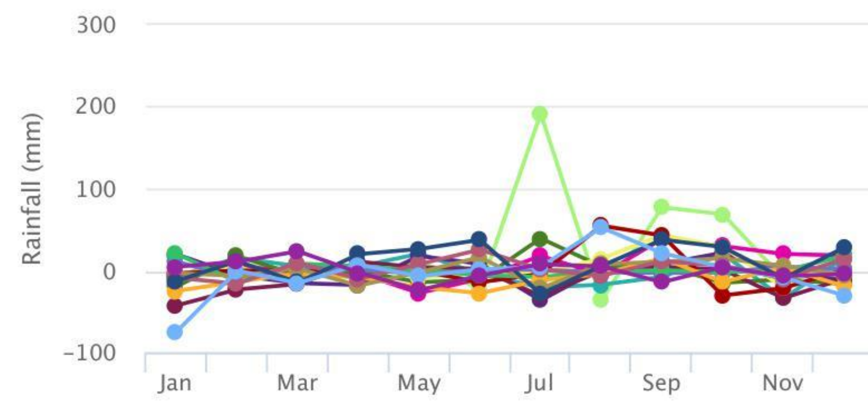
[28] Available at: http://climexp.knmi.nl/plot_atlas_form.py

Figure 5: Projected rainfall change: RCP 2.6 and RCP 4.5 scenarios

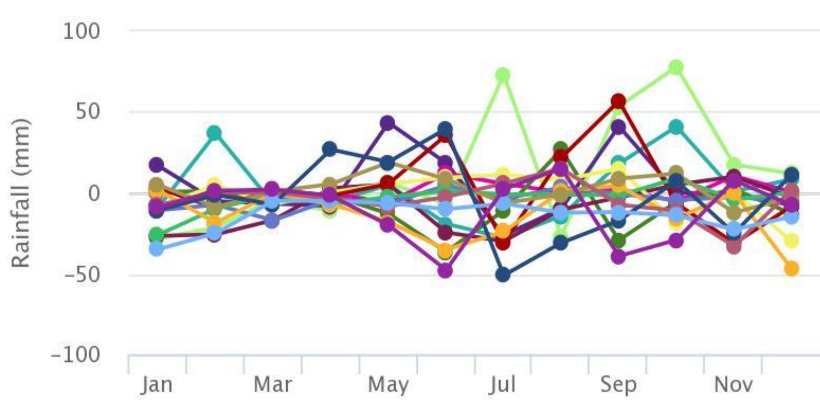
Projected change in rainfall for Tepatitlan 2040 RCP 2.6



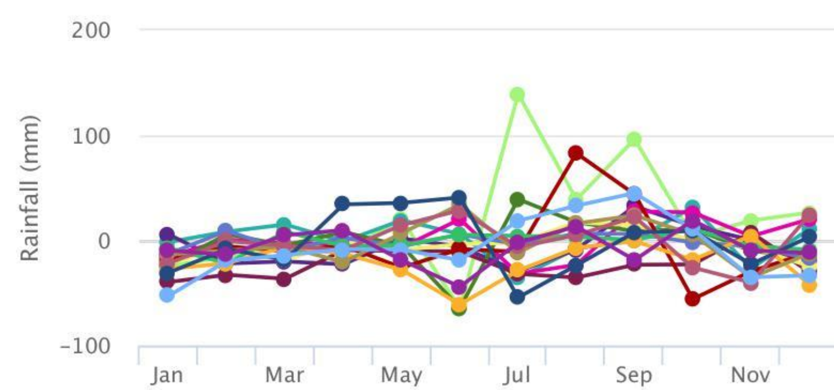
Projected change in rainfall for Tepatitlan 2099 RCP 2.6



Projected change in rainfall for Tepatitlan 2040 RCP 4.5



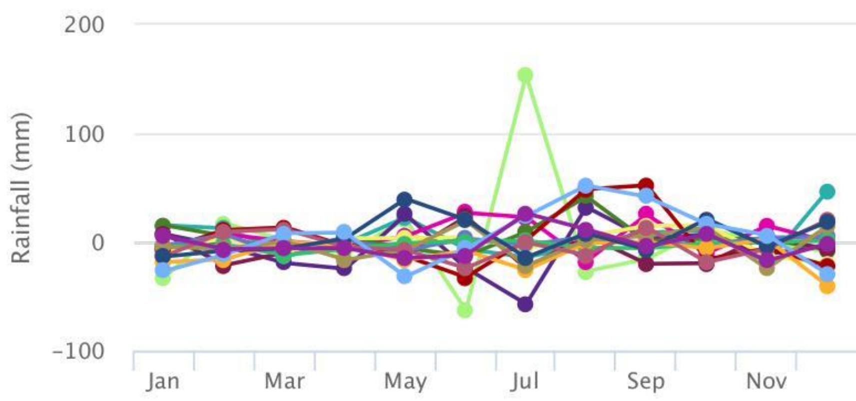
Projected change in rainfall for Tepatitlan 2099 RCP 4.5



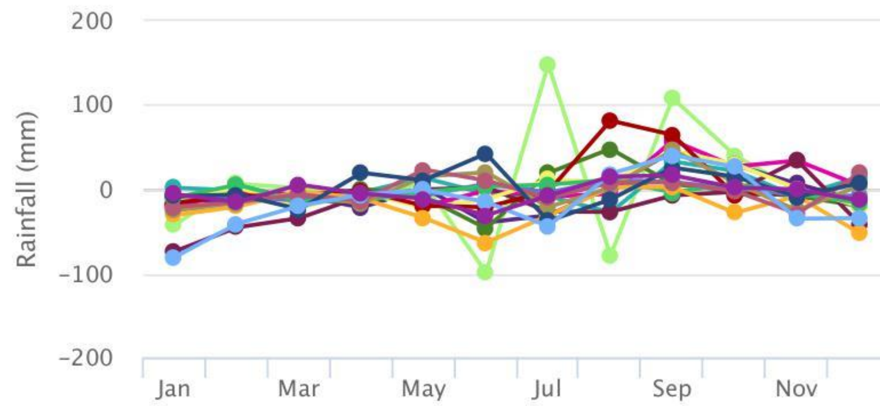
Source: World Bank Climate Change Knowledge Portal

Figure 6: Projected rainfall change: RCP 2.6 and RCP 4.5 scenarios

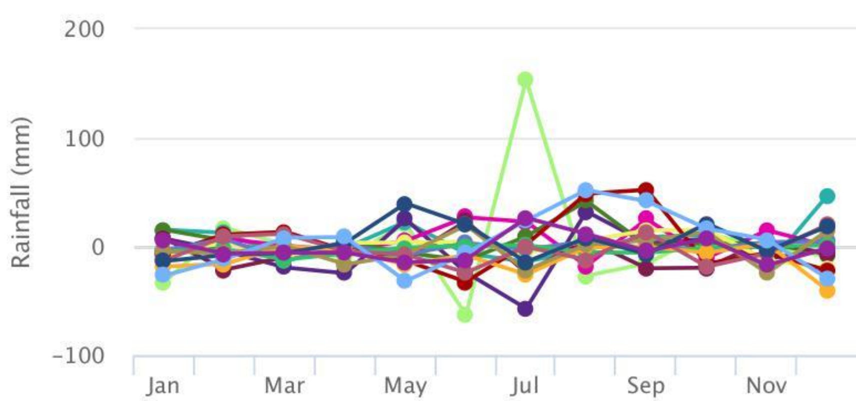
Projected change in rainfall for Tepatitlan 2040 RCP 6



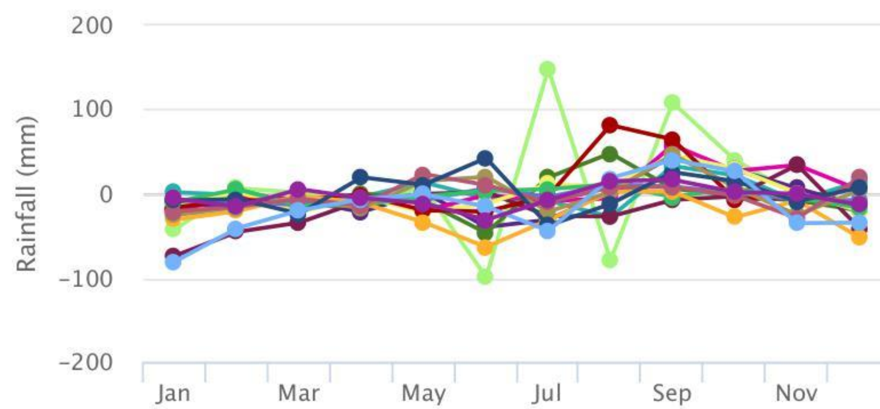
Projected change in rainfall for Tepatitlan 2099 RCP 6



Projected change in rainfall for Tepatitlan 2040 RCP 8.5



Projected change in rainfall for Tepatitlan 2099 RCP 8.5



Source: World Bank Climate Change Knowledge Portal

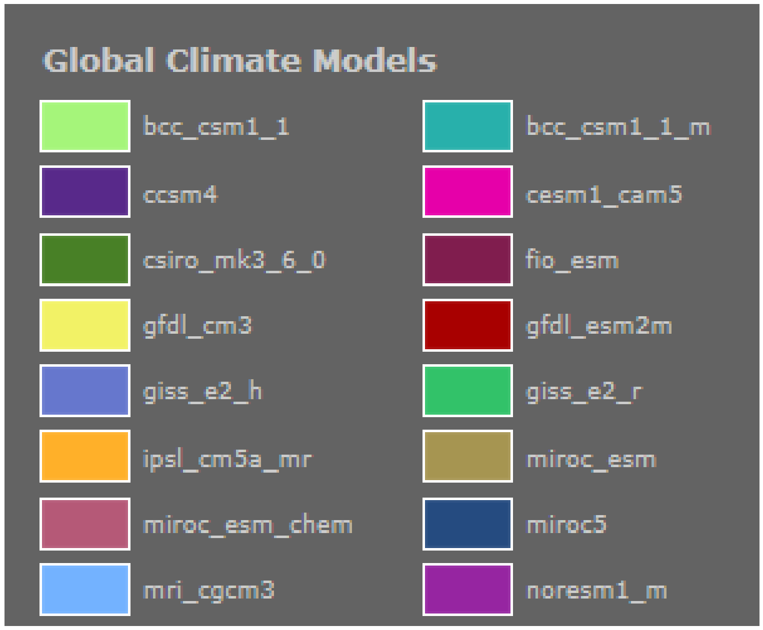


Table 2: Projected rainfall changes 2017 – 2039 and 2040 – 2099

Projected Rainfall changes 2017 – 2039 (%)	Mean	Max decrease	Max increase
RCP 2.6	-0.99	-12.91	+ 7.74
RCP 4.5	-3.53	-19.69	+ 6.10
RCP 6	-0.53	-15.61	+ 7.33
RCP 8.5	-3.27	-23.32	+ 6.51
Projected Rainfall changes 2040 - 2099 (%)	**Mean**	**Max decrease**	**Max increase**
RCP 2.6	-0.74	-15.06	+ 12.99
RCP 4.5	-5.06	-30.33	+ 9.85
RCP 6	-4.29	-34.01	+ 11.39
RCP 8.5	-12.53	-40.42	+14.23

Source: Climate Explorer. European Climate Assessment and Data[29]

[29] Available at: http://climexp.knmi.nl/plot_atlas_form.py

3. Potential climate change impacts on the Margarita's supply chain

Climate change is already causing significant economic losses globally to agriculture and livestock production while contributing to further environmental degradation. To mitigate losses associated with climate change and to seize associated opportunities, it is crucial to have a good understanding of climate change impacts and their potential effects to the supply chain.

The results of the literature review and expert consultations, as well as the analysis of the projected climate changes, enabled the identification of the main potential climate change impacts on the Margarita project's supply chain, which are summarised below:

Table 3: Potential climate change impacts on the Margarita project

Expected Climate Change	Potential impacts on Margarita's supply chain
Rainwater shortage and hydric stress	Lower yields of forage plants and reduction of their quality: Livestock does not cover their sustenance requirements, milk production decreases, reproductive problems appear. Need to purchase more fodder crops from suppliers at higher prices. Additional manpower is needed to get alternative sources of water.
Temperature rising	Decrease in food intake. Decrease in milk production (-10% to 25%) and conception rate. Need to purchase more fodder crops from suppliers at higher prices. Higher risks of mastitis, which is the most important disease that farmers are facing nowadays.
Extreme climate events more frequent and intense **(strong winds and heavy rains)**	Power cuts (milk refrigeration problems). Roads become impassable – logistical problems for milk collection and transportation. Damage to productive infrastructures.

All the impacts identified will reduce yields, and increase costs and the risk of cattle health problems. No positive impacts have been identified. The progress made under the Margarita project is likely to be halted and possibly reduced because of the compound effect of these impacts, unless adaptation actions are taken.

An analysis of the observed climate changes and their past impacts on crops, milk production, storage and transportation activities was jointly developed with Margarita's farmers and Danone and Technoserve's technicians during the two workshops. This participative risk identification and assessment allowed the team and partners to confirm the above-mentioned potential climate change impacts as the key climate change threats to Margarita's supply chain.

This first assessment of the most relevant climate change impacts on Margarita laid the foundation for the adoption of relevant adaptation measures to reduce the risks associated with climate change, while achieving Danone's business and sustainability targets, including future carbon neutrality.

The following table present the main GHG emission sources in the dairy sector as well as some possible solutions to reduce them:

Table 4: GHG emissions in the dairy sector and mitigation strategies

GHG emissions in the dairy sector
Livestock production accounts for 14.5% of total GHG emissions and contributes to 64.8% of the agricultural sector's emissions globally. The main sources of GHG emissions in dairy farming (FAO, 2013[30]) are: • Enteric fermentation of ruminants (46% - methane CH_4, whose comparative global warming potential[31] is more than 25 times greater than CO_2 over a 100-year period.) • Management, fertilization, and forage production (36% - nitrous oxide N_2O, with a global warming potential (100-year) of 298. According to FAO (2013), there is a direct relationship between increased productivity and GHG emissions reduction.
How to reduce GHG emissions on dairy farming?
• Improve feed quality, with less fibrous forages and balanced formulas, which enhance digestion and nutrient utilization, decreases production of methane and manure, increases productivity and reduces the risk of mortality. • Improve herd management (reduction of unproductive cows, replacement of lower productive wombs) which leads to costs reduction. • Reduce manure storage time. • Organic/ sustainable fertilization. • Technologies for manure processing: biodigesters, which allow manure reuse, decrease fertilization costs and reduce energy consumption in stables. ***All of these actions can be affected by changes in climatic conditions***

[30] Food and Agriculture Organization of the United Nations – FAO (2013). Climate Smart Agriculture Sourcebook. 570 p. Available at: http://www.fao.org/docrep/018/i3325e/i3325e.pdf. [Accessed on 21 April 2017]

[31] The Global Warming Potential (GWP) was developed to measure how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2).

4. Business case for a resilient low-carbon dairy supply chain

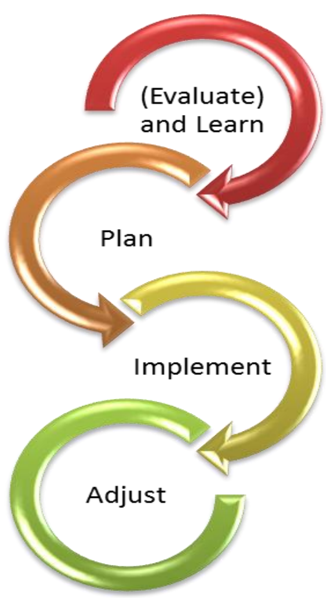
A sustainable and resilient dairy supply chain, while ensuring stable productivity levels, requires an integrated approach where the productive outputs of agricultural practices are linked to the provision of social and environmental goods and services, biodiversity conservation, land protection, mitigation, and adaptation to climate change.

Climate resilience can be analysed from both the point of view of the supply chain as a whole, and the individual farmers, as they are the main component of Margarita's supply chain. These are intimately connected, since in very concentrated and inflexible supply chains like this, building individual farmer's resilience will result in a more climate resilient supply chain.

4.1. Summary of climate change impacts on each receptor in the supply chain

Based on an adaptive management approach - an iterative, learning process which facilitates decision making in the context of uncertainty (see figure below), another key step for a transformational resilient pathway is **awareness raising and knowledge creation**. Indeed, a good understanding of climate change risks and their potential impacts on the key elements of the supply chain is needed to **identify the main vulnerability areas** and to **propose adequate solutions** to cope with potential climate change impacts.

Figure 7: Adaptive management approach – making decisions in the context of uncertainty



In this particular case, **water scarcity, higher temperatures and more frequent and intense extreme weather events** were identified as the main climate changes for the geographic area where the Margarita project is located, and the in-country mission allowed the identification of the main climate change impacts on the supply chain for Margarita as follows:

- Main climate impacts for Margarita's farmers:
- Decrease in milk production.
    - Additional manpower is needed to get access to alternative
    - sources of water.
    - Higher risks of mastitis, which is the most important disease
    - that farmers are facing nowadays. This leads to production
    - reduction.
    - Lower yields of forage plants and reduction of their quality:
    - Need to purchase more fodder crops from suppliers at higher
    - prices.
    - Power cuts (milk refrigeration problems).
    - Damage to productive infrastructures.
- Main climate impacts for Margarita's farmers' suppliers (animal feed suppliers):
    - Lower yields of forage plants and reduction of their quality.
    - Revenues decrease.
- Main climate impacts for Margarita's transporters (Union Farmer's and Danone's transporters):
    - Roads become impassable – logistical problems for
    - milk collection and transportation.

The participative identification and analysis of the potential climate change impacts, based on past observations of climate related events, increased stakeholders' awareness of the potential climate changes and their consequences on the dairy supply chain.

4.2. The selection of adaptation options

The literature review illustrated a series of potential adaptation options, whose relevance and adaptability to Margarita's context and needs have been evaluated through meetings with farmers and technicians before and during the in-country mission. A multicriteria analysis was undertaken to identify the most relevant adaptation options for the Margarita project. The main criteria used to analyse and prioritise the potential adaptation options were:

- The capacity of the proposed measure to respond to one or more key climate risks identified.

- The probability of an effective implementation of the measure in the short term, given the existing economic, technical, institutional and human capacities and the willingness of farmers to apply it.
- The cost-efficiency of the measure and the existing possible financial options.
- The co-benefits provided through the measure, including its contribution to GHG emissions reduction.
- The contribution of the adaptation option to a "transformational change", meaning that the measure has an impact beyond a specific investment and contributes to a paradigm shift to achieve more resilient dairy farming.
- The possibility of replication and scaling up.
- This served as a starting point for the identification and prioritisation of key actions to enhance Margarita's resilience in a climate change context.

4.2.1. Actions for farmers

From an individual point of view, the following measures were proposed to address the main potential impacts on Margarita's farmers, as they are the main element of Danone's supply chain in Jalisco. These **recommendations emerged from a closed working collaboration with the main stakeholders**, who firmly believed that the best way to make a positive contribution towards Danone's business and sustainability targets in a climate change context required **concrete (investment) measures with an important mitigation component, while continuing to improve the livelihood and managerial skills of Margarita's farmers**. Four priority resilient and low carbon measures for the Margarita project were selected, which are described in detail in Section 7:

Table 5: Proposed key resilient and low-carbon measures for the Margarita Project

Key resilient and low-carbon investment options for the Margarita Project:
• Water harvesting, storage and treatment systems: install rainwater catchment systems to increase the amount of water available, even during periods of low or sporadic rainfall; • Farm reforestation: plant or protect trees and bushes to favour water infiltration and preservation, protect cattle from heat stress and solar radiation and capture and store CO_2; • Biodigesters: use of manure and slurry management and treatment techniques which reduce GHG emissions, improve soil quality and moisture preservation, and lead to reductions of chemical fertilizers' and its associated costs and environmental impacts; • Solar panels: install solar panels on farms to reduce reliance on centralised grid supplies, provides greater resilience in the event of disruption during extreme events, decrease GHG emissions from conventional energy sources, reduce the energy bill and can provide shade and shelter to the cattle.

We have observed that there is a **threshold effect**[32] in terms of the size of the farm (around 40 to 50 productive cows) **for measures requiring high initial investments** (installing biodigesters or solar panels in farms, for instance[33]). Farmers with a greater number of cattle and a stronger financial situation may consider these kinds of non-productive investments. Therefore, biodigesters and solar panels are recommended for farms with more than 40 cattle. The co-benefit impact on GHG emissions reduction of these two measures will be consequently higher than for a typical Margarita farm with an average of 28 cattle per fam.

However, **measures aiming at reinforcing the financial and managerial sustainability** of the farms, **productive investments** (additional cattle, milking parlors, more efficient stabling systems, etc.) and **adaptation measures not needing important initial investments that can be introduced progressively**, should be prioritized **for farmers below the threshold**.

Thus, the stakeholders also validated the need of including other measures that didn't need important initial investments, could be introduced in a progressive manner, and promote transformational changes towards a more climate resilience supply chain:

[32] IDB and Danone may wish to consider what actions they can take to encourage research into the development of commercially viable biodigestors and solar panels for small farmers.

[33] See Section 7 for more details on the technical and financial aspects of these two adaptation measures.

Table 6: Other key resilient and low-carbon measures for the Margarita Project

Other key resilient and low-carbon measures for the Margarita Project
• Improve feed quality, using less fibrous forages and balanced formulas, and adapt dietary patterns under heat stress conditions; • Install feeders and drinking troughs in the farmyards, to improve feed efficiency; • Surveillance and early detection of infectious diseases; • Test and progressively introduce agricultural practices to improve soil quality and preserve soil moisture, such as: crop rotation (avoid monoculture of maize), no till / reduce till, leave harvest residues in the fields, cover crops; • Introducing new cattle breeds and crop varieties more resilient to drought; • Installing and/or using early warning systems for droughts, heatwaves and fires; • Encouraging the participation of farmers to agricultural insurance systems (i.e. parametric insurance)

4.2.2. Actions for other parts of the supply chain

An adaptation option to reduce the climate vulnerability of Danone's and the Union Farmer's transporters was also proposed (improving secondary roads and pathways) but it was not selected as a priority measure as it was considered not to be the responsibility of Danone or Danone's associates, since public paths and roads fall within the competence of municipalities and the State.

4.2.3. Actions for Danone

From **Danone's point of view**, some actions could be taken to increase the climate resilience of Margarita's supply chain as a whole. These actions aim at promoting an **enabling environment** which paves the way for the implementation of climate change measures and boosts their contribution to climate resilience:

- Develop awareness raising activities regarding potential climate change impacts and possible adaptation measures;
- Encourage or enable measures which minimize the direct consequences of climate change impacts on physical assets;
- Provide support to Margarita's farmers for the implementation of concrete adaptation measures which contribute to improving their resilience in a climate change context;

- Propose capacity building activities and pilot projects regarding new practices and technologies to gain a better understanding of their real implications and needs (i.e. biodigesters, cover crops);
- Enable institutional agreements with public and private entities that provide training and capacity building activities for farmers about the new practices and technologies to be introduced in farms;
- Establish the framework for more efficient access to new technologies: Danone is negotiating with some firms working on solar panels and biodigesters to have advantageous conditions for their associate famers;
- Enable financial arrangements to facilitate the access of Margarita's associates to financial sources (grants and loans) and to ensure more favourable financial conditions;
- Allow institutional arrangements to enable the effective implementation of some adaptation measures (i.e. agreements with CONAFOR to promote reforestation measures).

4.2.4. Recognition that Margarita project is already building resilience

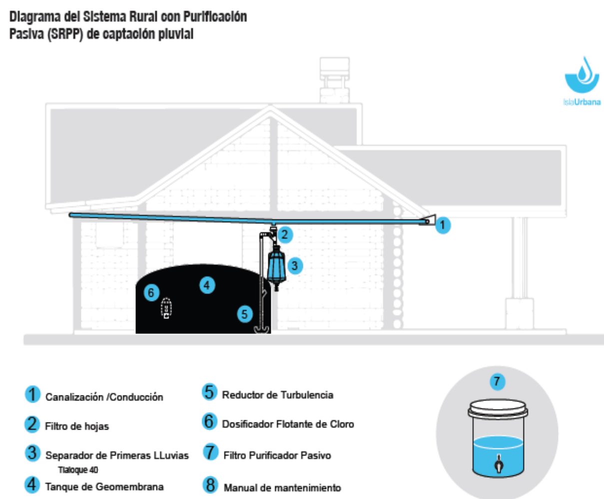
The Margarita project was established with the objective to create a **sustainable milk sourcing strategy,** through improving the livelihoods of small scale milk producers. Through this, the project is already **contributing to enhancing small farmers' resilience in the context of climate variability and change**. Indeed, the social and economic benefits emerging from Margarita are increasing the capacity of farmers to cope with climate change impacts and to seize opportunities to remain competitive. This constitutes the first practical step towards climate resilience in the milk supply chain in Jalisco and it could be considered as a **no-regret measure** that would generate net social and economic benefits under current climate and a range of future climate change scenarios (IPCC, 2014).

The next section presents in detail the four prioritized resilient and low-carbon investment options for the Margarita project.

5. Key proposed measures

<table>
<tr><th>Title of the measure</th><th>Water capturing and storage systems</th></tr>
<tr><td>Nature of the measure:
(adaptation, mitigation, crosscutting):</td><td>Adaptation</td></tr>
<tr><td colspan="2">

Brief description:



Source: Isla Urbana, Sistema de captación de lluvia rural,

This measure consists of the capture and storage of rainwater for reuse on-site. Rainwater is collected from impervious surfaces, such as roofs, and redirected to a reservoir. The harvested water can be stored and used as drinking water and for other purposes such cleaning operations (e.g. parlours' wash-down) depending on the treatment.

This is one of the oldest methods of self-supply of water. In Altos de Jalisco, where the Margarita project is located, this measure could be particularly useful, as the region is prone to both droughts and precipitations with heavy rains occurring in the months of June to September. During these wet months, rainwater harvesting systems could be helpful to collect and store water for the drier months. The existing roof surfaces on Margarita´s farms allow for rainwater catchments systems.

This measure has been very well-received by Margarita's farmers.

</td></tr>
<tr><td>Impacts</td><td>Increase water availability in drier periods, which is a major concern for Margarita's farmers. For example, given the annual average rainfall in Altos de Jalisco (900 mm), up to 90 000 litres of water could be captured and stored per year from an impermeable roof of 100 square meters. The average water consumption of a typical Margarita farm (28 cows) is 200 litres per cow per day[34] (including rearing and cleaning purposes). This amounts to2 044m³ per farm per year, which totals 818 USD per year[35] on water costs.</td></tr>
</table>

[34] Efecto del ambiente en los requerimientos de nutrientes de los animales domésticos, NRC 1981.

[35] The price of water for agricultural uses in Jalisco is 7,42 $ MEX per m^3 (0,40 USD/m^3). Source: Periodico Oficial del Estado de Jalisco de martes 13 de diciembre de 2016. Tomo CCCLXXXVII. Available at: http://www.seapal.gob.mx/Downloads/transparencia/II/e/12.-Reglamento-organico-com-tarifaria-2017.pdf

Main Facts and Figures	
Investment costs (per farm)	According to Isla Urbana, a Mexican firm specialised in rainfall catchment systems in urban and rural areas, the cost of a 15 000 litres tank system, the size needed for Margarita farmers, would amount to around 2 000 USD. The water stored can be used for animal consumption, cleaning purposes or human consumption depending on the treatment [36]. There is a possibility of receiving subsidies (up to 50%) from Instituto Nacional de Economía Social (INAES).
Return on Investment	5 to 6 years without subsidies
Advantages (of rainwater harvest):	• Increasing security of own water supply in drier months; • Average water collection volumes are predictable and it is possible to plan for a known payback period.
Disadvantages (of rainwater harvest):	• Finding a site for the reservoir (4 m X 4m, for a 15 m^3 reservoir) • Hidden disposal cost from excessive water use. Collected roof water is often regarded as "free"; however, the cost per m^3 of harvested water will be significantly lower than main supply, but not totally "free".
Potential stakeholders	• Isla Urbana
Enabling factors	• Technical capacity building activities on the use and maintenance of the water catchment systems; • Support to access to existing financial sources (grants or loans)
Replicability and scale up possibilities	• Easily replicable when impermeable roof surfaces are present. • Easy to scale up

[36] Renata Fenton, Isla Urbana, personal communication, 11 May 2017.

Title of the measure	Planting trees in Margarita farms
Nature of the measure (adaptation, mitigation, crosscutting)	**Crosscutting (both adaptation and mitigation benefits)**

(**Source:** http://www.informador.com.mx/jalisco/2013/477814/6/proyectan-un-jalisco-verde-con-cinco-millones-de-arboles-nuevos.htm)

Brief description: This measure (inspired by the Program for the Sustainable Use of Natural Resources for Primary Production - PROGAN) consists of planting 30 trees or bushes per dairy cow, that is, 840 trees or bushes planted for a typical farm of the Margarita project, which has, on average, 28 cows. Trees and bushes can be planted on outside bounds or as windbreakers. Farmers who do not have sufficient surface area available on their farms, should plant trees on strategic sites, for example on higher parts of microbasins, in wildlife corridors, or in areas with erosion problems, etc.

A document issued by a recognized authority should be provided by farmers to demonstrate that they have effectively planted a determined number of trees or bushes in the selected areas.

The species of trees and bushes to plant are established by the PROGAN guidelines for Jalisco[37].

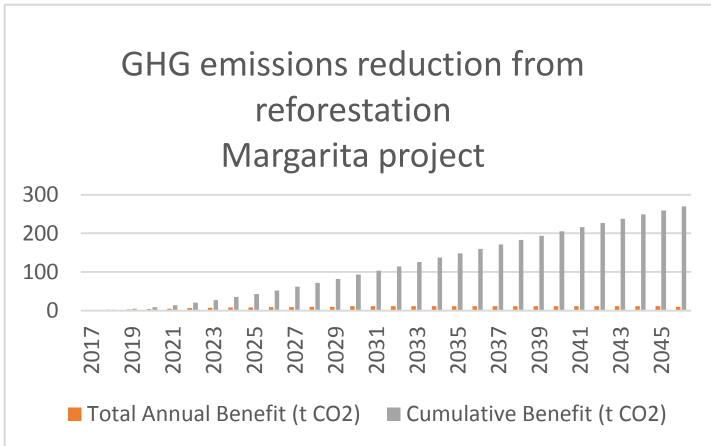
The measure includes an agreement with the Mexican National Forest Commission (CONAFOR) so that it will provide plants to the farmers at no additional cost, as well as capacity building activities, as part of their reforestation mandate in Jalisco.

This measure could be included as an additional condition to receive an annual bonus for each litre of milk delivered to Danone by its associated farmers. A monitoring and surveillance system should be established to ensure the farmer's compliancy with this environmental conditionality to receive the annual bonus.

Farmers could also apply to the Payment for ecosystem services Programme from CONAFOR.

Main Facts and Figures

[37] See: INIFAP (2010). Guía PROGAN Para cumplir los compromisos de los beneficiarios. Jalisco. Programa de Uso Sustentable de Recursos Naturales para la Producción Primaria, Componente: Producción Pecuaria Sustentable y Ordenamiento Ganadero y Apícola PROGAN. Coordinación General de Ganadería. Available at: http://www.inifap.gob.mx/Documents/inicio/guias/guia_jal.pdf.

Direct impacts	• Reduction of GHG emissions: Based on the Agriculture, Forestry and Other Land Use (AFOLU) Calculator it is estimated that 1 ton of $CO_{2equivalent}$ per year per farm would be sequestered, growing to 270 t CO_{2e} per farm over a 30-year period. (See Annex 1: Carbon benefits of Reforestation/Afforestation in Jalisco for details on the calculation method) The following figure shows the GHG emissions reduction from reforestation measures in the Margarita Project:  • Provide shade and shelter to cattle, reducing heat stress. It has been proven that tree shade is a much more efficient measure to protect cattle from heat stress and solar radiation, than the use of sprinklers (Alonso-Spilsbury and al., 2012). • Improve the infiltration of rainwater and moisture preservation in soils.
Investment costs (per farm)	Plants will be provided by CONAFOR. Farmers should ensure the maintenance of the trees and bushes through irrigation and fertilization, following CONAFOR's recommendations.
Return of Investment	NA
Advantages:	• No initial investment costs • As this is an ecosystem-based adaptation measure it provides multiple co-benefits. This includes all the ecosystem services provided by trees such as biodiversity conservation and enhancement, habitat for animal species, shade for cattle, improved water infiltration, avoided soil erosion, etc. • Depending on the species (i.e. guaje - *Leucaena leucocephala*) trees can provide additional fodder for cattle. • Subject to the type of tree planted (mesquite - *Prosopis glandulosa*), they may provide new income for the farmer – timber or non-timber forest products. • Some trees (i.e. moringa - *Moringa oleifera*) can be associated to honey production.
Barriers to its	• Need to fertilize and irrigate plants at early growth stages.

implementation:	• Need to control and verify the correct application of the measure. • Awareness and capacity building activities are needed.
Potential stakeholders	• CONAFOR (providing plants and technical support)
Global objective for Margarita	• 50% of Margarita's farms planting trees • Global impact: 150 t CO_2e to 40 500 t CO_2e over a 30-year period
Enabling factors	• Awareness raising activities; • Capacity building activities: planting and maintenance of the trees; • Institutional arrangements with entities providing plants and capacity building activities (CONAFOR); • Support to access to existing financial sources (grants or loans).
Replicability and scale up possibilities	• Easily replicable and scalable.

Title of the measure	Installation of biodigesters in Margarita's farms
Nature of the measure (adaptation, mitigation, crosscutting):	**Crosscutting (both adaptation and mitigation benefits)**

Brief description:

Source: https://phys.org/news/2016-01-bio-digester-energy-farms.html

A biodigester is a system for the treatment of manure through anaerobic digestion which allows the capture of methane biogas. Through this process, fresh manure/slurry is decomposed and stabilised by micro-organisms in a controlled system in the absence of oxygen. As a result, biogas is captured and can be used to produce heat and electricity (a power generator is needed). In that case, the biodogester is designed to cover the whole electricity needs of the farm.

The leachate (also called "biol") can be used as a fertiliser and soil conditioner, contributing to the improvement of soil quality and moisture preservation.

This system requires extra manpower dedicated to feed and irrigate the biodigester, and efficient manure collection requires animals to be stabled on walking alleys. Additional water consumption to humidify manure is also required (2 litres of water per litre of manure) which can be a challenge in Altos de Jalisco region due to the low water availability in the drier months. The use of wash water is possible, depending on the type and amount of cleanser used. Wash water should be analyzed to decide whether it could be used to irrigate the biodigester or not.

The biol must be diluted before using it as a fertilizer if crops are already in place. The dilution rate depends on the final content on nutriments of the leachate (especially N, P and K). The biol should therefore be analyzed to measure the content on N, P and K, to determine the dilution rate to effectively replace the chemical fertilizer by this organic manure.

The disposal of the biol in the fields should be done following the best fertilizing practices to avoid diffuse pollution and its consequences. Spreading fertilizer in high humidity conditions can provoke the production of N_20 which has a global warming potential 310 times higher than CO_2. The quantity of biol to be applied and the timing for applying it, is therefore crucial.

Appropriate equipment for liquid spreading of manure is also needed, which can be a limiting factor for Margarita's farmers.

Finally, it is important to note that biodigesters are modular systems which allow the addition of supplementary bags if needed (for example, if the number of cattle increases).

Main facts and figures	
Direct impacts	GHG emissions reduction: The use of the biodigester as a standard piece of farm equipment has the potential to avoid the emission of 2.22 kg CO_2e per day from 1 milking cow[38] (32.4 t Co_2e per year for a farm with 40 milking cows), including 11.5 t CO_2e avoided per year, considering only the production of electricity through renewable sources. Therefore, anaerobic digestion is an effective and recommended way to reduce GHGs from livestock manure: • Through emissions from storage; • By replacement of fossil fuel based fertiliser; • Through the production of renewable energy to replace that from fossil fuels. Electricity production: A farm of 40 milking cows can produce up to 90 kw/day[39] by using a biodigester (the

[38] Lukehurst C. and Bywater A., 2015

[39] Leticia Mendoza Ramírez, CEO BIOGEMEX – Mexican biodigesters' firm. Personal communication 18th May.

	average electricity consumption for a farm like this would be around 25 kW daily[40]). Reduction of fertilizers costs: Up to 100%[41]. From 1 600 USD per year for an average farm with 12 ha.[42] Reduction of the electricity bill: Up to 100%[43]. Annual electricity costs for a farm with 40 cows total around 1 300 USD per year[44][45]. Reduction of fuel bill (for heating purposes): Up to 100%[46]. Annual costs for heating are low: around 54 USD to 110 USD.[47] Increase of water costs for irrigating the biodigester (the addition of 2 litres of water per litre of manure[48] is needed to humidify the manure before loading it into the biodigester): 409 USD per year[49]. 740 USD to 1 478 USD per year[50].
Other impacts:	• Reducing pathogen potential of manure • Decreasing cattle bedding • Enhancing organic fertilizer value • Killing weed seeds in manure • Improved air quality from the replacement of fossil fuels, wood and peat • Improved water quality
Investment costs (per farm)	The cost of a biodigester varies depending upon the size of the farm, the techniques for manure management, and the possibility of generating electricity. Depending on the system selected, the initial costs can range from 4 000 – 10 800 USD (for a typical Margarita farm)[51]. Possible subsidies from SAGARPA: Up to 50% of the total cost of the project (maximum 5 Million pesos) [52].
Estimated Return on Investment	3 - 4 years[53]

[40] Ing. David Roque. iRames, solar panels firm. Personal communication, 17 May 2017.
[41] Alex Eaton, CEO Biobolsa – Mexican biodigesters' firm. Personal communication, 9th May 2017.
[42] Alex Eaton, CEO Biobolsa – Mexican biodigesters' firm. Personal communication, 9th May 2017. Confirmed at the workshops with Margarita's farmers, 17 and 18 May 2017.
[43] Leticia Mendoza Ramírez, CEO BIOGEMEX – Mexican biodigesters' firm, personal communication 18th May.and Alex Eaton, CEO Biobolsa – Mexican biodigesters' firm. Personal communication, 9th May 2017.
[44] Workshops with farmers, Tepatitlán de Morelos and San Juan de Lagos, May 2017.
[45] Price of electricity for agricultural uses: 0.580 $MEX during the day and 0.290 $MEX during the night. Source: Comisión Federal de Electricidad http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/Tarifas/tarifas_negocio.asp?Tarifa=9N&Anio=2017&mes=5
[46] Alex Eaton, CEO Biobolsa, personal communication, 9th May 2017.
[47] Workshops with farmers, Tepatitlán de Morelos and San Juan de Lagos, May 2017.
[48] Leticia Mendoza Ramírez, CEO BIOGEMEX – Mexican biodigesters' firm. Personal communication 18th May.
[49] Water prices for agricultural uses: 7.42$MEX/m^3. Source: Periódico Oficial del Estado de Jalisco de martes 13 de diciembre de 2016. Tomo CCCLXXXVII. Available at: http://www.seapal.gob.mx/Downloads/transparencia/II/e/12.-Reglamento-organico-com-tarifaria-2017.pdf
[50] Francisco Javier Sánchez, technician, Biobolsa, personal communication, 17th May 2017
[51] Alex Eaton, CEO Biobolsa, personal communication, 9th May 2017.

[52] SAGARPA. Acciones y Programas > Programa de Fomento a la Agricultura 2017. Componente de Energías Renovables 2017. Available at: http://www.gob.mx/sagarpa/acciones-y-programas/componente-de-energias-renovables-2017

[53] Alex Eaton, CEO Biobolsa, personal communication, 9th May 2017.

Advantages	• Heat and electric production possible. • The time of return of investment is short, even without subsidies. • Potential generation of income through selling the leachate: According to Biobolsa and BIOGEMEX, the leachate (liquid fertilizer) could be sold as a fertilizer for some specialized crops like avocado, but the demand for this kind of products has not been proven yet. Further analysis is therefore needed. • The time devoted to moving, handling and processing manure is minimized when animals are stabled in walking alleys. • Relevant to farmers with: • High consumption of chemical fertilizers; • Problems with manure management; • Land to dispose manure; • Irrigation systems or adequate machinery allowing the spread of biol in the fields. • Compared with traditional practices of spreading onto land, the reduction in nitrate and other pollutant discharges will have positive effects on ground and surface waters. Surface water courses, because of changes in temperature and precipitation, will be under greater stress and have less capacity to accept the pollutants. Using biodigestors will reduce the discharges and reduce the negative impacts on water quality, treatment of drinking water and water ecosystems. • Reduced reliance on centralised grid supplies provides greater resilience in the event of disruption during extreme events. • Installing biodigesters will provide farmers with a more reliable energy supply.
Barriers to its implementation	• Capital needed for initial investment (operational costs such as maintenance related costs are not expected to be high for small scale digesters). • Need to add water to the manure as water availability is already a major concern in the Altos de Jalisco area. Changes in precipitation will need to be considered. • Managing the leachate: According to Biobolsa and BIOGEMEX, 3 m^3 of leachate will be produced daily. Further research is needed in order to find a proper way to manage the leachate and find commercial applications. • Farmers perceive the system to be very complex, and pilot projects are needed to have a better understanding of the real implications of the biodigestors. We recommend 2 pilot projects (one in Tepatitlán and one in the San Juan de Lagos area) with interested farmers. • Capacity building activities for farmers and Margarita's technicians are also needed.
Potential stakeholders	• Biobolsa • BIOGEMEX
Global objective for Margarita	• 15% of Margarita's farms with a Biodigester • Global impact: 1 012.5 t CO_2e per year

Enabling factors	• Pilot projects; • Capacity building activities for both Danone's technicians and farmers; • Support to access to existing financial sources (grants or loans). • Commercial arrangements.
Replicability and scale up possibilities	• Certain conditions are needed for effective replication and scaling up: • animals stabled on walking alleys to enable efficient manure collection; • water availability to irrigate the biodigester and to dilute the leachate; • land to dispose the manure; • appropriate equipment for spreading of liquid manure.

Title of the measure	Installation of solar panels in Margarita's dairy farms
Nature of the measure (adaptation, mitigation, crosscutting):	Crosscutting (adaptation and mitigation benefits)

Brief description:

(**Source**: https://www.tecma.com/solar-panel-manufacturing-in-mexico-is-dominant-in-ciudad-juarez/)

Approximately 30 farmers involved in the Margarita project have already installed solar panels. Up until last year, farmers received subsidies from Instituto Nacional de Economía Social (INAES) that covered the total initial investment cost. Farmers would deposit INAES "payback" money into a bank account in their name, which could be used for expenses or investments related to their farms, at the end of the "reimbursement" period. Now INAES covers only one part of the expenses (35% to 50%) and the rest is covered by loans provided by financial institutions like FIRA (Mexico's Bank that provides financial resources to saving banks) over 2 or 3 years and with interest rates around 10% per year (in Mexico, these are considered low interest rates). Subsidies of up to 50% of the total amount of the investment could also be obtained from SAGARPA.

Main Facts and Figures

Impacts

GHG emissions reduction: Energy production through solar panels reduces farmers' consumption of electricity from fossil sources. Average electricity production for farms where solar panels are already installed in Margarita (40 cows) is 12 500 kWh[54] per year, that is a GHG emission reduction of 7 t CO_2e[55] annually.

Reduction of the energy bill: From an average of 1 300 USD per year to the minimum fee (16 USD- 20 USD per year)[56].

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[54] Ing. David Roque. iRames. Personal communication, 17 May 2017.

[55] Average Emission factor for Electricity Consumption in Mexico is (2000 to 2014 last year available): 0,5548 tCO2e/MWh. Source: Subsecretaría de Planeación y Política Ambiental. Dirección General de Políticas para el Cambio Climático (2015). AVISO para el reporte del Registro Nacional de Emisiones. Available at: http://www.geimexico.org/image/2015/aviso_factor_de_emision_electrico%202014%20Semarnat.pdf and http://www.geimexico.org/factor.html

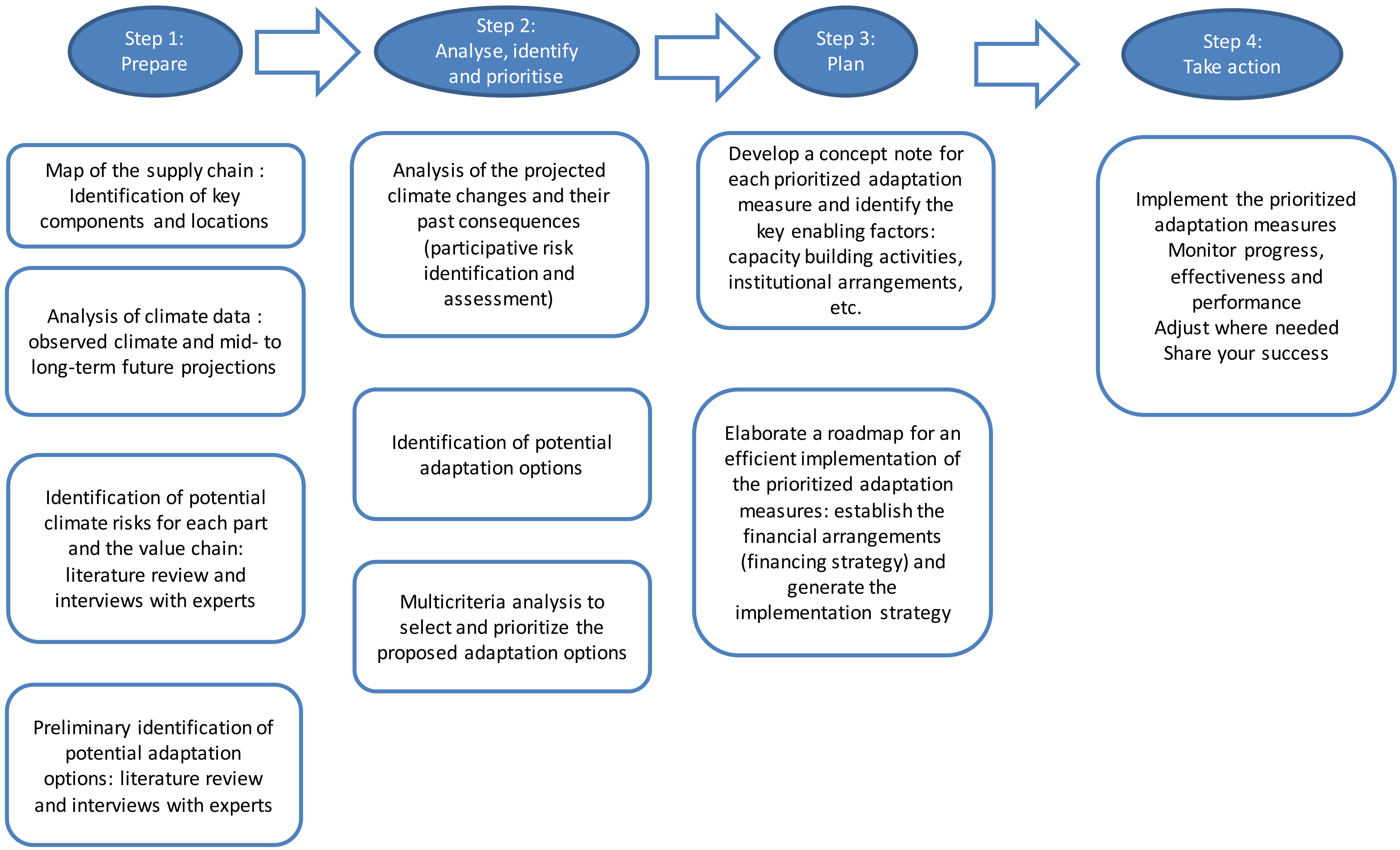
[56] Ing. David Roque. iRames. Personal communication, 17 May 2017 and Workshop with Margarita´s farmers, May 2017.

Co-benefits for climate change adaptation: Solar panel can provide shade for cattle. Ensuring that low income households have access to energy supplies, provides adaptive capacity and increases resilience.	
Investment costs (per farm)	The investment costs depend on the type and number of solar panels installed. An average of 20 panels is needed to cover the energy consumption of a farm with around 40 cattle which amounts to around 13 000 USD.
Return of Investment	3 to 4 years
Advantages:	• Immediate reduction of electricity bill • Subsidised investment and good return on investment. • Reduced reliance on centralised grid supplies provides greater resilience in the event of disruption during extreme events. • Installing solar panels will provide farmers with a more reliable energy supply
Disadvantages:	• Important initial investment needed. • Request for subsidies is often perceived as a complex process.
Potential stakeholders	• iRames
Global objective for Margarita	• 15% of Margarita's farms with solar panels • Global impact: 315 t CO2e per year
Enabling factors	• Support to access to existing financial sources (grants or loans); • Commercial agreements.
Replicability and scale up possibilities	• Easily replicable and scalable.

6. A methodological approach for supply chain climate risk assessment and management

One of the main objectives of this mandate is to lay the foundations for a climate risk assessment and management process that could be replicated across Danone's Latin and Central American operations. The proposed approach, which is summarized below, is based on a literature review and the experience of the project team.

Figure 8: Methodological approach for supply chain climate risk assessment and management



Step 1: Prepare

The first stage consists of preparing the assessment process. Mapping the supply chain and identifying the key components and their geographic locations, will allow subsequent identification of the most vulnerable components of the supply chain. An analysis of the observed and current climate, and mid- to long-term future projections for each location will follow.

Based on a literature review and interviews with technical experts, the main potential climate change impacts on the supply chain will be identified. A preliminary identification of potential solutions, based on a documentary research and interviews with experts, will also be completed. Focus will be placed on low-regret and no-regret measures, and flexible options that can be implemented in a progressive manner and contribute to enhancing the adaptive capacity of the supply chain.

Step 2 : Analyse, identify and prioritize

The second phase of the process includes the analysis of the main climate risks to the supply chain and each of its components, as well as the identification and prioritization of the most relevant options to manage adverse impacts and take advantage of opportunities.

Based on our experience, we recommend that the risk identification and impact assessment are undertaken using participatory approaches.

Five main areas should be considered in the analysis of potential climate risks to the supply chain:

1. the physical risk to assets and operations;
2. the availability and / or the costs of inputs;
3. the regulatory risks;
4. the impacts on the workforce availability and productivity; and
5. the reputational risks.

Adaptation measures can then be identified, such as:

- Concrete adaptation options to address climate change impacts;
- Adaptation measures to diversify and deconcentrate the supply; and,
- Measures favouring an enabling environment for the implementation of the selected adaptation measures and contributing towards a more resilient supply chain.

Generally, due to limited time and resources, a prioritisation exercise is needed to select the adaptation measures that should be implemented first. We recommend a multicriteria analysis, based on prioritization criteria that should be validated (and could be weighted) by stakeholders. The prioritization criteria used in the supply chain climate risk assessment of Danone's Margarita project were:

- The capacity of the proposed measure to respond to one or more key climate risks identified.
- The probability of an effective implementation of the measure in the short term, given the existing economic, technical, institutional and human capacities and the willingness of farmers to apply it.
- The cost-efficiency of the measure and the available financial options.
- The co-benefits provided by the measure, including its contribution to GHG emissions reduction.
- The contribution of the adaptation option to a "transformational change", i.e. the measure has an impact beyond a specific investment and contributes to a paradigm shift to achieve more resilient dairy farming.
- The potential for replication and scaling up.

Step 3: Plan

Once the priority adaptation measures have been selected, further analysis should be undertaken in order to identify the key elements for an efficient implementation of the adaptation measures, including new products, technologies and technical specifications; awareness raising and communication activities; capacity building activities; commercial, financial and institutional arrangements, etc. The objective of these measures is to create an enabling environment for climate resilience throughout the supply chain.

We recommend that a roadmap is elaborated to establish a framework for implementation. This will include both concrete activities for the implementation of the selected measures, and strategic actions ("soft" adaptation measures) which contribute to a more resilient supply chain. The basic structure of a roadmap contains the following elements:

- Breakdown of activities and sub-activities;
- Date of launching, milestones, and deadlines;
- Stakeholders in charge of the implementation;
- Other stakeholders involved;
- Financial (assigned budget lines) and technical resources needed;
- Commercial, financial, and/ or institutional arrangements needed;
- Success Indicators – for monitoring and evaluation purposes.

Step 4: Take action, evaluate (learn) and adjust

The final step of the process involves implementation and monitoring the progress, the effectiveness, and the performance of the selected adaptation measures. This continued improvement approach allows the identification and the implementation of potential adjustments, where needed.

Finally, sharing the results of the process with the key stakeholders of the supply chain and the sector will also contribute to a more resilient supply chain, by increasing awareness and sharing lessons learnt.

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Annex 1: Carbon benefits of Reforestation/Afforestation in Jalisco

Carbon benefits of Danone Reforestation/Afforestation in Altos De Jalisco, Mexico

Tool: USAID's Agriculture, Forestry and Other Land Use (AFOLU) Calculator, December 2014

'The AFOLU Calculator employs IPCC-based accounting methods that allow users to estimate the CO_2 benefits and potential climate impacts of eight different types of land-based project activities: forest protection, forest management, afforestation/reforestation, agroforestry, cropland management, grazing land management, forest degradation by fuelwood, and support/development of policies. Each of these tools within the AFOLU Calculator transparently documents the methods, discusses the assumptions, and presents the underlying data along with its associated sources of uncertainties.'[57]

With a few basic inputs, the tool estimates how much the total annual benefit (tCO2) of planting the area is, and the cumulative benefit for ~30 years.

Assumptions:

- The small holding farms are on average 5 hectares; up to 840 trees will be planted along the pathways and other non-productive surfaces. Therefore, the assumed amount of land planted per farm, would be no more than 10%, or .5 hectare per farm.
- Calculations are based on planting only, not protection, as the ratio of planted to protected trees is unknown.
- Native species will be used, set out in the Guia Progran Jalisco, which will be optimally suited to the climate and soil conditions of the area.
- CONAFOR - a Mexican governmental institution in charge of public reforestation projects - provide technical support / capacity building activities to the smallholders, as well as plants for free.
- Irrigation is not certain as water availability is a concern in the area, and fertilizers may only be available in the form of organic manure. Both irrigation and fertilization efforts depend on the willingness of farmers and the efficiency of Danone's monitoring system to verify if farmers are following CONAFOR prescriptions and ensuring good maintenance practises (to avoid the death of trees). However, as the proposed planted trees would be highly optimal to the climate and soil conditions, it is assumed there are not additional requirements for irrigation and fertilizer inputs.
- CONAFOR will develop capacity building activities and provide technical support to farmers undertaking tree planting activities.

[57] http://www.afolucarbon.org/

Results: Based on the above assumptions, the AFOLU Calculator estimates that **1 ton (US) of CO_2 per year per farm would be sequestered**, growing to **270 t CO_2 per farm over a 30-year period**.

See table below with annual and cumulative benefit.

Benefits			
Year	**Estimated Effectiveness (%)**	**Total Annual Benefit (t CO_2)**	**Cumulative Benefit (t CO_2)**
2017	90	1	1
2018	90	2	2
2019	90	3	5
2020	90	4	9
2021	90	5	14
2022	90	6	20
2023	90	7	27
2024	90	8	35
2025	90	8	43
2026	90	9	52
2027	90	9	62
2028	90	10	72
2029	90	10	82
2030	90	11	93
2031	90	11	103
2032	90	11	114
2033	90	11	126
2034	90	11	137
2035	90	11	148
2036	90	11	160
2037	90	11	171
2038	90	11	183
2039	90	11	194
2040	90	11	205
2041	90	11	216
2042	90	11	227
2043	90	11	238
2044	90	11	249
2045	90	11	259
2046	90	10	270

Annex 2: List of persons interviewed

Alex Eaton, CEO Biobolsa.

Cesar Venegas Rodríguez, Coordinator, Famers´ Union.

Cosme Almada Galindo, Incremental Value México – Ivm. MARGARITA Project Financing Advisor.

David Roque. iRames, Sells and projects engineer.

Eloisa Ayala, consultant for the Margarita project, Technoserve.

Fernando Saucedo Rabago, Milk SSD Strategy & Margarita Project.

Francisco Javier Sánchez, Technician, Biobolsa.

Gabriela Campuzano, Country Director, TechnoServe.

José Luis Dávalos Flores, Professor at the National Autonomous University of Mexico (UNAM).

José Manuel Jasso Aguilar, State Manager in Jalisco for CONAFOR, and coll. s

Leticia Mendoza Ramírez, CEO BIOGEMEX

María Luisa Luque Sánchez, CEO NUUP.

Pierre Bou, Ecosystem Sourcing Director.

Polly Ericksen, Program Leader, Sustainable Livestock Systems, CGIAR.

Rafael Olea Pérez, Professor at the National Autonomous University of Mexico, (UNAM).

Renata Fenton, Design Director, Isla Urbana.