Learning Material for the WFSC Short course

Designing for Food Systems Resilience: A Circular Approach

Learning objectives (1st modul – Wednesday morning):

- Familirarize with the concepts of resilience, circular and solidar economies, agroecology, transdisciplinarity
- Understand the purpose of tackling Food System resilience with systemic and transdisciplinary methods
- Gather enough information to understand the main dynamics and the context of the tomato value chains nowadays

Reading and knowledge material:

General on Agroecology

- Edmundo Barrios, Barbara Gemmill-Herren, Abram Bicksler, Emma Siliprandi, Ronnie Brathwaite, Soren Moller, Caterina Batello & Pablo Tittonell (2020) The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives, Ecosystems and People, 16:1, 230-247, DOI: 10.1080/26395916.2020.1808705

General on Resilience

- Meuwissen M. P.M., and 32 co-authors (2019) A framework to assess the resilience of farming systems, Agricultural Systems, Volume 176, 102656, https://doi.org/10.1016/j.agsy.2019.102656
- Walker, B. 2020. Resilience: what it is and is not. Ecology and Society 25(2):11. https://doi.org/10.5751/ES-11647-250211

General on Circular Economy

- Ellen Macarthur Foundation (2013). Towards the circular economy: economic and business rationale for an accelerated transition.

General on Tomato

- Empire of Red Gold – Movie extract from Java Film : https://www.youtube.com/watch?v=Yjy1DoI7WFo
- Smal text here-under (optional)
- Sarah Ruth Sippel (2015) All you need is export? Moroccan farmers juggling global and local markets, handbook on the globalisation of agriculture ISBN: 978 1 78643 653 5
- FAO. 2020. Fruit and vegetables – your dietary essentials. The International Year of Fruits and Vegetables, 2021, background paper. Rome. https://doi.org/10.4060/cb2395en

Quick overview on Fresh fruits and vegetables and a focus on tomato – in Africa and Morocco

Based on the dissertation of Kenza Benabderrazik: Operationalizing resilience in face of climate change. The case of tomato producers in Morocco and Ghana. A thesis submitted to attain the degree of DOCTOR OF SCIENCES of ETH ZURICH. 2021.

Fresh fruits and vegetables in Africa

Fresh fruits and vegetables (FFV) are essential elements for a healthy human diet. They provide essential nutrients, such as vitamins, fibers, minerals, and have many health benefits and even prevent sickness(e.g. night blindness, diabetes, etc.) (Willett et al., 2019). Therefore, a large number of public health institutions encourage the consumption of fruits and vegetables (Mesbah Zekar et al., 2017). Among different food categories, life-cycle assessment studies show that grains, fruits, and vegetables have the lowest environmental effects per serving (Clune et al., 2017; Davis et al., 2016; Eyhorn et al., 2019).

Besides the potential health and environmental benefits of the FFV diet, FFVs are high-value products and their exports lead to high and rather stable foreign exchange earnings (Van den Broeck and Maertens, 2016). International trade is highly regulated, through standards, such as Globalgap, and the production for export is mainly realized by agro-industrials (Feyaerts et al., 2020). In a field related to modern food supply chains, thus horticultural exports are the most important agri-food export category, constituting 32.8% of total agri-food exports from Africa. However, in the scientific debate, horticultural exports in Africa have received very little attention (Van den Broeck and Maertens, 2016).

Most studies investigating the effect of climate change on food production indicate an aggregate reduction in future agricultural productivity, particularly in low-latitude regions. One study projected an 8% reduction in mean yield of all crops by 2050 across Africa (Knox et al., 2016). Furthermore, the effects of climate change threaten smallholder producers as fruits and vegetables are considered a high-value crop (Feyaerts et al., 2020) as horticultural production is a significant source of farmers' income in Africa (Abdulai, 2016).

Fruits and vegetables appear to be crucial for a healthy and sustainable diet. Their lack of consumption is a main contributor to micronutrient deficiency in Africa. Moreover, the continent shows both local and global potential dynamics regarding the production, trade and consumption of these products. The following section will provide more specificities on tomato and its current role and characteristic in the African food system.

Tomato production

Tomato (Solanum lycopersicum, L.) belongs to the Solanaceae family also called nightshades, which include more than 3000 species (Knapp, 2002). Pepper, potato, eggplants and tobacco are among other crops from the family of the nightshade. Tomato originated from the Andean region, which is modern day Chile, Bolivia, Ecuador, Colombia and Peru (Melomey et al., 2019).

Tomato is utilized as a fresh crop or processed into various forms (e.g. paste, puree and juices). Tomato is a rich source of vitamins (A and C), minerals (iron, phosphorus), lycopene, Beta-carotene, as

well as containing a high amount of water and low amount of calories (Melomey et al., 2019). Arising from historical global food trade and human diasporas, tomato is considered to be the most important vegetable in the world due to increasing commercial and dietary value, widespread production as well as being a model plant for research (Kimura and Sinha, 2008). This generates new dynamics in local and global production, which in turn affect one another.

Moreover, like many FFVs, tomato is a high value crop that is sometimes one of the main sources of income for its producers. Finally, depending on market structures and opportunities, as well as because of the perishability of the crop, the market prices can be particularly volatile, putting the producers into a vulnerable situation (Feyaerts et al., 2020).

As with many horticultural crops, the diversity of production practices covers a wide spectrum of agricultural management methods and processes, from greenhouse fertigated to open-field rainfed production. With producers around the world recording yields from 2 $ton.ha^{-1}$ (in some locations I studied in Ghana) to 600 $ton.ha^{-1}$ (in Dutch greenhouses) (Heuvelink, 2018). These wide ranges of production practices and cultivar also make the crop react differently to climate shocks – the crop is sensitive to environmental changes, either lack of water or too much water can be very determinant for the growth of the crop (Guodaar and Asante, 2018).

All in all, tomato is a fascinating crop to focus on as it sheds light on some of the major challenges of food systems. As a key crop to tackle food system resilience, I will now explicit how tomatoes occupy a central place in both the Moroccan agricultural systems.

Morrocan production system

Morocco is among the world's leading tomato production and exportation countries (FAOStat). The demand for tomato consumption in the country is high, as tomatoes constitute an essential ingredient of Moroccan Mediterranean cuisine (Darfour-Oduro et al., 2018). The domestic market is supplied with non-export-oriented seasonal production mostly located in the northern part of the country, such as in the Rabat-Salé-Kénitra region. The production is intensive and open-field. On the other hand, Morocco also exports tomatoes in the off-season (early production), almost exclusively from the Souss-Massa region in the south-west. The fruit is produced in unheated greenhouses from October to March and supplies both international and national markets. The Souss- Massa region accounts for about 60% of national tomato production and 80% of national greenhouse production (Codron et al., 2014). Most of the fresh tomatoes exported are directed to the EU market (France, Switzerland, etc.) and Russia.

Tomato plays a key role in Morocco, where tomato production and value-chain has mainly been shaped by the agricultural policies and strategies implemented by the authorities over the last decades, among them the Green Moroccan Plan (GMP) (Akesbi, 2014; Faysse, 2015; Ouraich and Tyner, 2018). The GMP was a strategy that started in 2008 and ended in 2019, aiming to modernize high added-value agriculture while upholding smallholder farmers.

Moroccan agricultural sector suffers from climate variability, mostly drought, and the irrigation management strategies have led horticultural growers to rely mostly on drip irrigation, through groundwater supply. As a results climate effects are mostly indirect but play a crucial role for the tomato system. In this case, there is a strong link between groundwater management and sustainable producers' livelihood (Ameur et al., 2017; Faysse et al., 2014; Kuper et al.). Accounting for the effects

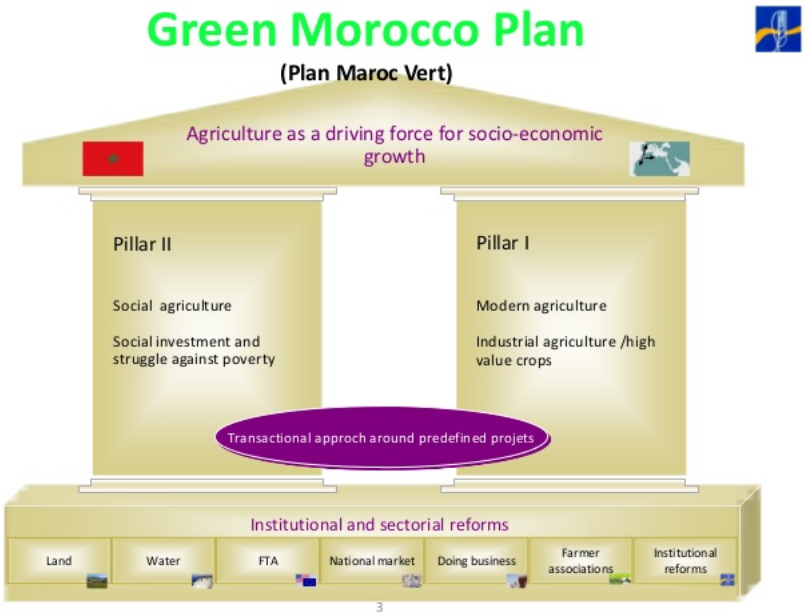
of the droughts in this case study requires to consider long timeframes and to focus on several levels of the agricultural system, from the farm to the regional level.

Agricultural strategy and water governance

In 2008, the Moroccan government launched an agricultural strategy, the Green Moroccan Plan (GMP), to rehabilitate agriculture and turn it into the main engine of economic growth and a tool against poverty in Morocco. This strategy was based on two pillars and was expected to reach both large and small actors along the agricultural value chains.

The first pillar of the strategy aimed to promote modern agriculture, with high added value crops adapted to export markets.

The second pillar aimed to develop an approach to fight against poverty by significantly increasing agricultural income for the most vulnerable farmers, particularly in disadvantaged or peripheral areas (Plan Maroc Vert, 2008 (Akesbi, 2012)).



Moroccan agriculture has essentially been shaped and divided by these two pillars. The differences between these two systems became particularly visible in the fruit and vegetable sector, with 517 thousand tons of fresh tomato exported, making the crop one of the flagship products for export (FAOStat for 2017). Among other targets, this latter strategy aims at converting 50% of the Moroccan irrigated agricultural land area by 2020 to drip irrigation through a national subsidy program (Alonso et al., 2019). However, over the past decade, the expected results of this strategy, officially ending in 2020, have been widely disputed (Akesbi, 2014; Faysse, 2015; Ouraich and Tyner, 2018; Sippel, 2016). Previous studies argue, on the one hand, too much focus on agricultural intensive practices and productivist models to the expense of natural resources preservation. On the other hand, the subsidies conversion to drip irrigation and the expansion of intensive farming had severe impacts on water contrary to what was announced. The latter underlines the need to integrate major challenges related to water management or global competitiveness (Boudhar et al., 2017; Schyns and Hoekstra, 2014).

A dual production system

The diversity of horticultural production systems, for tomato especially, ranges from open-field grown systems to greenhouse production systems (soil or soil-less culture) (Georgios K. and Maximilin, 2017). In Morocco, exported tomatoes are produced in greenhouses that are extensively mechanized and generates a yield from 120 to 250 t ha-1 (wet weight). This system benefits from better connection to processing industry and cooperatives that ensure conditioning of the crop and access to export markets. Around 85% of total tomatoes destined for export are produced in the Souss-Massa region (OMRVASM, 2015). Considered as one of the most important agricultural poles, 55% of the exported fruits and vegetables are produced in this region in order to meet the European off-season demand (from September to May). This semi-arid region is characterized by a low average rainfall of 200 mm year-1 and average temperature of 24 ºC (Ait Brahim et al., 2017; Malki et al., 2017). The high-water demand for the crops has led to the over-exploitation of groundwater for irrigation purposes. The Chtouka aquifer located in the region has recorded an annual deficit of 58-60 Million m3 per year over the last two decades (Hirich, 2016; Malki et al., 2017). Agricultural productivity has subsequently increased groundwater resources depletion and degradation rates over the last decades (Payen et al., 2014). Due to its strategic economic and political importance, the region has been extensively studied over the last decades and quantitative information on the water and agricultural situation is available in the scientific and grey literature. Several studies (Ait Brahim et al., 2017; Malki et al., 2017) showed the groundwater depletion patterns as well as its impacts on the quality of the water.

In contrast to large export producers, smaller producers are growing tomatoes in irrigated open-fields (from April to October) along with other vegetables throughout the year, generating lower yields from 40 to 80 t ha-1 (see Figure 1). For clarity reasons, open-field smaller producers will be referred to as farmers in the following sections. According to the data provided by the ministry of agriculture, the Rabat-Sale-Kénitra (RSK) region has produced most of the irrigated and open-field tomatoes in recent years, 73 thousand tons in 2017 (DSS, 2017). RSK is considered as one of the most important areas for fresh fruit and vegetable production. Such production, using drip-irrigation has fostered extensive groundwater exploitation. For the RSK region, we found no studies reporting quantitatively on the depletion of the resources, however, several studies on Morocco and regions close-by reported on the groundwater over-exploitation and the subsequent issues regarding water quality and availability (Hirich, 2016; Malki et al., 2017; Najib et al., 2016).

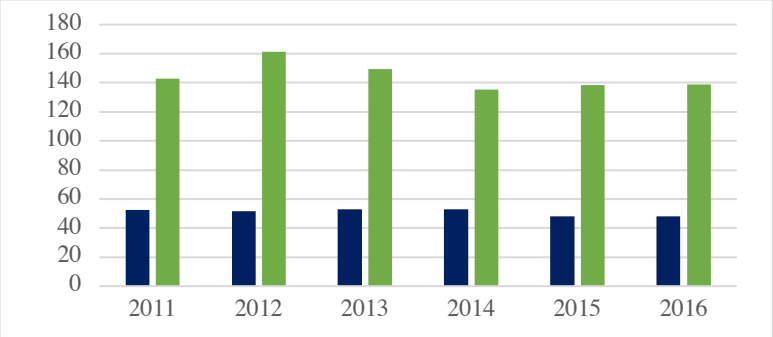


Figure 1: Average yield in both regions from 2011 to 2016 (in ton.ha-1)- in dark blue open-field production in RSK, in light green greenhouse production in SM- Data provided by the Ministry of Agriculture

Stakeholder description

Policymaker – Agricultural ministery

You are a representative in the national government of your home country – Morocco, affiliated to the minestry of agriculture. You see the agriculture as a key economic sector that employ 40% of your country's population. You are trying to come up with national and regional policies that would uphold and support the farmers and the rest of the sector. You know that the climate variability are heavily affecting the production and subsequently the wages and employments for millions of citizens. It is crucial for you to ensure a short-term viability of this sector, however you are well aware that there is a need to face the long term consequences of water scarcity , soil depletion and globalized trade.

Ministry of agriculture:

The current minister of agriculture comes from the Souss-massa Region - the horticultural production area around Agadir. He is one of the richest individials of Morocco. He has been leading this ministery since more than 13 years and has pushed to enhanced the horticultural export sector over the last decades. He also took the lead in making the closest harbour (of Agadir city) suited for fruits and vegetable exports around the world and also contributed to the establishment of the desalinization plant that will open this year for an alternative water supply of the region.

Politician in the EU

You are a politician in the EU very concerned about giving a guiding framework for your next elections. You get pressure from consumers' organizations and activists. On one hand, prices for tomato need to be stable – as it's a key food item, especially for low-income groups, and families with children. They require you to implement clearer Food safety and quality measures. On the other hand, you receive calls for a value-chain legislation for sustainability and fairness become louder, so you think e.g. about suggestions of a market incentive for more sustainable agricultural goods and food items. However, the tomato industry frequently expresses its concerns about their competitiveness and jobs in the EU food industry, should you lobby for such a restrictive approach.

Supermarket General Manager - Europe

Your country has few large supermarket chains that compete with one another. You are the general manager of one location of one of those supermarkets in a small town. In that small town, your supermarket is the main source of food for people (the other large supermarket chain does not have a location in your town), but there is also a small butcher and a small fruit and vegetable shop where some people shop. You like to provide a fruits and vegetable shelf that is colorful and supplied yearly with tomato, cucumbers and pepper. You know that some people care about the provenance of the vegetables so you make sure to make it transparent.

Consumer in Morocco

You are the parent of a family of 4 children and earns 2'500 MAD (~250$) per month. 40% of your income is usually spent on food. Everyday you cook lunch and dinner for your family - there's no days without at least few tomatoes in the yummy dishes you prepare (tchaktchouka, kefta, tagine , etc.).

Your family is fond of traditional Moroccan food, that you learnd to cook through your grandmother when you were a kid. The prices of tomatoes in the market are increasing at each drought – however, the prices could also decrease drastically when green , watery and untasty tomatoes are coming from Souss-Massa, the very one that were intended to be exported but couldn't because they didn't met the European (discussable) standards.

Consumer in Europe

You are a parent of a family in Switzerland with a monthly income of 5000 CHF (5000 $). You are worried about children becoming less healthy. You remember when YOU were a child – you played outside everyday and were very active, and your family also very rarely ate any takeaway/fast food. You always had home cooked meals. You think the real problem here is that (1) kids spend too much on screens these days and (2) other parents aren't trying hard enough to encourage their kids to eat healthy and instead are buying them fast food all the time. So you decided to cook as many meals as possible with colorful vegetables. Your kids happen to love your tomato salad and gazpacho and pasta with fresh tomato cubes, so you started to cook one of them 3 times a week – every week of the year. In winter- December, janurary and February - your tomatoes are coming from Morocco. You heard it was better to eat seasonal but you believe the health of your children is your priority.

Greenhouse farmer or company

Farm owners are often foreign, but from a long generation of farmers. Their families often have a long farming tradition of a diverse range of fruits and vegetables. Many of those fruits and vegetables were sold locally, providing healthy food to people. In early 90's many of them invested in buiding several greenhouses on their land, each of them was heavily subsidiesed by the state. They tried to grow banana but several years later and after the EU agreements with Morocco, they switched to Tomato. Now horticultural farm mostly just grows tomato for export. Some are switching to berries because the market prospects are better. Water availability is a problem, each year you they dig deeper in their own well to be able to reach enough water for the crop. However, the export trade is bringing enough money for the family and enables owners for instance to pay 3 technicians to make sure that the European standards are repected. They are aware that the price of water will double in the coming years thanks to the desalinization plant that the governemant had build, but this increase of water won't decrease significantly their income. Some owners visit their farm only once a year.

Export firm: export firms are often Moroccan-European joint ventures and try to implement vertically integrated businesses that control the whole value chain (production, packaging, exportation, distribution and commercialization in Europe).

Open field farmers or "prosumers": rural families in Morocco

Rural farming families who have not sold their land yet to external investors produce a range of food crops in rotation, using mulch, some compost and other agroecological practices. They also produce tomatoes for the national markets and use pesticides which is why many of them do not consume their tomatoes or harvest some before spraying. They feel sidelined by governmental support which goes mainly to export-oriented greenhouse production. Local farmers suffer a lot from the general depletion of groundwater. Their tomatoes are mainly bought by "lead farmers", intermediaries who sell them to market traders of the main tomato paste company, Aicha.

Lead farmers: Lead farmers are successful farmers who were selected by the ministry of agriculture in the frame of the Green Morocco Plan (social agriculture). Their main fundtion is to pool and market the produce form the small farmers for local markets and industries such as Aicha, which gives them basically an intermediary role.

Processing firm: Aicha is a Morrocan firm and leader in tomato paste production. They buy tomato from open field farmers mainly for the national market through “lead frmers”. Recently, Aicha has also expanded to other African countries.

Cooperatives negotiate export quota. Tomato export to Europe works from October to March. Members are the horticultural companies. The cooperatives also organize cleaning and packaging of fresh tomato for export.

Hired technitians for horticultural production: These experts have a special education in horticultural production and advise greenhouse growers/horticultural companies on specific topics of production, also for tomato.

Workers/tomato pickers: Seasonal workers from iffernet places in Morocco. During the harvest season they come in thousands to the Agadir area. Conditions are very harsh, especially for women (work exploitation and rape), temperature in the greenhouses is up to 50°C. Still, obtaining labor is one of the most difficult things for the horticultural farm managers in terms of cost and availability. Also small farmers need labor and find it hard to organize.

GlobalGAP certification agent: The tomatoes have to comply with the rules for the European market. This means that all the tomato producers willing to export have to comply to Global Gap which is a private sector body that sets voluntary standards for the certification of agricultural products around the globe. The aim is to establish one standard for Good Agricultural Practice with different product applications capable of fitting to the whole of global agriculture.

Input suppliers

Seeds for greenhouse tomatoes for export come from all over the world, e.g. Israel, Peru, France and Morocco. Many are from the Bayer/Monsanto owned seed company Seminis, which has more than 20% of the global market share of fruit and vegetable seeds.

Fertilizers come e.g. from OCP morocco (the world’s largest supplier of phosphorus) who employs 23000 people in Morocco – as one of the key and biggest company of the country.

Pesticide suppliers are e.g. Corteva (former Dow/Dupont)

Trade actor (selling Moroccan tomato to Europe) who are they?

Wholesale market Rungers in France: The tomatoes form morocco reach this giant wholesale market to be distributed all over Europe (including Switzerland) form here. Byuers are…