EIP-AGRI Focus Group

Climate-smart (sub)tropical food crops in the EU

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Table of contents

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Executive summary

The Focus Group considered options for climate-smart **(sub)tropical agriculture in the outermost regions (ORs) of Europe and in continental Europe where (sub)tropical crops are produced**. After a description of the current state of play, the Focus Group experts identified good practices at different levels, from the levels of plants and cropping systems up to landscape and value chain levels. Detailed examples were given to illustrate **farming practices that increase the sustainability and resilience of farming systems**, including agro-ecology, agroforestry and mixed crop-livestock production systems. These can help to make (sub)tropical cropping systems economically viable and more resilient to their environment, including climate change and market fluctuations.

The Focus Group has also identified knowledge gaps. Four Minipapers were written to further explore these. The first Minipaper focuses on the **eco-efficiency of traditional systems**. These systems provide several ecosystem and cultural services, while their economic viability needs to be improved. The second Minipaper highlights **seven issues and options on technical aspects that would need to be improved for climate-smart (sub)tropical crops**. This Minipaper includes recommendations at the plant level and cropping system level, including technology such as exploring genetic varieties adapted to climate change, improving water management or developing knowledge around integrated pest and disease management. Other issues are related to managing organic fertilisation, including animal residues, compost, and permanent cropping, or developing knowledge on low-input diversified cropping systems and agroforestry. The third Minipaper considered the **need for knowledge exchange on (sub)tropical systems**, including exchanges between outermost regions and continental Europe through visits and digital platforms. Finally, a last topic of interest was related to the **need to explore value chains and local processing facilities**, to label the quality of (sub)tropical products and improve the self-sufficiency of ORs. The Focus Group has identified **future actions to improve climate-smart (sub)tropical crops**, either as innovative projects such as Operational Groups or research needs from practice.

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1. Introduction

Agriculture in the outermost regions (ORs) of the EU[1] is mostly oriented toward exports of products such as **sugar cane and banana**. These are produced as **monocultures**, which are more sensitive to pests, diseases and **threats posed by climate change** (Debaeke et al., 2017[2]). Such monocultures are largely **reliant on imported, highly subsidised inputs**. At the same time, these ORs are generally very dependent on **imported food**, especially on livestock products and processed food such as milled products and beverages (Posei, 2016[3]). Their agricultural trade balance shows a large deficit, as most of these regions import more than they export and face big market competition with neighbouring countries (such as Suriname and Brazil for French Guyana).

However, more diversified farming systems still cover a large part of the agricultural area in the ORs (Stark et al., 2016[4]). These diversified farms represent up to 80% of all the farms in the OR territory, with an average size under 10 ha for most ORs (Posei, 2016). The proportion of diversified systems in relation to monocultures depends on the OR concerned. For instance, in Reunion Island, 57% of the agricultural area is dedicated to sugar cane whereas in Mayotte, monoculture represents only 16% of Utilised Agricultural Area (UAA). **Diversified systems, such as agroforestry or mixed crop-livestock systems**, adapt better to local conditions and are potentially more environment-friendly, resilient to climate change and to market fluctuations through a higher diversity. They can produce a wider range of different foods, from staple crops, to fruit and vegetables, as well as animal products. Market gardening, tuber and fruit production, or pig and poultry breeding **targeting the local market** are successful diversification options in ORs, but currently they do not meet total local demand. However, these diversified systems, which include **traditional subsistence/small-scale farming**, are hampered, among others, by excessive product safety demands which often hinder crop-livestock diversification or small-scale livestock units, by high production costs and a lack of processing options. Furthermore, diversified systems are generally more **labour-intensive and more complex to manage** compared with more intensified, input-dependent farming systems. Such **knowledge-intensive systems** thus require specific training options.

Moreover, (sub)tropical crops are increasingly of high interest for continental EU as well, as they can be **relevant options in a climate change** context. Climate change and the resulting changes in temperature and rainfall may bring further changes in land suitability and crop choices in continental EU. In this context, (sub)tropical crops are key to the **"Farm to Fork" Strategy**[5], part of the European Commission's Green Deal. The **European Green Deal** is aiming to transform the EU into a resource-efficient and competitive economy with no net greenhouse gas emissions by 2050, and where economic growth is decoupled from resource use. The "Farm to Fork" Strategy considers in particular 'the ongoing transformation of food systems worldwide and the goal of making Europe's food system the gold standard for sustainability'. The Strategy aims at building a food chain that works for producers, consumers, climate and the environment. It recognises in particular the

[1] The European Union (EU) counts nine ORs, which are geographically very distant from the European mainland but which are an integral part of the EU. These are French Guiana, Guadeloupe, Martinique, Mayotte, Reunion Island and Saint-Martin (France), Azores and Madeira (Portugal), and the Canary Islands (Spain).

[2] Debaeke P. et al. (2017). Climate-smart cropping systems for temperate and tropical agriculture: mitigation, adaptation and trade-offs. Cah. Agric. 2017, 26, 34002.

[3] https://ec.europa.eu/agriculture/newsroom/318_en

[4] Stark F. et al. (2016). Crop-livestock integration, from single practice to global functioning in the tropics: Case studies in Guadeloupe. European Journal of Agronomy 80, 9-20.

[5] https://www.ifpri.org/event/european-green-deal-farm-fork-strategy-sustainable-food

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urgent need to reduce agricultural dependence on inputs, improve animal welfare, and reverse biodiversity loss, and to strengthen farmers' efforts to tackle climate change, protect the environment and preserve biodiversity.

In view of the Farm to Fork Strategy, **(sub)tropical crops, both in ORs and in continental Europe**, can be interesting options to promote **more sustainable and resilient production systems** (other than mono-cropping systems), that are **better adapted to the challenges posed by climate change**.

Objectives of the Focus Group

The Focus Group (FG) addressed the following main question: **how to promote (sub)tropical crop diversification and integrated crop-livestock production systems to make them economically viable and more resilient to climate change and market fluctuations?**

The FG considered **both (sub)tropical agriculture in which (sub)tropical crops are associated with other crops** like vegetables and trees, and **continental agriculture in which (sub)tropical crops are produced**.

Process of the FG on tropical crops in the EU

The FG was launched by the European Commission, DG AGRI in 2020 as part of the activities carried out under the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). It brought together 20 experts (see **Annex 1**) from across the EU to share knowledge and practices around the main question. Experts were selected to combine different backgrounds (farmers, advisers, researchers and industry representatives).

In order to address the main question, the FG met twice (online due to the Covid restrictions):

- In May 2020, three half-days were dedicated to the Focus Group to take stock of the current status of tropical crops in ORs and continental EU. In preparation to the meeting, a starting paper was developed to spark discussions. The experts shared their knowledge of successful case studies and identified themes for which information was lacking. At the end of the meeting, the experts identified key topics for further analysis and discussion, which was done through the production of dedicated Minipapers.
- In January 2021, a one-day meeting allowed the experts to share new knowledge developed through the Minipapers and to elaborate recommendations, including ideas for Operational Groups or other innovative projects and needs for research from practice.

The final report of the FG builds upon the outcomes of the FG discussions and the Minipapers. The experts also contributed concrete examples of successful case studies and literature.

This FG aimed in particular to increase the **understanding of current farming practices for (sub)tropical crops,** and to discuss ways to **facilitate knowledge and innovation exchange** of these practices between farmers, researchers, farm advisers and other relevant actors in the continental EU and ORs. Two main levels were considered:

i) identifying and assessing the adoption of **farming practices that increase the sustainability and resilience of farming systems**, including agro-ecology, agroforestry and mixed crop-livestock production systems, to make them economically viable and more resilient to climate change, and,

ii) identifying options for the development of **innovative value chains** for these products, including circular economy.

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Main tasks

The Focus Group carried out the following main tasks:

- Provide an **overview of common farming practices of (sub)tropical crops**, both for conventional and organic systems.
- **Identify the challenges and opportunities for the sustainable development** of such farming practices both in outermost and continental regions of the EU.
- Propose **innovative, climate-smart, cost-effective farming practices and business models** relying on the efficient use of local resources and strengthening the local economy.
- Discuss the **adoption potential (enabling and limiting factors)** of those innovative farming practices of (sub)tropical crops in the outermost and continental regions of the EU.
- Identify **research and innovation needs**, and provide **ideas for Operational Groups** and other innovative projects.

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2. State of play

a. Framing key issues

Agriculture in outermost regions of the EU

The agriculture of ORs of the EU is mostly oriented towards **exports of highly subsidised agricultural products** that are very dependent on imported inputs. Tropical and subtropical food crops are crops that are naturally grown in the relevant climatic regions of our planet, without the need for greenhouses. These crops require the specific and unique environmental conditions that are formed by temperature and precipitation ranges. They include very popular crops such as bananas, sugar cane, avocado, custard apple, mango, peanuts, sweet potato, and a wide range of citrus trees, as well as lesser-known (sub)tropical crops. Key figures on agriculture in the ORs of the EU are given in Table 1.

Table 1: Key figures on agriculture in the ORs (except Saint-Martin)*

OR	Guadeloupe	Martinique	Guiana	La Réunion	Azores	Madeira	Canary Islands	SAI North Region	SAI South Region
1. UAA (ha)	30 960	24 170	29745	42 200	118590	5 260	52 210	168 610	106 080
2. N° of agricultural holdings	6 976	2 994	5 912	7 651	13540	13 610	14 170	29 662	21 088
3. Employment (AWU)	7 795	7 050	6 880	11 657	11532	13 220	22 140	15 910	9 960
4. Farm labour force (persons)	12 990	8 850	8 250	15 970	27 702	30 770	41 880	50 150	36 440

*** Source: POSEI, 2016 ; UAA: Utilised Agricultural Area, AWU: Agricultural Work Units**

Farming systems and (sub)tropical crops in outermost regions

Agricultural systems are very different from one OR to another. The proportion of diversified systems compared to monocultures highly depends on the region that is considered. The main types of production vary according to the region, with a predominance of **banana and sugar cane** in Guadeloupe and Martinique, **sugar cane** in Reunion Island and rainfed **cassava and rice** in French Guiana, mainly for local consumption and grown on savannahs along the coast. In Guadeloupe, **banana production represents 8% of arable lands, sugar cane around 40%**, whereas all other crops occupy nearly 40% of the agricultural area. Only 12% of land remains uncultivated. In Martinique, the proportion of arable lands cultivated with **banana is around 27**%, whereas the area devoted to sugar cane is less important**.**

In Reunion Island, **monoculture of sugar cane** is the main type of production (57% of UAA). **Important vegetable crops** are tomatoes, lettuce and potatoes, while pineapple is the most cultivated fruit. Well-established animal production chains, organised around cooperatives, favour local production and consumption of livestock products. In French Guiana, **agroforestry** is mostly implemented by farmers who wish to limit the use of chemical inputs. In Mayotte, agricultural products are not exported. More than 95% of farms are small multi-activity farming businesses and there is a widespread traditional system called the **"Mahorais garden".** This is **a multi-crop production system** with **11 to 16 crops, in which food crops** are combined with fruit trees, with permanent ground cover provided by growing plants.

In the Canary Islands**, fruits and vegetables** are the main types of production. The **three main crops are bananas** (exported to continental Europe), **vineyards and potatoes**. A large part of the **vegetable production is exported**, mainly tomatoes and cucumbers (exported directly to Rotterdam/Southampton). Regarding fruits, whereas banana and avocado are exported to the mainland, the rest of the (sub)tropical fruits (papaya, passion fruits, cherimoya, mango or pitaya) are destined for local consumption on the islands. However, they are starting to be exported experimentally to the European mainland. Permanent pasture is the

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main agricultural land use in the Azores. **Banana** is the main fruit produced (5.0053t/year), followed by **anona** (251 t/year) and **passion fruit** (13 t/year). The production areas of other subtropical crops like mango, papaya and avocado are increasing in the Azores. Farms producing tropical fruits in Portugal, including Madeira and the Azores, are small (less than 5 ha), and they are low-input systems. On Madeira, systems are mainly diversified and multifunctional, including intercropping and crop associations. Madeira produces subtropical fruits on 15% of its agricultural area, the major production being banana (91% of production) and subtropical crops on 12% of its agricultural area, sweet potato and sugar cane being the major ones. **Annex 2** summarises the main types of crops and farming systems in ORs.

Food balance in the EU's outermost regions

Overall, **all ORs import more food and agricultural inputs than they export**. These regions rely in particular on imports for animal feed and by-products, cereals and flour (because of the absence of milling industries). Agro-industries to process food products are particularly lacking in French Guiana, whereas in Reunion Island agro-industries cover the food needs better, especially for processing livestock products. Imports of frozen meat, beverages and vegetables are still quite common in all ORs. In general, market options to sell the products are lacking. In the Azores, for instance, only 50% of banana production is sold in local markets, whereas the other half is either deposited in landfills or used for animal feed because of an excessive seasonal production and a lack of market channels. Cherimoya, for instance, is a traditional plant but local consumption is not significant and the plant is also not exported.

In terms of agricultural area, agriculture in ORs is mainly based on small farming, dedicated to own consumption. This is often not accounted for in statistics or accountancy. Still, these diversified farms represent up to 80% of the farms in the territory, with an average size under 10 ha for most ORs (Posei, 2016). These systems include market gardening, orchards, tuber and fruit production, pig, poultry and rabbit breeding. **Products destined for the local market are not sufficient to fulfil local demand, and the agricultural trade balance shows a large deficit (Agreste, 2015[6]).** Moreover, both livestock and crop production depend to a great extent on imported and increasingly expensive feed concentrate and mineral fertiliser.

A focus on (sub)tropical crops in continental EU

(Sub)tropical crops are of great interest for continental EU, as they can be relevant **options in a context of climate change** and more varied diets. Spain and Portugal are the main EU producers of (sub)tropical fruits. Spain produces mainly **avocados**, with 80% of production being exported, as well as **cherimoyas**, **custard apple, mangos**, **papaya, pitaya** and **sweet potatoes**. The use of chemical inputs is low thanks to the dry climate in Southern Spain, and to the relatively new introduction of these crops which are consequently mostly free of the main pests and diseases that affect them in tropical countries. Precision farming is helping farmers to limit **the use of water for irrigation.** Only papaya is grown in greenhouses. **Pineapple and banana** are produced only in Spain's OR, the Canary Islands, where the other fruits that were cited previously are also produced. Some experimental plantings of lychee, longan, starfruit, guava and others are also ongoing. In mainland Portugal, **avocado** is also the main tropical crop produced, whereas **sweet potato** production is increasing too. Cultivation of other (sub)tropical crops is developing, such as bamboo or fruits like mango, pineapple, lychee, papaya, cherimoya, custard apple and guava. Farms producing tropical fruits in Portugal are

[6] Agreste, Ministère de l'agriculture, de l'agroalimentaire et de la forêt, 2015. Statistique Agricole Annuelle, Edition 2015, Données En Lignes, from http://agreste.agriculture.gouv.fr/IMG/pdf/D97115A11.pdf

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small (less than 5 ha) and use low levels of chemical inputs. In other parts of the EU, specifically in the southern regions, the production of (sub)tropical crops is also increasing, due to a significant increase in European consumer demand, in particular for avocado. As a result of the high demand and prices for avocado, in some regions, **orange tree orchards,** traditionally cultivated in Crete (Greece) and Spain**, are being replaced by avocados**. This may raise concerns regarding their high demand for water. **Kiwi fruit** acreage and production in Europe has increased consistently in the last decade. The leading producers are Italy, France, Greece, Portugal and Spain. **Annex 3** summarises the main (sub)tropical crops produced in continental EU.

(Sub)tropical crops may thus be relevant climate-smart options for continental Europe, which can increase diversification and reduce the reliance on imports. Furthermore, ORs could be relevant sites for experiments on crops in a context of climate change.

b. Good practices and innovations for climate-smart (sub)tropical crops

Regarding climate change, the major problems include **climate warming, soil erosion and soil loss**. **Contamination and soil salinisation** are other threats that soils face in these regions (UNEP/MAP 2012). Tillage strongly affects soil biota, organic matter and structure, possibly causing fertility loss and desertification, which could be related to unsustainable farming practices. Combatting desertification is one of the objectives set by the Sustainable Development Goals (SDG 15).

More conventional agriculture, which is generally input-dependent and based on monocrops, potentially has negative effects on soil quality, biodiversity and water management (Debaeke et al., 2017[7]), making them less resilient in the face of climate change. Therefore a **transition towards more ecologically friendly, multifunctional, multi-cropping systems, implementing practices such as agro-ecology, agroforestry or crop-livestock systems, becomes necessary.**

The Focus Group adopted a **systems approach to (sub)tropical crops**, and considered **good practices and innovations** developed in **multifunctional agriculture**, that can simultaneously address **one or various issues** (pest management, climate change, food self-sufficiency, etc.) such as:

- **Reducing the use of inputs** by improving farm autonomy (in fertilisation, animal feed,…) thus reducing production costs and improving farmers' income,
- Diversifying options to enhance crop protection through **integrated pest and disease management** (biotic and abiotic),
- **Enhancing soil fertility and health**, global biodiversity, limiting use of water in dry areas, or enhancing closed water loops,
- Developing **innovative value chains** for the products of multifunctional agriculture,
- Improving **local food self-sufficiency** through diversification of production (livestock, vegetables,…)

Recent reviews have highlighted three relevant levers for climate-smart agricultural practices in tropical areas: i) **limiting N_2O, CH_4 and CO_2 emissions**, ii) **storing more carbon** in soils, and iii) **developing green energy production**, through methanisation or agrifuels. Such climate-smart solutions for (sub)tropical crops already exist both in the EU's ORs and in continental EU. All these **agro-ecological options** are leading to a **satisfying compromise between food production, and adaptation and mitigation to climate change,**

[7] Debaeke P. et al. (2017). Climate-smart cropping systems for temperate and tropical agriculture: mitigation, adaptation and trade-offs. Cah. Agric. 2017, 26, 34002.

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thanks to new biological regulations that have emerged in such low-chemical input and diversified cropping systems (Debaeke et al., 2017).

The practices considered should **not be seen as individual or isolated practices**, but as part of a **system design approach** that considers all diversification options that could be relevant at different levels. Five main levels of analysis are considered:

i. the **plant level,** including **breeding resistant varieties** and/or using **local varieties** that are better adapted to pest and climate change,
ii. the **cropping system level**, considering the **diversification of cropping systems**, including conservation agriculture or agroforestry practices,
iii. the **farm level**, considering the **integration of livestock** into the system,
iv. the **landscape level**, considering **knowledge exchange and the integration of farming practices in the territory**, which implies for instance collaboration between neighbouring farmers to promote local autonomy in animal feed and fertilisation, etc.
v. the **value chain level,** considering the **benefits of multifunctional and diversified systems** beyond the farm level and market diversification options.

i. Technical innovations at plant level: Breeding and/or using local pest-resistant varieties that are better adapted to climate change

At plant level, efforts have been made to promote/rescue **varieties, including rootstocks, that are resistant to pests, diseases and climate change** and to **(re)introduce local multiple-purpose crops adapted to the specific soil and climate conditions**. Local breeding programmes evaluate the potential of "exotic" cultivars in ORs. Crop improvement programmes on banana, sweet potato and avocado have been carried out, increasing the availability of germplasm for disease-resistant varieties that can be introduced in other regions, including in continental Europe. Some initiatives are considering traditional crops that have been abandoned in OR and that could be reintroduced with some limitations, such as local perception and the resulting lack of demand. **Water management options**, especially in dry climate areas in Southern Europe, and **biofertilisation** are also relevant options to consider. In **Box 1**, two examples of good practices or innovations at plant level are presented. **Annex 4** provides more examples of good practices and innovations at plant level.

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Box 1: Successful innovations for tropical crops at plant level

+BDMIRA: A project to improve sweet potato varieties in Portugal

This project is led by researchers at INIAV, the Portuguese institute for agronomy and veterinary research. The aim is to **increase the productivity of the sweet potato variety 'Lira'** in the Mira Irrigation Perimeter (PRM). The objective is to empower nurserymen and producers to help them follow a production model. The project also helps develop organisational dynamics relying on a new innovative technology for the propagation of plants that are free of viruses and other diseases. It also supports the development of production and conservation technologies that are better adapted to soil and climatic conditions and the local production system.

More information about +BDMIRA **in the EIP-AGRI database** or **on the project website**

CASBio: A project on local multiple-purpose crops adapted to soil and climate in Madeira

The CASBio project brings several partners together with the goal to characterise and monitor the Madeiran agro-systems. It assesses target crops, like sweet potato, taro and banana, to understand the impact of climate constraints on crop resilience and productivity. The project has undertaken an assessment of local crop landraces and germplasm of sweet potato and taro, in relation to drought tolerance. The aim is to provide local farmers with propagation material that is more resilient to the scarcity of water resources.

ii. Diversification at cropping system level: introducing trees, multiple crops, conservation agriculture practices and green manure

At cropping system level, short-term strategies were identified, such as **shifting sowing dates, changing species, cultivars and crop rotations**, modifying **soil management and fertilisation**, and introducing or **expanding irrigation and/or using seeded fallow intercrops**. Adapting irrigation and drainage during mid-season would allow reducing CH_4 emissions. At this level, diversification that includes a large diversity of multiple-purpose and local crops and trees is important. The potential of **agroforestry and (re)introduction of hedges** in temperate and tropical contexts has been highlighted. When considering (sub)tropical farming systems in ORs, there is a need to also include continental vegetables or trees that could be smartly combined with tropical crops.

In order to store more carbon in soils, apart from agroforestry, **conservation agriculture** includes a set of sustainable practices such as no-tillage, sowing cover crops, mulching, and finally introducing or maintaining grasslands. **Plants that provide ecosystem services could be included to favour pollination. Leguminous** species could help limit nitrogen chemical fertilisation. Biological control in banana, or the use of tropical species intercropped with temperate crops like olive trees and tomato in continental Europe, could also be considered. Options like using green manure for pineapple or **mulching of rice straw in citrus soils in Spain** can have a positive impact on soil fertility. **Site-specific practices** need to be developed in a systems

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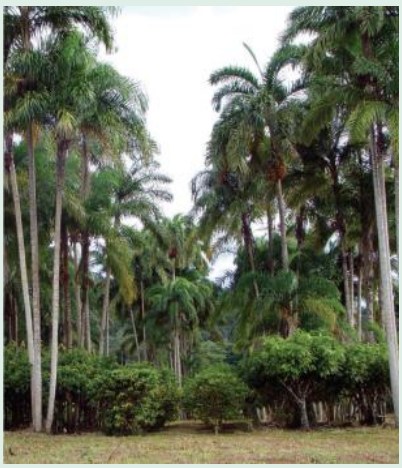
approach. In **Box 2**, two case studies of good practices at cropping system level are presented. **Annex 5** provides more examples of good practices and innovations at cropping system level.

Box 2: Successful case studies at cropping system level

Villandia Farm in French Guiana: a diversity of crop-tree associations at parcel level (Julien Villard, member of the FG)

The cropping system is organised according to the existing topography along contour lines to prevent erosion. For instance, pineapples are planted on steep hills to promote drainage, citrus on mild slopes, bananas on low-lying areas. Existing shrubs and trees are maintained to enhance biodiversity and biological control. Agroforestry started with the association of bananas and cocoa; cocoa is also combined with acai. The farm currently produces citrus and pineapples. Drip irrigation is implemented to manage water and nutrients. Soil conservation measures are implemented, such as the introduction of nitrogen-fixing ground cover (Arachis pintoi), keeping existing trees to stabilise soil and prevent excessive runoff. Local varieties that are resistant to pests and diseases are used as much as possible.

More information **on the project website**. Read the **inspirational idea on the EIP-AGRI website**.



Silvo-arable farms with orange trees and vegetables in Crete, Greece

Avocado production is a very dynamic and rapidly growing sector worldwide. Particularly in the Mediterranean EU, avocado is an increasingly interesting option, despite the fact that it requires quite favourable climate and soil conditions and water for irrigation. For instance, the Chania Regional Unit (Crete, Greece) has good climatic conditions for avocado cultivation. In Southern Europe, avocado production tends to replace the traditional orange trees. These systems have been studied under the framework of the AGFORWARD project (www.agforward.eu).
Researchers analysed the technical-economic results of avocado production in three "typical" representative farms, of which: the «Professional» maintains orange production, the «New» is now entering the agricultural sector, while the «Dynamic» completely replaces oranges with avocados. In all cases, the economic results were very satisfactory. However, specific reference should be made to the very high capital returns, since the cultivation requires relatively low fixed capital (only with the exception of the high prices of land). It is also labour-intensive, and is characterised by product prices that are much higher than international ones, since production mainly covers the needs of the domestic market. Practices varied significantly across the three types. However, production is generally extensive with less use of pesticides, a low application of nitrogen and no mechanisation.

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Photo credit: Anastasia Pantera

In the Azores and Madeira, using traps and attractants to manage pests in banana production

Traps and attractants allow farmers to develop biological control and thus limit pesticide use. The use of Cosmotrack traps with aggregation pheromones has allowed them to monitor and fight the Cosmopolitus sordidus (banana weevil) in banana orchards on the Antillean and Azorean islands (see examples in the picture below). This practice allows farms to move to better agro-ecological and environment-friendly practices. It also helps to reduce the use of chemical products to a minimum. Various types of traps and attractants were tested according to the type of orchard. Tephri and Ceratrap traps with food attractants proved helpful in monitoring and fighting the Ceratitis capitata (fruit fly) adults in citrus orchards on the Azorean Islands. The use of funnel traps with specific pheromones helped to monitor and fight Mythimna unipuncta (armyworm moth) adults in Azorean pastures (**INTERREG/MAC projects, POMAC**: **CUARENTAGRI**; **BIOMUSA**; INTERFRUTA).



Photo credit: David Horta Lopes

iii. Diversification at farm level: including animals and diversifying rotations

Including livestock on the farm has proven to be a strong lever of **crop diversification** and valorisation of **local varieties,** in particular of **leguminous crops** that can be grown alone or mixed with other crops. They also bring other benefits such as reducing the use of nitrogen fertilisers. Introducing small ruminants, pigs and poultry in the system would allow such diversification. It would in particular provide new food and feed sources, while using crop residues as fertiliser (Stark et al., 2018[8]). Integrating small ruminants allows maintaining or **including grassland into crop rotations**. For example, in the Azores, a rotation including pasture and corn for silage was implemented in the low areas as an efficient way to feed cattle.

Cover crops can be used to reduce weeds, feed animals and fertilise at the same time. These can be introduced between trees. For instance, **leguminous crops** that would be added into crop rotations may be either a source of food (chickpea, ambrevede) or animal feed (alfalfa,…). Introducing livestock would also allow more options for **green fertilisation** (recycling manure and slurry for crops, composting manure, methanisation,…) and would contribute to reducing the dependence on imports. In **Box 3,** successful case studies of good practices at farm level are presented. **Annex 6** provides more examples of good practices and innovations at farm level.

[8] Stark, F., González-García, E., Navegantes, L. et al. Crop-livestock integration determines the agroecological performance of mixed farming systems in Latino-Caribbean farms. Agron. Sustain. Dev. 38, 4 (2018). https://doi.org/10.1007/s13593-017-0479-x

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Box 3: Good practices at farm level

Traditional crop-livestock integration systems to recycle by-products in the ORs

Some ORs import several animal products. Integrating livestock on local farms can help to provide local food. It also allows farmers to recycle by-products. For instance, in Guadeloupe, cows can graze crop residues under fruit trees. Bread fruits and sugar cane juice can be used to feed pigs. In the Azores, banana is used to produce a typical beverage; banana crop by-products can be used to feed animals.

Mahorais gardens: a traditional multistrata cropping system in Mayotte

Jardins mahorais or Mahorais gardens are traditional agroforestry systems. These systems, which cover food needs and provide building materials as well as products for traditional ceremonies, use very few inputs. Production is generally not sold except occasionally on an informal basis. They have several strata and combine various food and forest plant species on the same small area (usually less than one ha). The most represented crops are banana and cassava. Approximately 90% of the areas combine several food plant species, up to 11 or 12 per hectare.

Traditionally, the system consists of three strata. The highest includes coconut trees and other big fruit trees such as mango, jackfruit or breadfruit. The middle stratum includes medium-sized fruit trees such as papaya, citrus and guava, while the lower stratum can be used more intensively with subsistence crops such as cassava, banana, and various fruits and vegetables. Weeds are buried, thus restoring organic matter to the soil. Natural fallows can be set up to let the soil "rest" and to feed animals. The very low use of pesticide treatments allows *Jardins mahorais* to find a balance between beneficial insects and pests. Traditional cattle (mainly zebus) "vache au *piquet*" farming is widely practised and can be associated with the highest stratum of agricultural systems. Mechanisation and tillage are reduced. Women represent more than half of the agricultural workers. Many farmers have another activity (civil servants, among others), or are quite old or retired, but it is also common that the owner of the farm does not work on the farm him/herself and instead employs foreign workers.

Traditional agro-systems in the biosphere reserves of Madeira

Both Biosphere Reserves in the Madeira region, Santana and Porto Santo, are characterised by important agriculture activities, based on traditional agro-systems and agrobiodiversity (agricultural diversity). The Porto Santo is a UNESCO Reserve of Biosphere, since 2020. Agriculture, with its traditional knowledge and activities, and agrodiversity, which includes 27 food crops and 108 crop wild relative species, including 34 forages and

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N-fixing species, were factors in its recognition by UNESCO. Agriculture is seen as a pillar in the sustainability of Porto Santo Reserve, providing ecological and support services, like carbon sequestration, nutrient and water recycling, forage and refuge for native and wild biodiversity.

The traditional agro-systems and local crop varieties can be adaptated to changing climate, if the mixed agroforestry systems are implemented. Agroforestry and mixed farming systems can be an alternative to develop sustainable food systems, recovering the soil. These systems can also help rebuild soil fertility in the remaining agricultural land which is still in use, providing food production for the local community, as well as residues and raw material for the development and production of by-products and new materials. The agro-systems and food products produced are used to develop recreative and cultural services, supporting sustainable tourism activities, gastronomy and agritourism.

Photo credit: Miguel Angelo Carvalho / Pictures show (1) the Porto Santo Biosphere reserve logo (2) the typical agro-system with vineyards and dry stone walls with cast stones, called muro de croche (3) photo of Pedro Menezes / local fruits and products of Porto Santo in a traditional farmer's house.

iv. Diversification options at landscape level through multi-actor coordination

There are only few examples of innovations at landscape level. However, knowledge exchange on the practical implementation of agricultural practices is important. In Guadeloupe, for instance, a regional organisation is **selecting less aggressive and more productive bees** for crop pollination. The **cooperation between livestock and crop farmers** allows imports of feed and fertiliser to be limited. **Nutrient recycling** is an example of fruitful collaboration between livestock and crop farmers in the Canary Islands and Reunion Island. In the Canary Islands, farmers producing pig meat **deliver manure** to banana growers. The manure is composted on the banana farm and used for fertilisation. This promotes circular economy on the island. The establishment of **machinery sharing groups** has been considered as a good option to share tree-cutting equipment. Finally, **moving crops to more suitable locations**, such as from the ORs to continental Europe, has been cited as relevant in a climate change perspective (Debaeke et al., 2017). Detailed case studies of good practices or innovations at landscape level are presented in **Box 4**.

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Box 4: VALAB: A multilevel Operational Group to improve vanilla production in Guadeloupe

Integrated ecosystem-based value enhancement of the Guadeloupe Forest Agrobiodiversity

The Union of Vanilla Producers of Guadeloupe helped farmers to diversify their production systems and activities as a solution for the economic difficulties of vanilla monoculture and other perennial monocultures. This was the basis for the VALAB project, which aims to **study the feasibility of small-scale farming systems that will respect the integrity of the Guadeloupean forest biodiversity**. This multi-actor project aims to improve the viability of vanilla-based systems. The project involves the association of vanilla producers, the national park of Guadeloupe, economic actors and researchers. Their method combines undergrowth field surveys, analysis of stakeholder preferences, bringing partners together around the VALAB design, and participatory workshops with the local vanilla producer association, Syaprovag (on ecosystem services and sustainable agricultural production).

More information about VALAB **on the website of the French rural network**

Canary Islands: livestock and crop farmers collaborating in a local circular economy
Project "Agricultura es mucho más" – "Agriculture is much more"

The project led to the elaboration of the SEFEL system (System of Elaboration of Liquid Ecological Fertilisers). With this system, farmers can make organic liquid fertilisers from local pig waste and goat whey, using an aerobic process. Composted manure from local pig production is then sold to crop or vegetable farms. This creates a local circular economy process. The biofertiliser is mainly used in banana production on the island of La Palma.

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iv. A focus on innovation in value chains for products from multifunctional agriculture

Innovative value chains are key to create added value for the products of multifunctional agriculture. In some ORs like Reunion Island or Guadeloupe, farmers have developed a **Community Supported Agriculture (CSA),** providing vegetable and fruit baskets to consumers who come to the farm on a weekly basis. This system allows farmers to establish a strong link with the consumers while getting a fair price for their products. Farmers can inform their customers about their agro-ecological way of farming and the benefits it brings for the environment and society at large. The integration of **diverse varieties of local crops and/or livestock** also contributes to the **local food self-sufficiency of the ORs**.

In Southern Europe and ORs, competition of (sub)tropical crop production with third countries is high. Due to the dry climate in Southern Europe, certain fruits can be produced using small amounts of pesticides. A **certification scheme of local and low-input products from continental Europe** could thus be an alternative to the conventional market. Consumers would need to be involved in such a process. Up to now, at European level, there is a label to differentiate the productions of the ORs, which can be used by various actors, including local farmers (Figure 1).

This allows producers to display a European origin of OR productions. It also shows a local origin, because it can be specified according to individual territories. It has a double requirement of origin and quality:

- **A requirement of local origin for processed products: these must be 100% local.**
- **Quality criteria set in locally defined specifications**. European regulations impose basic quality criteria. These criteria reassure consumers that these products are safe to consume.

Figure 1: Certification label of origin for products from ORs

More recently, the Covid situation has led some growers' organisations who were originally selling most of their produce through mass retail distributors to organise themselves for direct selling. This is the case in Guadeloupe and other ORs. Detailed examples of value chains developed by farmers are described in Box 5.

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Box 5: Examples of relevant value chains on two agro-ecological farms

"L'ilôt Paradis" - Sandrine Baud's farm in Reunion Island (member of the FG)

After farming for 20 years, working with sugar cane, Sandrine rented a new parcel of 2 ha. She began growing many different vegetables, following agro-ecological practices. In particular, this means diversifying crops, developing intercropping and agroforestry to limit inputs, and using manure and compost to improve soil quality. She then developed her own commercialisation channels. This is rare in Reunion Island, since close relations between farmers and consumers are not common. Sandrine has developed a consumer group, a CSA (Community Supported Agriculture) with 27 local consumers. The CSA allowed her to develop social relationships between members, for instance by organising farm visits and cooking lessons. Sandrine is now cooperating with one of her neighbours, which allowed her to introduce chicken on the farm. The prices are lower than on the farmers' market, which caters mostly to tourists in Reunion Island. In the future, Sandrine would like to have more opportunities to have discussions with advisers and researchers on agro-ecological practices. Only 3-4 farmers are implementing agro-ecology in Reunion Island, and they live quite isolated.

Agro-ecological farming in Guadeloupe (FR) – Christophe Latchman (member of the FG)

After having settled on his farm in 2005, Christophe Latchman (member of the FG) had difficulties to build an agro-ecological system, get technical advice and make people understand the value of sustainable farming and agro-ecology. He is now producing vegetables and banana and he has 1 ha of orchard with mangos, avocados and other tropical crops (60 varieties of crops). He also developed a CSA, providing fruit and vegetable baskets to local consumers. He organises his marketing with 9 other farmers and also sells some products on the local farmers' market. He stopped selling to the supermarket 7 years ago because he had to use plastic packaging. He is now thinking of diversifying his farm more, starting with touristic activities. Christophe and his wife are planning to build 5 lodges to receive tourists or researchers visiting the INRAE centre next to the farm. Hosting tourists could be an opportunity to benefit from the 5 ha of forest he is taking care of, by producing essential oils and organising visits to show local plants. Christophe underlined that he lacks relevant technical advice that is relevant to his system.

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Valuing the production of the traditional Azores pineapple

The 'pineapple of the Azores', *Ananas comosus L. Merr.*, Smooth Cayenne variety, is a product of Protected Designation of Origin (PDO), produced exclusively on the island of São Miguel. The pineapple was brought from Brazil by Portuguese navigators, and was introduced to São Miguel in the 17th - 18th centuries. Initially considered as a botanical curiosity, its production gained importance from the 19th century onwards. This was mainly thanks to the efforts of generations of farmers who persistently perfected the cultivation techniques that gave it its specific characteristics. Nowadays, the production of the Azores pineapple is an important contribution to regional agricultural production.

Pineapple is grown in traditional greenhouses on the island of São Miguel, situated mainly on its hottest and sunniest southern coast. In all stages of cultivation, "warm beds" are used, prepared from leiva, firewood, old earth, sawdust and wood shavings. The planting density is 33,000 to 45,000 plants per hectare. Harvesting takes place two years after planting.
The cultural conditions of the Azores pineapple differ from all pineapples produced worldwide. This is due to the organic production and protected environment, in a subtropical climate, with colder temperatures and varying photoperiods throughout the year. These factors give the pineapple its unique characteristics.

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The challenge of developing local processing facilities in ORs

Most food processing techniques were transposed to the ORs using technologies that are not adapted to local agriculture. Most local farms have **lost the traditional knowledge, tools and know-how for processing their agricultural products**. This knowledge and tools and on-farm processing facilities were common up to several decades ago, when trading with the outside world was still limited, especially in the Overseas islands. These processing facilities are currently lacking in ORs, while conserving fruits in particular would be useful in view of the seasonality of production. Creating small collective or individual processing facilities at farm level would allow producers to expand the food supply chain in local areas.

Some **relevant examples of small-scale innovative transformation tools** include the production of flour (cassava, yam, banana, sweet potato,...), jam workshops, the production of dried fruit, and lacto-fermentation of vegetables. There is a need to (re)develop and upscale such suitable, customisable facilities on farms. Farmers or farmers' collectives may experiment, design, and build facilities and adaptations themselves. The "Atelier Paysan" association shares **open-source notices** to develop on-farm material, such as a solar oven and autoclave that have been self-built by farmers (**Figure 2**). More examples of relevant options for farmers to develop processing facilities are described in **Box 6**.

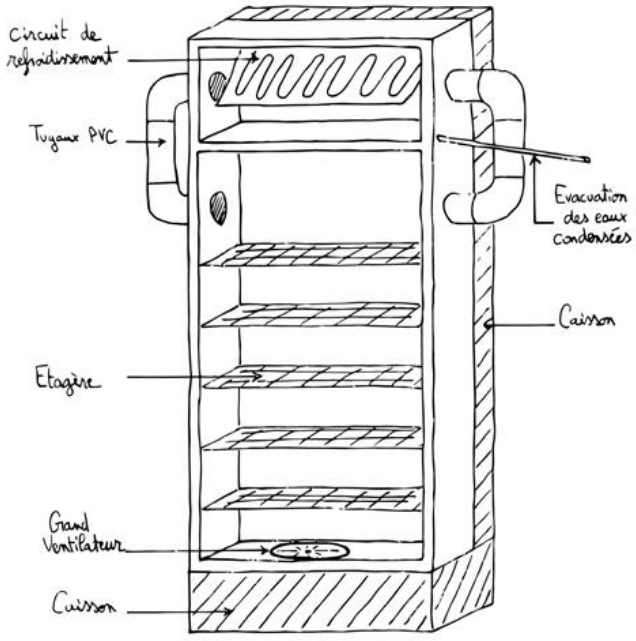

Figure 2: an example of the transformation from an old fridge to a fruit dryer

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Box 6: Relevant options for farmers to develop processing facilities

"Bananeraie Bio de Bourbon": processing local production for direct sales – Reunion island (FR)

Due to the passage of several hurricanes, Katiuscia Payet, organic banana producer, started to diversify her activity by creating innovative products. The organic banana plantation of Bourbon was born seven years ago in the West of the island, at Colimaçons. Katiuscia Payet is transforming the organic bananas into flour, dried bananas and jam. In local markets, banana / chocolate jam, candied banana / tangor, wild pepper banana, and fresh bananas sell well. At the same time, the flower of the banana tree, the "fig baba", is transformed into pickles; the flowers are combined with seasonal vegetables and fruits (fig baba / green mango pickles, fig baba / chouchou, or fig baba / pineapple).

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Processing local food from the traditional autonomous *Fazendas Madeiras*

Traditional Madeiran agro-systems (farms) called Fazenda usually cover less than one hectare. They are organised in one or more small terrace or field plots (called *poios*), bounded by volcanic stonewalls, and irrigated by water canals (*levadas*), which bring water from the upper mountains. In organisation and structure, the Madeiran fazendas resemble the traditional agro-systems in terraces of North and Beira's' mountain valleys of the Portuguese mainland.

The local agricultural production is dedicated to own consumption, and the surpluses are sold directly to end consumers, through the local market and stores, or processed into different food products. This includes the **industrial processing of sweet potato by a local *Insular de Moinhos*, a middle-sized milling industry, located in Madeira.** These composite flours were used to produce Pão de batata and bolo do caco, traditional breads of Madeira protected with a POD.

The **local fruits** are also processed to produce traditional beverages, like juices, poncha and rum, or desserts. In all these cases the industrial processing of local agricultural production represents a positive trend, shortening food supply chains and making local food systems more sustainable. Still, there are two major difficulties and constraints. The decrease in local agricultural production creates shortages in local food production and insufficient raw material for the self-supply of consumption or industry. Also, the lack of integration between the primary sector, the agri-food industry and the market creates periodical cases of

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food waste. However, the current COVID crisis is disrupting external food supply chains, and the need to guarantee local food security gave a wider visibility to these positive trends and stressed their importance.

vi. Knowledge exchange as a key element for improving the sustainability of tropical cropping systems

There are several examples of how to facilitate knowledge exchange between small-scale diverse farms and conventional farms. These address the problem of lack of information; technical support; scaling and different farming system approaches (local production traditions, organic, intensive). Knowledge exchange should not only focus on the agro-system and food production, but consider all ecosystem services, including: ecological and environmental; provisional; socio-economic and cultural dimensions. Some concrete successful case studies are presented in **Box 7** (to see more examples, see **Minipaper 3**).

Box 7: Successful examples of knowledge exchange between ORs and/or continental Europe

(see more examples in **Minipaper 3**)

In the Azores, Madeira, Canary Islands and Cape Verde, there are some cases of knowledge exchange between researchers, technicians and farmers, which allowed farmers to apply new knowledge and skills to develop their business. The photos below show an example of a field workshop led by the Pervemac II project in Cape Verde. Projects such as CASBio, AHIDAGRO, FRUITMAC and VERCOCHAR helped to develop the knowledge related to agricultural sustainability, agro-systems and crops adaptation to climate change. This knowledge and expertise was spread to technicians, farmers, and consumers through practical courses in organic farming, workshops and webinars taught by the University of Madeira. The photos below show some examples of training and techniques that were used in short training courses for farmers by the Madeira agricultural school.

Photo credit : Miguel Angelo Carvalho

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Promoting the agro-ecological transition in the French overseas departments and territories

The TransAgriDom project (2018-2021) brings together nineteen actors from the RITAs (Réseaux d'innovation et de transfert agricole dans les DOM), which are agricultural innovation and transfer networks. Its aim is to intensify the synergy between the French overseas territories, so that they can support each other in their agro-ecological transition. Researchers, engineers, technicians, trainers, teachers, advisers and producers work together to accelerate innovation and promote their uptake by farmers, to foster modes of production that are more respectful of people and their environment.

This project, led by CIRAD, was funded by the French Rural Network and Europe. It follows up on a previous project, **AgroEcoDom** (2015-2018) which had similar objectives. The project facilitates sharing of knowledge, experience and good practice, in particular between Operational Groups of the European Innovation Partnership for agricultural productivity and sustainability (EIP-AGRI). Thus, meetings combine field visits and discussions with producers, workshops, technical seminars and institutional colloquia. The work themes are adapted to the territories and to current events. TransAgriDom is interested, among other things, in plans providing ecosystem services, crop fertilisation and soil fertility, digital tools for the agro-ecological protection of crops, food autonomy for ruminant farms, grassland management, animal health and welfare, honey quality and apiary management, agroforestry and agritourism. TransAgriDom makes the most of the knowledge that is produced on advisory, training and communication support: technical data sheets, films, methodological collections, databases, dialogue tools, etc.

Meetings in French Guiana: Field trip, workshop, honey blind tasting / Photo credit: Olivier Guérin

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3. Outcomes of discussions and recommendations of the Focus Group

a. Key dimensions to improve sustainability of tropical cropping systems

Based on this state of play and on the main ideas that were shared on innovations and good practices, the Focus Group experts identified four key themes that could be further elaborated to improve the sustainability of tropical cropping systems in ORs and continental Europe (Figure 3).

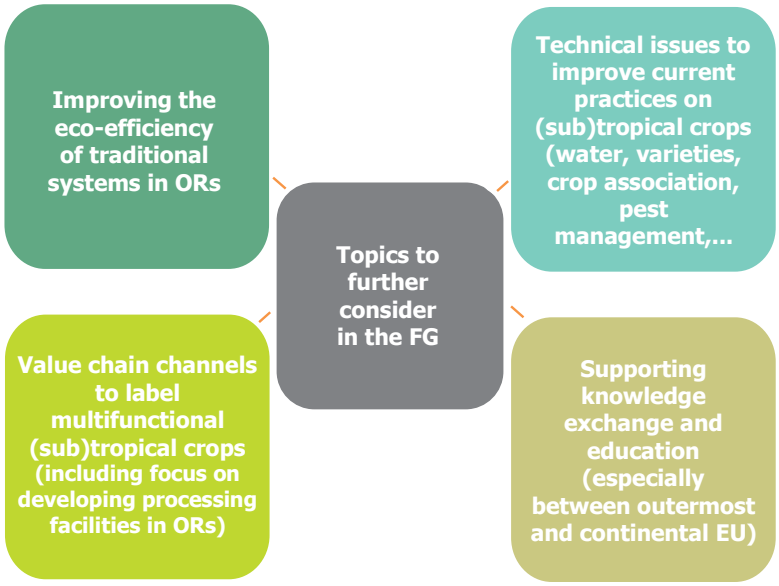

Figure 3: Key themes to be further explored in the FG

Concerns around the eco-efficiency of tropical cropping systems has led to a focus on technical challenges to be considered in ORs and continental Europe. Specific attention was paid to improving traditional systems in ORs following agro-ecological principles, as these systems are essential to rural areas on a local level. A major challenge to the profitability of these systems was related to the lack of value chains, including labelling and certifications. The experts also identified a need to develop new locally adapted processing facilities. Finally, knowledge exchange between ORs, and between ORs and continental Europe was lacking, while the Focus Group experts considered that this could make a real difference for the future of tropical cropping systems. The main information needs are summarised in table 2.

For each topic, the experts identified the main challenges to address, and the information that would be needed to further develop knowledge on the topic. This was done in four Minipapers, which were written collectively based on the experts' knowledge of successful case studies. The four Minipapers that were finalised, explore the following aspects:

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- **MP 1**: Improvement of traditional systems in an agro-ecological way
- **MP 2**: Technical practices to achieve low-input production in tropical crops
- **MP 3**: Training and sharing experience from small-scale diverse farms to conventional models to promote agro-ecological practices
- **MP 4**: Value chains and channels for EU (sub)tropical crops: Local initiatives for global solutions

Table 2: Information needs identified

Topic of interest	Challenge to cope with	Examples	Lack of information
Promoting diversified systems	• Naturally growing local plants to be used as plants that provide ecosystem services • Promote the conservation of agrodiversity and biodiversity, enhance crop associations • Promote landscape conservation • Small-scale farming systems that allow the introduction of such multiple crops	• Agroforestry with non-food crops – timber, fodder, honey, medicine, oils,…) • Agro-silvopastoral systems (introduction of livestock) • Waste of vegetable farming used to feed animals; Trees used for windbreaks and fodder for animals • Growing a variety of multiple fruits and local vegetables to limit inputs	• Lack of data and successful examples on these systems in the different areas – successful examples • How to develop these systems further? • Mapping of soil-climate conditions both for continental regions and ORs • Lack of technical-economic data to quantify the efficiency of diversified systems
Value chains to label multifunctional (sub)tropical crop systems	• Marketing channels - promote the multifunctional role and ecosystem services of local agro-systems or food production systems in outermost regions • Certification and traceability • Increasing food demand of consumers and population	• The need to promote the sustainability of food supply chains, namely through lowering the carbon footprint • Promote greening and sustainable practices in local agro-systems	• Strong demand for tropical products originating from ORs (niche markets) • Lack of data on the imbalance of food production/ consumption and its negative impacts on the ecological footprint • Need to add information on sustainability (carbon, water footprint for example, use of agrochemicals etc.) of the whole value chain as a certification of "high-value" products
Local processing facilities	• Set up/develop the industry • Sectors are unstructured and are concentrated in private homes • Increasing demand of consumers and population • Use of collective facilities, business model	• Producer organisations (example in Reunion Island / Guadeloupe) • Markets for dried fruits	• Lack of quantified information on the sector: levels of production, location, to evaluate the need for processing options • Successful relevant options and scalability

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Sustainable cropping systems	• Soil fertility, circular economy, income diversification • Reducing the water footprint of subtropical fruit production • Low-input banana systems or other alternatives to intensive monoculture • Low-input vegetables and legume systems • Biological control / limiting inputs on major (sub)tropical crops • Need to face technical issues related to the development of new crops/cultivars	• Symbiosis (for leguminous trees) • Agro-silvopastoral systems (introduction of livestock) • Use of reclaimed water, especially for perennial crops • Breeding varieties adapted to drought, and desalinisation	• Information on relevant technologies for diversified systems • Better protection against pests and diseases. Biological control. Reduced use of pesticides • Better understanding of pests and disease epidemiology • Lack of data on the productivity of the system. Need for more studies on the sustainability of the system
Knowledge exchange	• Expansion of subtropical crops to different regions in Europe: sustainable practices • Push-Pull approach to mitigate pest problems to be adapted in different agro-systems • Education - Extension services • Use of social networks	• Need to establish trials of different crops and different varieties of each crop in the different regions and combinations of different crops in the same orchard • Development of complex agro-systems including different species with dedicated contribution • Example in Eastern Africa, over 100 000 smallholders using it in 2015 • Need for systemic and cross-cutting approach between ORs and continental Europe • Development of Whatsapp or Facebook groups to exchange knowledge between farmers	• Reliable cartography on crops and varieties both for continental regions and ORs • Knowledge exchange between experts operating in temperate and tropical agro-systems • How to develop lifelong and vocational education in tropical agriculture

Innovative projects on climate-smart (sub)tropical crops

The Focus Group experts collected and listed existing innovative projects on climate-smart options for (sub)tropical crops in the ORs of the EU and in continental EU (**Annex 8**). These projects are relevant for the five different scales of analysis mentioned previously: plant, cropping system, farm, landscape, and value chains.

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b. Recommendations

Following the analysis of successful case studies and the identification of information gaps, the Focus Group experts identified the remaining needs that need to be addressed in the future to improve the sustainability of tropical cropping systems in ORs and continental Europe. Based on this, they identified needs for further research and proposed new ideas for innovation, suggesting themes for Operational Groups (OGs) and other innovative projects.

Improve technical practices to improve low-input tropical cropping systems

Both in European continental regions and ORs, **some technical practices and innovative solutions have already been implemented to initiate an agro-ecological transition at different scales**. However, these generally appear to be **limited to certain tropical crops, or to certain farming systems, and/or to one given scale**.

This section lists seven key issues that have been identified. They concern technical aspects that need to be addressed to achieve climate-smart (sub)tropical food crops in the EU:

1. **Grow varieties and/or cultivars that can adapt to low-input conditions** in parts of continental regions and ORs in the EU, and that meet market demand
2. Develop alternative and effective **solutions to the use of chemical pesticides for pest and disease management**
3. Proceed to an **economically viable substitution of chemical fertilisation with organic fertilisation**
4. **Restore and/or maintain soil fertility** through use of permanent **cover crops**, associated crops, simplified agricultural practices and **livestock and/or trees**
5. Develop **functional biodiversity in above-ground compartments**
6. Develop **innovative and diversified cropping systems**
7. Use of technology for **better water management**

All these key issues should be addressed to enhance climate-smart tropical cropping systems. Table 3 provides further details on the challenges in improving knowledge on technical aspects. Minipaper 2 describes, for each challenge, the technical issues encountered at farm, landscape or regional levels. **These key issues should be further explored through research projects** that look specifically at the challenges faced by these systems, both in ORs and continental Europe, and that develop tailored solutions and tools.

Table 3: Key issues and challenges to improve technical aspects for climate-smart (sub)tropical cropping systems

Key issues	Challenges	Scales to consider
Grow varieties and or cultivars that can adapt to agro-ecological conditions in some parts of continental regions and ORs in the EU and that meet market demand	Production of sub(tropical) cultivars and/or valorisation of local crops when available and relevant in continental Europe	Farm, landscape, regional
	Production of varieties/cultivars adapted to short production seasons in a tropical environment due to climate change	Farm, landscape, regional
	Protection of cultivated crops from climate change in a (sub)tropical environment	Farm
	Overcome erratic and/or intense climate events	Regional
Develop alternative and effective solutions to the use of chemical	Development of effective IPM programmes in continental and outermost regions	Plant, farm, landscape, regional

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pesticides for pest and disease management (PDM)	Avoid the entrance of foreign pests and diseases that could jeopardise agro-ecological (sub)tropical crop production	International
	Development of biological control and/or natural plant extracts for effective pest and disease management (PDM)	Landscape, regional
Proceed to an economically viable substitution of chemical fertilisation with organic fertilisation	Use (on-farm) organic fertilisation sources (crop-livestock integration, green manure, legume species,…)	Farm
	Optimise organic mineralisation, plant assimilation and consider adapted legume species	Landscape
Restore and/or maintain soil fertility by use of permanent cover crops, associated crops and simplified cultural technologies	Predict sustainability of soil fertility	Regional
	Mechanisation of planting/harvesting of cover crops	Farm
	Management of cover crops	Regional
	Generalise soil permanent coverage (intercropping)	Landscape, regional
	Reduce soil impact, develop simplified cultural technologies	Farm, landscape
Develop functional biodiversity in above-ground compartments	Understand variations in functional biodiversity in relation to climate change	Farm, landscape, regional
	Restore aerial biodiversity	Farm, landscape, regional
	Restore soil biodiversity	Farm
Develop innovative and functional cropping systems	Develop innovative cropping systems	Farm, landscape
	Develop innovative crop-farming systems	Farm, landscape
Use of technology for best water management	Reduce/optimise water use	Farm, landscape
	Manage intensive frost climatic events	Farm, landscape
	Manage intensive drought climatic events	Farm, landscape

a. Explore pathways to improve traditional systems following agro-ecological approaches

Agriculture in (sub)tropical European territories can take many forms, ranging from self-sufficient family farming, on rather small areas in ORs, to more intensive production in organised sectors such as sugar cane or dessert bananas in the French Overseas Departments. Even if some of the technical practices and key issues presented below could improve traditional cropping systems, they should receive specific attention, **as they have a strong potential to support an agro-ecological transition**.

So-called traditional cropping systems are as diverse as the territories and populations they are closely linked to. However, they share a number of charcteristics, including:

- They often call upon family labour
- The cultivated areas per farm are relatively small, from 1 to 2 ha on average
- They represent a very large majority of the cultivated areas and farms in the territories concerned
- Their basis is subsistence agriculture. The commercial purpose is secondary.
- The use of inputs is minimal, agro-biodiversity is important
- The lack of structuring of the sectors under consideration makes access to financial aid and advice difficult for these farms. This also reduces the possibilities of interaction between farmers.
- These systems are mostly operated on the basis of empirical knowledge.

For more details and examples, see **Minipaper 1**.

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However, the evolution of markets and consumer demands brings new needs to traditional farmers (food, education, health, access to new technologies, etc.). Income increase becomes necessary. Several avenues are open to them, including combining farming with another economic activity **and the intensification of their agricultural system**, with **increased productivity, improved product quality and access to market** and distribution channels, etc.. This allows them to place their activity in a more remunerative market circuit. In regions where family and social values are important, it is however **not easy to reconcile changes in the farming system with the conservation of traditional values**. Options to combine farming with other economic activities, or having a partner working outside of the farm should also be considered in the viability of such systems.

After these assumptions were shared and information gaps were identified, Focus Group experts developed a cross-cutting analysis of case studies of traditional systems in ORs in **Minipaper 1**. The aim was to identify common challenges and opportunities. This Minipaper addressed the need to describe several types of traditional systems found in the (sub)tropical territories of the EU, and to highlight their advantages, limits and perspectives. **The different services they provide (food, environmental, social, etc.) need to be considered, not just productivity and economical aspects.** The experts highlighted the need to work collectively and in a cross-cutting way between ORs. This could help to **develop ways to intensify agricultural production, which would improve farmers' incomes and preserve the agro-ecological character of these production systems, without disrupting the services they provide.**

Develop value chains for climate-smart tropical cropping systems

Important products and crops, especially those produced in ORs, do not receive the remuneration they deserve in mainstream markets, and they **lack value chains related to their multifunctional roles**. Whereas many types of production in ORs are low-input, there are few labels available. The multiple services provided by traditional low-input systems in ORs are not paid for through the commercialisation of products, for instance. **Quality products are not adequately labelled, certified nor recognised** and they do not reach consumers with specific priorities regarding origin, quality characteristics, production practices etc. Besides labels, measures should also be directed to increase consumer information that could ultimately increase the demand for these products.

Existing labels are already found in ORs and could be adapted or combined. Especially certifications on farm-level practices, such as **organic or biodynamic production**, are well-known and recognise the environmental quality of production. Certifications of origin or locality, such as DPO / DO (Protected Designations of Origin / Appellations d'Origine) are used in ORs. Finally, **Fair trade labels are already well set** for bananas; cocoa; sugar cane/ sugar. Information and Communication Technologies would assist the acceptance of new foods by consumers and farmers, especially traditional food that is produced locally but is not always appreciated by local consumers. Communication on value chains could advocate health and environmental benefits (including shorter supply chains) to also avoid negative public perceptions in continental Europe (e.g. water consumption in avocado growing in Southern Europe). Examples can be found in **Minipaper 4**.

The certification process could take into account the **carbon footprint, the environmental impact, distances to markets and related (transport) costs**. **It may be worth combining existing labels** to **better consider the services that are provided** by traditional systems. The implementation of **block chain technology** for traceability and certification of products along the whole value chain could support this.

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The development of processing facilities requires specific attention. Creating small collective or individual processing facilities on the farm may allow the creation of added value to farm produce, and can allow food supply to be expanded in the territories. This should be **scaled up, and knowledge on customisable processing facility tools should be shared** with initiatives such as the Atelier Paysan. The development of on-farm processing should be done through **experimentation, design and adaptation by the farmers themselves**. Local industries, such as milling factories or fruit drying facilities could also promote a better valorisation of the products and could be led by small enterprises, farmer cooperatives or collectives.

Encourage knowledge exchange between ORs and/or continental regions

Even if farmers are aware of existing agro-ecological practices on tropical cropping systems, they lack information on how to adapt these to their farms/crops in order to be economically viable while limiting risk. Furthermore, some practices observed at small scales in traditional systems may not be easily upscaled on larger farms. To increase knowledge sharing, **pioneer farmers should be taken out of their 'niche'** and show their peers how they have innovated.

For instance, nowadays **on the islands of the Azores and Madeira, organic farming** is one of the production systems that integrates agro-ecological practices. These organic farmers provide examples of how agricultural production can move away from the use of chemical inputs. This was achieved through **visits and meetings where knowledge** and the **experience of pioneer farmers** was shared. Relevant examples have been developed in **the banana sector in Guadeloupe and Martinique**, where a high level of agro-ecological practices was reached through the systematic implementation of good practices. **Regular meetings and visits between OR sites and continental Europe** are also organised to share experience, involving advisers and farmers. More concrete examples are presented in **Minipaper 3**.

The Focus Group experts consider that there is a **need to capitalise on existing successful examples and involve pioneer farmers** to encourage knowledge sharing on good practices in tropical cropping systems. Communicating on best practices, such as climate change mitigation and environment-friendly practices could be enhanced through **open-access data and user-friendly tools** (e.g. with maps of soil-climatic conditions and environment-friendly practices developed for these conditions, locations of pioneer farmers, calculator for irrigation needs in relation to climatic conditions, or the carbon or water footprint of different types of farm production,…). Nevertheless, some farmers still prefer knowledge exchange among small groups, allowing (local) trust-building, rather than using larger platforms.

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b. Ideas for Operational Groups and other innovative projects

The FG experts identified the following themes and ideas for innovative projects / Operational Groups (Table 4).

Table 4: Ideas for Operational Groups and other innovative projects

Topic of interest (MP)	Knowledge gaps identified	Ideas for Operational Groups or other innovative projects
Improving traditional systems in an agro-ecological way (MP1)	• Eco-efficiency of traditional practices combining crops and livestock to limit inputs	• Identify and evaluate the different **services provided by traditional systems** (food, environmental, social, etc.) • Interregional or local projects in ORs to explore and evaluate existing practices regarding the use of green covers with leguminous crops or cereals to improve soil fertility and avoid soil erosion, the use of animals for weed management, enhancing self-sufficiency in animal feeding
Technical practices for sustainable tropical cropping systems (MP2)	• Reduce the use of pesticides • Effects of animal residues on tropical crops • Transfer tropical crops to other conditions	• Study the **application and implementation of biological and biotechnical control strategies** as alternative solutions to control pests and diseases that affect tropical crops • Study how the **application of animal manure and compost** may reduce or entirely replace the use of chemical fertilisers on tropical food crops • Consider and evaluate the options for cultivating additional (sub)tropical crops in ORs and mainland EU (cooperation project)
Fostering knowledge exchange on good practices in tropical cropping systems (MP3)	• **Only few examples of knowledge exchange between ORs and continental Europe** – develop platforms, tools (maps,…), training programmes, visits,… • New pests and diseases related to climate change	• Develop a **digital platform that can be used by small farmers to get advice** on agroforestry, biological control, composting, mixed cropping etc. ➔ Develop a web platform connecting ORs and continental Europe, including production procedures in different soil-climatic contexts ➔ Create **forecast and early detection advisory agricultural services** which disseminates warning alerts to farmers based on models to predict shocks • Develop new ways to create a better connection and knowledge exchange **between farmers and educational institutions**, for instance by **creating practical courses in different agricultural areas** based on pioneer farmer knowledge. ➔ Consider living labs • Platform to share **specific information with/among growers about specific new pests**

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Developing value chains including processing facilities for tropical crops, especially in ORs (MP4)	• Knowledge on existing labels that could be adapted to OR products	• Explore the **relevance of adapting existing labels to certify the quality** of products from climate-smart tropical cropping systems ➔ Study policy measures or protect products through **market-related measures - connecting producers and consumers** / test which approaches would benefit producers ➔ Test ways to create value for producers - showing carbon sequestered, biodiversity enhanced,…
	• Adapt processing facilities to farms and local-level small enterprises	• Develop **customised solutions to construct low-cost and small-scale food processing equipment** ➔ Study the **feasibility of creating processing facilities for a collective of farmers or small cooperatives** (size, type, investments, organisation,…)
	• Reducing the distance between farmers and consumers, and valorise by-products	• **Develop circular economy channels to use more local products** ➔ use all the by-products, including biomass etc. - to reduce imports - eg Madeira - small enterprise producing germination Boxes using banana bracts

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c. Research needs from practice

The FG experts identified the following research needs from practice to promote the development of climate-smart (sub)tropical systems (Table 5).

Table 5: List of themes for research needs from practice

Topic of interest (MP)	Knowledge gaps identified	Ideas for research needs from practice
Improving traditional systems in an agro-ecological way (MP1)	• How to evaluate the services provided by traditional systems • Interregional or local projects in ORs to identify ways to intensify traditional systems in a sustainable way • Level of eco-efficiency of traditional practices combining crops and livestock to limit inputs	• Develop and apply a **multicriteria framework to evaluate the services provide**d by traditional tropical cropping systems in ORs ➔ Build tools to calculate /estimate ecosystem services at farm level ➔ Evaluate and compare the performance of the different systems • Develop research to design **eco-intensive traditional systems** and adapt them to local conditions ➔ Apply participative design methods ➔ Consider multicriteria evaluation, including the services provided • Explore and evaluate the eco-efficiency of traditional practices ➔ Circular: Manure to worms to chicken feed to chicken manure ➔ Microbiome research (fertilisation, pest and disease control,….) ➔ Better characterise the quality of organic fertilisers produced on the farm (mineralisation, choice of fertilisers, consider manure, composts, green manure and biostimulants,…)
Technical practices for sustainable tropical cropping systems (MP2)	• Solving the major pest and disease problems in the different climatic zones • Relevant agro-ecological alternatives to monocultures • Effect of manure and compost on soils and crops • Implementing IPM in different contexts	• Development of well-adapted healthy propagation material, but also in other domains, such as cultivation practices, diseases, organisational innovation and commercialisation as well as the development of innovative products (eg. oil, cosmetics) for such species. • **Explore and evaluate alternative, innovative practices** such as **agroforestry** under the specific pedoclimatic conditions of each island ➔ agrodiversity and genetic resources of crops used in the agroforestry systems, with evaluation of the traits promoting their resilience to climate change ➔ knowledge of the pests and diseases of the most important tropical cultures and the inclusion of IPM strategies to control them • **Assess, compare and monitor the agroforestry systems from different soil-climatic regions**, using common tools and methodologies and studying how they may contribute to achieving the **Green Deal and especially the Farm to Fork Strategy** • Gain knowledge on **mixed cropping systems and mixed crop-livestock systems adapted to ORs**. And especially on how to implement techniques and practices that promote sustainable use of soil nutrients and local farming resources. • Implement biotechnological and biological control strategies to reduce the application of chemicals

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		➔ how to **implement IPM practices (biotechnical, biological, and cultural practices)** focused on small areas and small farmers. ➔ consider different climatic zones and crops • Study and **evaluate the resilience to climate change of a diversity of tropical cropping systems** to make the activity more economically and environmentally sustainable for farmers
Fostering/promoting knowledge exchange on good practices in tropical cropping systems (MP3)	• Tools to efficiently share knowledge among farmers • Tools for communication between farmers and other actors	• Develop **digital tools to increase the knowledge about climate-smart tropical cropping systems**, including production procedures in different soil-climatic contexts and examples of solutions in different contexts for small-scale diverse farms, organic and conventional farms. • **Study and monitor the sustainability of agro-systems** under organic farming • **Explore ways** to improve **communication between farmers and educational institutions**, to improve knowledge exchange and **create practical courses in different agricultural areas**
Developing value chains including processing facilities for tropical crops, especially in ORs (MP4)	• How to relate traditional systems of ORs to sustainability/services provided to develop labels	• Development of **local resilient food systems and value chains** to decrease the ecological footprint and foster a circular economy • Encourage two 'layers' - practices and products – and find out more about both the practices and the products, and their values ➔ Consider intangible cultural heritage – UNESCO, example of biosphere reserve products in Madeira ➔ Links with Green Deal and Farm to Fork Strategy > biodiversity - linked label - including soil biodiversity ➔ Compare nutritional value/food safety of imported vs local products • **Evaluate the impacts of the services** provided by farmers/farms and make sure they are reflected in food production prices ➔ Develop value chains to recognise local resilient food systems ➔ Value a low ecological footprint, low transport and circular economy, e.g. labels for tropical fruits produced in Europe (less chemicals, grown following EU standards).

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4. Conclusions

The Focus Group has identified a large number of climate-smart practices for (sub)tropical crops, both in ORs and continental Europe. Case studies were highlighted at different levels from the parcel up to the value chain and regional levels. Relevant options already exist for low-input cropping systems, including traditional systems in ORs that enhance diversity (multistrata systems, agroforestry, crop-livestock integration,…). Still, a lack of value chains to recognise the agro-ecological nature of these systems was underlined. The Focus Group insisted on the need to develop knowledge exchange between ORs and continental Europe, to share the existing good practices and support the development of new ones. The Focus Group has identified **future actions to improve climate-smart (sub)tropical crops**, either as innovative projects such as Operational Groups or as research needs from practice.

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Annex 1: Members of the Focus Group

Name of the expert	Professional background	Country
Villard, Julien	Farmer	French Guiana
Latchman, Christophe	Farmer	Guadeloupe (France)
Hernandez Reyes, Rafael	Farmer	Canary Islands (Spain)
Vanderschuren, Hervé	Researcher	Belgium
Pinheiro de Carvalho, Miguel Angelo	Researcher	Madeira (Portugal)
Hormaza, Jose Inaki	Researcher	Canary Islands (Spain)
Yemadje, Pierrot	Researcher	Mayotte (France)
Pantera, Anastasia	Researcher	Greece
Thevenin, Jean-Marc	Researcher	France
Horta Lopes, David	Researcher	Portugal
Hueso Martín, Juan José	Researcher	Spain
Goulao, Luis	Researcher	Portugal
Auguste ep. St Fort, Marie Santa	Adviser	French Guiana
Perpiñá, Benjamin	Adviser	Spain
Adriaens, Maurice	Adviser	Netherlands Antilles
Ragkos, Athanasios	Researcher	Greece
Champoiseau, Patrice	Researcher	Guadeloupe (France)
Puerta Piñero, Carolina	Researcher	Spain
Baud, Sandrine Micheline	Farmer	La Réunion (France)
Lucas, Eric	Adviser	La Réunion (France)
	Facilitation team	
Rychawy, Julie	Coordinating expert	EIP-AGRI Service Point
Karasinski, Céline	Task manager	EIP-AGRI Service Point
Dejongh Audenaert, Katrien	Backup	EIP-AGRI Service Point

You can contact Focus Group members through the online EIP-AGRI Network.
Only registered users can access this area. If you already have an account, you can log in here
If you want to become part of the EIP-AGRI Network, please register to the website through this link

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Annex 2: Farming systems and main (sub)tropical crops in ORs of the EU

Outermost region	Main crops	Main types of farms	Broader context / local challenges for agriculture
Guadeloupe (France)	• Sugar cane (40%) • Banana (8%) • Other crops (40%) • Uncultivated lands (12%)	• Smaller farms (80 %; <3 ha): diversified systems (vegetables, crops, fruits, ornamentals, aromatics, livestock) • Largest farms (20%; >100 ha): banana, sugar cane monoculture	• Banana production mainly for export to mainland market • Production/commercialisation well organised • Over the last decade, direct commercialisation increased
Martinique (France)	• Banana (27%) • Sugar cane (16%)	• 29% of farms < 2 ha diversified, mostly for vegetable production and livestock • 63% are 2-20 ha; diversified • 6% are >20 ha but occupy 54% UAA, monocultures	• Production well organised by banana growers' organisation • Bankrupt of a major cooperative led producers to develop direct sales
French Guiana (France)	• Cassava (42%) • Fruit crops (9%) • Other crops for auto-consumption (11%)	• 80 % family farms traditional itinerant manual agriculture; subsistence slash-and-burn cultivation, practised by women - 5 400 farms • 20% mechanised commercial farming (on the coastal strip) - 600 commercial farms.	• Agriculture booming (+20% UAA on 2010-2016) to cover the growing needs for food linked to demography • Lack of processing facilities to favour local self-sufficiency in food (such as milling industries, slaughterhouses)
Reunion island (France)	• Sugar cane (57%) • 24,336 ha • Fresh vegetable (4%) • Fruit production (6% - pineapple and banana • Forage (3%)	• 46% of farms producing sugar cane, as monoculture with 10% of UAA for diversification • Decline in traditional production of geranium and vanilla led to development of fruit and vegetable, meat and egg production	• Sugar cane as 1st industrial economic activity • Agriculture diversified for 20 years - import-substitution logic for animal industries • Increasing tensions for land use (housing, infrastructure, transport and agriculture)
Mayotte (France)	• "Mahorais gardens" 4 to 16 crops on field with trees • 8% of farms produced tomato, eggplant	• Associated crops represent 84% of growing area • 16% for monoculture • 87% of growing area has trees) • Irrigation is low and is an issue	• Most of the production is for family food (80% of farms). Only 60% of farms sold their production • Fruit and vegetable are sold through direct sales, mass distribution and cooperatives
Canary islands (Spain)	• Banana (17%) • Vineyards (12%) • Avocado (3%) • Citrus (2.5%) • Mango (1%)	• Environmentally friendly with no or very limited use of pesticides • No traditional combined use with livestock	• Import of (sub)tropical fruits not allowed to the islands, most of production consumed locally • Exceptions are banana and avocado exported to mainland

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Azores (Portugal)	• Mostly pasture and corn for cattle feeding • Banana	• Specialised farms based on intensive to semi-intensive milk and meat production • Other farms dedicated to subtropical fruit species normally focus on selling	• Fruit marketing chains: proximity and short (3 actors) • Main current problem: channelling of excess production of bananas and anona (lost; deposited in landfill or fed to animals)
Madeira (Portugal)	• Subtropical crops (12%) sugar cane, taro, sweet potato • Subtropical fruits (15%) banana, custard apple, mango, avocado, passion fruit	• Traditional subsistence / small-scale farming side-by-side (57%) with some cash or commercial export or local consumption productions • 9,761 farms are < 1ha • 589 farms less 5 hectares • 21 farms more than 5 hectares	• Urbanisation and tourism led to the abandon of agriculture areas • Long-distance unsustainable supply • All crops mainly released for the local market and consumption

Source: Agreste, Agricultural Census 2000-2010, Annual Statistics for 2014, expert homework

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Annex 3: Farming systems and main (sub)tropical crops in continental Europe

Country	Main (sub)tropical crops	Main types of farms	Broader context/local challenges for agriculture
Spain	• Avocado (70 000 tons/year, 17 158 ha) • Mango (30 000 t/year, 4722 ha) • Sweet potato (14 000 t/year, 665 ha) • Cherimoya (2 700 ha, 50 000 t) • Citrus fruits (7.000.000 t, 300.000 ha)	• Production mainly developed in Andalusia and Mediterranean coast • Production on large farm with mostly monoculture • Low use of inputs • Local markets in continental Europe	• Dry climate with low pest and disease development • Technologies developed to limit water use (use of reclaimed water) • Large competition with third-countries (avocado)
Portugal	• Avocado (4895 t, 1200 ha) • Citrus fruits (42 000 t, 21 000 ha) • Sweet potato (54 000 t, 3 000 ha) • Peanut (2500 t, 500 ha)	• Production mainly developed in Algarve for citrus and avocado • Sweet potato is produced in Aljezur region	• Dry climate with low pest and disease development
Greece	• Avocado (6630 t, 1657 ha) • Kiwi (100 000 t, 3330 ha) • Sweet potato (2000 t, 110 ha)	• Production of avocado and fruit mainly developed in Crete island • Agroforestry practices are developed, with vegetables produced in between tree rows	• Extensive systems highly diversified and including animals • Lack of water during summer droughts
Italy	• Avocado (n.a., 260 ha) • Kiwi (370 000 t, 12 333 ha) • Sweet potato (12000 t, 667 ha)	• Production of avocado concentrated in Sicily • Kiwi and sweet potatoes produced in mainland	• *To be precised*
France	• Kiwi (75 000 t, 2500 ha) • Sweet potato (under development	• Kiwi production is developed in Southern France • Sweet potato is under development in Northern France	• Low use of inputs on kiwi production

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Annex 4: Examples of good practices and innovations at plant level

Good practice/Innovation	Detailed example and area
Breeding and evaluating varieties (and rootstock) that are resistant to pests and climate change	- **Guadeloupe and Martinique**: including local breeding programmes and evaluating "exotic" cultivars potentially interesting for the Region: Using disease-free planting material through certified breeding programmes (*Citrus, pineapple, yam, plantain banana, tomato),* increase the diversity of cultivars to answer to consumer demand, evaluating the double grafting method for citrus to manage HLB (LIFE Vida for Citrus) - **Spain** (Andalucía, Canary Islands and Valencia Community): breeding resistant varieties for avocado - use of avocado germplasm collection to select cold tolerant varieties and rootstocks (OG Avocado Innovation) - **Portugal**: use of variety free of viruses and other diseases – (+BDMIRA)
(Re)introduce local multiple-purpose crops adapted to soil, climate and animal feed	- **Madeira**: Assess local crop landraces and germplasm of sweet potato and taro in relation to its drought tolerance, aiming to provide local farmers with propagation material that is more resilient to the scarcity of water resources (CASbio) - **Guadeloupe**: Yam multiplication programme through cutting beds to avoid anthracnosis, pineapple programme - **Reunion Island**: Recovery plan on local fruit and vegetable 'Lontan' variety, still used in Indian Ocean area (Germination Genetic Resources Management in Actions-Through an Indian Ocean Network) - **Reunion Island**: use non-hybrid seeds and create a local seed bank on local crops and vegetables. - **Portugal**: use of multipurpose leguminous plant fixing nitrogen and developing dense soil coverage allowing weeds suppression, lower evapotranspiration and erosion control such as a hyacinth bean (Lablab purpureus (L.)
Develop drip irrigation	- **French Guiana**: Develop drip irrigation for a better use of water - **Spain and Mediterranean countries**: Deficit irrigation as a strategy to save water in Mediterranean semiarid agro-systems, use of reclaimed water, rooftops to harvest water with bamboo (OG Avocado Innovation), optimising drip irrigation systems. - **Guadeloupe and Martinique**: cultivation of lettuce in gutter above ground
Plant fertilisation	- **Madeira, Canary Islands**: use of natural bio-stimulant substances or seaweed extracts as protectants and biofertilisers to improve crop protection to drought and pest constraints (AHIDAGRO) - **Guadeloupe and Martinique**: local platforms to compost grass and branches

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Annex 5: Examples of good practices and innovations at cropping system level

Good practice/Innovation	Detailed example and area
Use local multiple-purpose crops adapted to soil, climate and animal feeding	- **Azores**: Conservation and use of indigenous legumes in farming systems (Associação Agrícola da Ilha Terceira) - **Guadeloupe**: microfarms and farms with successful multicropping systems (citrus associated with passion fruit or other crops – INRAE experiments)
Introduce plants that provide ecosystem services	- **Spain:** Use of plant covers to increase the diversity of pollinators and biological pest control in avocado. (OG Avocado Innovation) - **French Guiana**: "Maison familiale rurale de Regina" with students and farmers to test different ways to produce better yield using plants that provide ecosystem services; Incorporate some "leguminous plants" like arachis pintoi/desmodium and others to enrich the soil - **Mayotte**: impact of plants that provide ecosystem services (Canavalia ensiformis, Vigna unguiculata) on banana crops to reduce weed and improve soil fertility (bioferm project) - **Spain:** Use cover crops for cherimoya and other fruits to favour production and natural pollination - **Guadeloupe and Martinique**: Implementation of Crotalaria spp to control soil nematodes before pineapple crop in Martinique and Bracchiaria in banana
Develop agroforestry	- **Portugal**: Introduce trees into parcels (agroforestry practices) creating windbreaks, soil fixation, erosion control, fertility, weed control, multipurpose trees - **Madeira**: create a resilient agroforestry system (with permanent and non-permanent crops to produce food, feed for animals, and produce biomass for multiple purposes creating an alliance between wild species of native Laurisilva forest and food crops, including some subtropical ones (AgroMac) - **French Guiana**: Association Panakuh – Local forestry association - **Reunion Island**: introduce local tree hedges into cropping systems to improve functional biodiversity (Agricultural Highschool Saint-Paul) - **Greece**: water reuse for optimum natural resources use and production (agroforestry) (hydrousa)
Develop conservation agriculture practices to limit/avoid tillage and to favour soil autofertility	- **Spain**: introduce conservation agriculture in avocado production (OG "Avocado Innovation") (Andalucia, Canary Islands and Valencia Community) - **Guadeloupe**: test conservation agriculture practices to develop the sustainable production of tomato, watermelon, and banana - **Reunion Island**: Grass cover under fruit tree plantations, seeding leguminous crops under mango trees (Biophyto project /Dephy Mangues) - **Madeira**: Soil coverage in organic farming, using mixtures of native nitrogen-fixing and grass species to add nitrogen, release organic matter and recycle nutrients; among the nitrogen-fixing species the incorporation of *Lupinus luteus* and *Vicia faba* are traditional practices
Improve biofertilisation and mulching	- **Reunion Island**: Using vegetal pests rich in minerals to produce enriched compost and liquid slurry - **Martinique**: Use of plants that provide ecosystem services such as crotalaria before planting pineapples or tomato - **Spain** (Valencia): Implantation of temporary cover crops and mulching of rice straw in citrus soils

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Biocontrol on plants / Integrated Pest and Disease Management (IPM)	- **Mayotte**: Using nests for insects to protect eggplants from fly stings - **Spain (Andalusia)**: Develop protected cultivation of fruit trees - **Reunion Island**: Use biocontrol through plant-eating bacterias against *ralstonia solanacearum* on tomato - **Martinique**: Use of plants that serve ecosystem functions such as crotalaria before the main crop to control pest and disease on tomatoes

Annex 6: Examples of good practices and innovations at farm level

Good practice/Innovation	Detailed example and area
Use local crops or by-products to feed animals	- **Madeira:** Diversified and high-quality food, using local crop varieties of (sub)tropical and temperate fruit tree and crops – in the examples of testing on organic subtropical fruit, custard apple and banana produced by farm "Fajã dos Padres", Jordan Andrade and "Adriano Ferraz farmers - **Guadeloupe**: Use of bread fruits and sugar cane juice to feed pigs / use of non-conformed or unsold fruits to feed animals (watermelon for cattle for example, banana for pigs) - **Azores**: Use by-products of banana crops for the production of a local beverage and build other products with major market value, processing banana production not sold into new products, develop rotation with pasture and corn silage to feed cattle; the implementation of the pasture/maize rotation in the low areas as a way to obtain corn silage and use less artificial concentrate supplement to feed cattle
Recycle organic manure and slurry to fertilise crops	- **Canary Islands**: elaboration of organic liquid fertilisers using an aerobic process from local pig waste and goat whey. Mainly used in banana production in La Palma island. Small-scale biorefinery for on-site application in rural environments with mixed crop and livestock activity (SEFEL system) - **Madeira, Azores, Canary Islands**: innovative practices using different kinds of compost, biochar (activate carbon), carbon capture methodologies to increase the organic matter and nutrients in the soil or restore soil productivity potential in the abandoned or eroded lands (Vercochar project) - **Mayotte**: Develop biofertilisation/organic matter of banana through on-farm experiment on livestock – focus on nutrients and carbon storage - **Guadeloupe and Martinique**: production of biostimulants from manure and slurry at farm level. As well as production of worm compost.

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Annex 7: Key issues for (sub)tropical cropping systems to face climate change

Key issue #1	**Grow varieties and or cultivars that can adapt to agro-ecological conditions in certain parts of the EU's continental regions and ORs and that meet market demand**	
Challenges	Technical issues	Scale
Production of sub(tropical) cultivars and/or valorisation of local crops when available and relevant in continental Europe	Availability of seeds and/or planting material	Regional
	Dedicated nurseries skilled in tropical species	Regional
	Cryopreservation of tropical germplasm	Regional
	Germination rates, virus-free and weed contamination	Farm
	Adaptability of sub(tropical) cultivars to various environments	Farm, landscape
	Low temperatures: negative impact on flowering, pollination, fruit set, fruit quality and yield in many tropical tree crops	Farm, landscape
Production of varieties/cultivars adapted to short production seasons in tropical environment due to climate change	Availability of seeds and/or planting material	Regional
	Selection/breeding of germplasm to photoperiod sensitivity in annual crops: short cycle varieties	Regional
	Selection/breeding and compatibility tests of rootstocks (for tropical fruit trees)	Regional
	Develop experimental facilities for characterisation, identification, evaluation of varieties	Farm, landscape
	High temperatures: negative impact on flowering, pollination, fruit set, fruit quality and yield in many legume crops	Farm, landscape
Protection of cultivated crops from climate change in (sub)tropical environment	Sustainable climate-controlled greenhouse cultivation of tropical fruits trees	Farm
Overcome erratic and/or intense climate events	Optimal regions in mainland Europe where subtropical crops can be produced are in the Mediterranean area, where water availability is scarce and the situation could worsen under the climate change scenario	Regional

Key issue #2	**Develop alternative and effective solutions to the use of chemical pesticides for pest and disease management (PDM)**	
Challenges	Technical issues	Scale
Avoid the entrance of foreign pests and diseases that could jeopardise agro-ecological (sub)tropical crop production	Design tools to be prepared to respond rapidly to new pests and diseases	International
Development of effective IPM programmes in continental and outermost regions	Uncertainty of pests behaviour and disease epidemiology under distinct climatic conditions: need for understanding surrounding environments and devising agro-climate modelling	Landscape
	Understand vector-diseases interactions under warmer climates	Farm (plant), landscape
Development of biological control and/or natural plant extracts for effective PDM	Identify and evaluate the potential of native/wild plants in ORs as source for PDM	Landscape, regional
	Development of experimental facilities for biological control and/or natural plant extracts to be used as bioprotectants and biostimulants	Landscape, regional
	Develop adapted ways of control (european legislation)	Regional

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Key issue #3	**Proceed to economic viable substitution of chemical to organic fertilisation**	
Challenges	Technical issues	Scale
Use organic fertilisation	Develop optimised fertilisation plans based on organic fertilisation to ensure commercially acceptable yields	Farm
Use on-farm organic fertilisation source	Identification and characterisation of locally available organic fertilisation sources	Farm
	Develop on-farm production facilities to transform local organic matter (farm biomass and wastes) to organic fertilisation source	Farm
	Identify (sub)tropical species (crops, weeds, trees) for on-farm biomass production	Farm
Optimise organic mineralisation and plant assimilation	Identify, develop mycorrhizal plants in association with crops	farm
	Develop pre-mycorrhization of plantlets in orchards	Farm, landscape
	Develop growth-promoting micro-organisms	Farm, landscape

Key issue #4	**Restore and/or maintain soil fertility by use of permanent cover crops, associated crops and simplified cultural technologies**	
Challenges	Technical issues	Scale
Predict sustainability of soil fertility	Evaluate impact on cultivated species of soil evolution under warm climate (eg. by comparison of soil quality between French Antilles and Madeira (volcanic soils) and Mediterranean)	Regional
Mechanisation of planting/harvesting of cover crops	Develop adapted sowing/seeding and harvesting machinery: adaptation of machinery and other tools to cope with crops seldom mechanised	Farm
Management of cover crops	Develop economically accepting solutions for cover crop management (ie. in the absence of herbicides)	Regional
Generalise soil permanent coverage (intercropping)	Identify and characterise locally adapted species (crops, weeds)	Landscape, regional
	Availability of seeds/planting material	Regional
Reduce soil impact, develop simplified cultural technologies	Develop adapted sowing/seeding and harvesting machinery	Farm, landscape
	Develop limited tillage	Farm, landscape

Key issue #5	**Develop functional biodiversity in aerial and soil compartments**	
Challenges	Technical issues	Scale
Understand variations in functional biodiversity in relation to climate change	Identify and characterise aerial and soil biodiversity in various environments	Farm, landscape, regional
	Develop models to understand variations in functional biodiversity	Farm, landscape, regional
Restore aerial biodiversity	Identification and implementation of species adapted for hedges or grass strips	Farm, landscape,
Restore soil biodiversity	See technical issues from key issue #3 and 4	
	Develop mulching strategies	Farm

Key issue #6	**Develop innovative and functional crop-farming systems**	
Challenges	Technical issues	Scale
Develop innovative cropping systems	Explore possibilities for underexploited intercropping (Mixed cropping, Row intercropping, Strip intercropping, Relay intercropping) and alley cropping	Farm, landscape
	Develop adapted sowing/seeding and harvesting machinery: adaptation of machinery and other tools to cope with crops seldom mechanised	Farm
Develop innovative crop-farming systems	Explore possibilities for underexploited farm-cropping systems	Farm, landscape

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Key issue #7	**Use of technology for best crop management**	
Challenges	Technical issues	Scale
Reduce/optimise water use	Develop water management tools particularly in orchards	Farm, landscape
Manage intensive frost climatic events	Develop automated and remotely controlled systems based on sensors and models ((e.g. anti-frost water aspersion)	Farm, landscape
Manage intensive drought climatic events	Develop automated and remotely controlled systems based on sensors and models (e.g. localised water irrigation)	Farm, landscape
Monitor plant growth and physiological disorders	Use of drones, climatic stations, data recorders	Farm, landscape
Develop decision tools to optimise crop management	Increase data records to develop decision tools	Farm, landscape

Key issue #8	**Commercialisation of tropical crops**	
Challenges	Technical issues	Scale
Optimise postharvest storage and handling	Manage chilling and heat injury in tropical fruits (storage and transportation)	Regional
Commercialisation and marketing	Information and Communication Technologies: to assist acceptance of new foods by consumers and farmers, to advocate health and environmental benefits (including shorter supply chains) to avoid negative perceptions from the public opinion (e.g. water consumption in avocado growing in Southern Europe)	Regional

Key issue #9	**Cross-cutting items**	
Challenges	Technical issues	Scale
Communicate on climate and environmentally friendly techniques and practices	Having open-access data and information/user-friendly tools (eg. how to calculate irrigation needs in relation to climatic conditions, or how to calculate carbon or water footprint of farm productions	Regional, national and international

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Annex 8: List of existing research projects and initiatives, and Operational Groups

Name of the project	Type	Area (Country)	Main objective	Leader
PEI Banane Martinique For a sustainable and ecologically intensive banana production in Martinique	OG	Martinique (France)	Develop agro-ecological alternatives of controlling black sigacoka, and reduce the use of herbicides and synthetic fertilisers and develop a multi-criteria evaluation of the sustainability, valuing biodiversity and technical-economical performance of new cropping systems	UGPBAN (banana producer association)
VALAB Integrated Ecosystemic value enhancement of the Guadeloupe Forest Agrobiodiversity	OG	Guadeloupe (France)	Study the feasibility of viable small-scale farming systems that will respect the integrity of the Guadeloupean forest biodiversity.	SYAPROVAG (vanilla producer association)
ITICan Innovative Technical Cultivation in Sugar Cane: Installation of Intercrop Service Plants (Fallow)	OG	Martinique (France)	n.a.	CTCS (Technical Institute for sugar cane and sugar)
Bioferm Management of conservatory of biomasses, nutrients and soil fertility in small famlily farms in OG Mayotte island and the transfer of information	OG	Mayotte (France)	Contribute to the sustainability of mixed agricultural production systems joining agriculture and farming animals by offering technical data to favour self-sufficiency and appropriate advice to farmers	Cirad
CARISMED Sustainable production of papaya in areas with a subtropical-Mediterranean climate	OG	Gran Canaria (Spain)	Diversify production with a wider range of crops (tropical fruit trees such as papaya with rapid entry into production and high yields)	Anecoop S. Coop. (local cooperative)
Europapaya Develop a productive model for papaya production in Spain	n.a.	Spain	Give a boost to the development and optimisation of a productive model for the intensive cultivation of papayas in Spain	Cajamar experimental station
PATATASS Evaluation of technical and economic potential for the integration of sweet potato crop in agrobiological and vegetable systems	OG	Normandy (France – continental EU)	Aiming at developing recommendations to include sweet potato interesting in the context of diversification, both with vegetables and market gardeners	Sileban (local institute for vegetable experiment)
+BDMIRA Sustainable and competitive **sweet potato** at Mira irrigation zone: innovative practices and organisational dynamic	OG	Mira (Portugal-continental EU)	Increase the productivity of the variety of sweet potato 'Lira' in Mira Irrigation Perimeter (PRM)	Instituto nacional de investigação agrária e veterinária ip

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Name of the project	Type	Area (Country)	Main objective	Leader
Sweet potatoes (Ipomea batatas) in a strategy of agricultural diversification in the Languedoc-Roussillon region	OG	Continental EU France Languedoc-Roussillon	Aiming at testing practices to include sweet potato interesting in the context of diversification, both with vegetables and market gardeners	n.a.
MUSA Microbial Uptakes for Sustainable management of major bananA pests and diseases	H2020	Italy/Spain/Belgium	Aiming at encompassing novel IPM methods based on microbial consortia and available banana (Musa spp.) and enset (Ensete ventricosum) germplasm, including newly developed elite hybrids	CNR, Istituto per la Protezione Sostenibile delle Piante, UO Bari (Coordinator) (CNR) Italy
BREEDCAFS BREEDing Coffee for AgroForestry System	H2020	Italy (and worldwide)	diversify the range of varieties available for this more sustainable production method	Cirad
TROPICSAFE Insect-borne prokaryote-associated diseases in tropical and subtropical perennial crops		Spain / Italy (and worldwide)	address economically important insect-borne prokaryote-associated diseases of perennial crops (palm, citrus and grapevine) grown in tropical and subtropical areas which are seriously affecting the trade and import of agricultural products and materials worldwide	Alma mater studiorum - universita di bologna
Avocado Innovation	OG	Spain	Significantly increase the profitability of avocado in Spain, adequately expanding its growing area and by introducing new production technologies, reducing its carbon footprint	ASAJA Málaga
PARADE-HLB (on Citrus), PRODIMAD (yam and taro), INTENSECOPLANTAIN (Plata banana), AgroEcoTOM (Tomato and other solanaceous crops), PAD (Pineapple), RESYMAR (mainly tomato)		Guadeloupe	Improvement varieties of plant in citrus, yam, taro, banana, tomato and pineapple	
AVEC	OG	Guadeloupe	Multidisciplinary and mutispecies that aims at better promoting experiments at farm level	

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The European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) is one of five EIPs launched by the European Commission in a bid to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as *through* the EIP-AGRI network.

EIPs aim to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- ✓ the EU Research and Innovation framework, Horizon 2020,
- ✓ the EU Rural Development Policy.

An EIP AGRI Focus Group* is one of several different building blocks of the EIP-AGRI network, which is funded under the EU Rural Development policy. Working on a narrowly defined issue, Focus Groups temporarily bring together around 20 experts (such as farmers, advisers, researchers, up- and downstream businesses and NGOs) to map and develop solutions within their field.

The concrete objectives of a Focus Group are:

- ✓ to take stock of the state of art of practice and research in its field, listing problems and opportunities;
- ✓ to identify needs from practice and propose directions for further research;
- ✓ to propose priorities for innovative actions by suggesting potential projects for Operational Groups working under Rural Development or other project formats to test solutions and opportunities, including ways to disseminate the practical knowledge gathered.

Results are normally published in a report within 12-18 months of the launch of a given Focus Group.

Experts are selected based on an open call for interest. Each expert is appointed based on his or her personal knowledge and experience in the particular field and therefore does not represent an organisation or a Member State.

*More details on EIP-AGRI Focus Group aims and process are given in its charter on:
http://ec.europa.eu/agriculture/eip/focus-groups/charter_en.pdf

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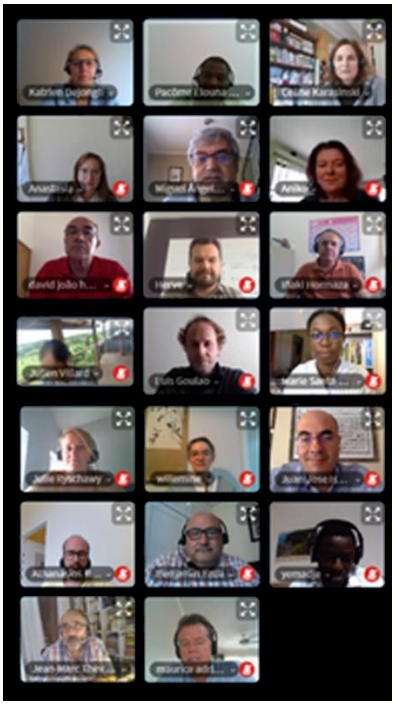

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