Technology Transfer for reducing the carbon footprint. The example of cleaner technologies for food processing

Final report for UNEP-DTIE (Paris)
(Date 20090330)

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CONTENTS

Executive Summary

1. The past 15 years, within the context of ‘sustainable consumption and production’, the life cycle of goods and services (i.e. products) has become more prominent into the picture. Recently increased attention is paid to the ‘carbon footprint’ of products.
2. In the same period there has been a growing multilateral understanding under the UNFCCC of the development and transfer of environmental sound technologies. There is an urgent call by developing countries for acceleration on the implementation up to 2012, before the post-Kyoto period.
3. Linking the carbon footprint of consumption with the GHG emissions in production is an opportunity to get higher societal and political support for measures along the life cycle of (food) products.

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4. In the coming decades the production in and the export by developing countries of cash crops will stay important in terms of volume. Meeting high standards of quality (incl. avoiding mycotoxins) of these commodities is essential for guaranteeing their income revenues.
5. In the past little attention has been paid to the environmental burdens from food processing in developing countries (cf. the supply side), although at present figures related to the consumption in developed countries (cf. the demand side) shows an important contribution to environmental problems such as climate change, deforestation etc.
6. The drying process of cash crops in particular seems to contribute considerable to the carbon footprint of the consumer products (coffee, tea, rice,). Therefore different types and sizes of solar dryers have been developed over the past decades.
7. Although the initial investment cost is high, in the literature, reflecting realities from pilot/demonstration projects, the payback time of solar dryers varies from less than two years up to approximately four years. Employment seems to shift from labor to get fire wood and to turn the cash crops for sun drying into labor needed for increased turn-over and higher prices due to improved quality of the product.

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8. Long experience under the UNFCCC with the development and transfer of environmental sound technologies (EST’s) has shown that removing barriers for the implementation of the full potential of these EST’s, means working on each of the five important key themes: technology needs and needs assessment, technology information, enabling environments, capacity-building and financial mechanisms.
9. The observations made in the specific reports on major barriers for the implementation of solar dryers are quite similar. Working on ‘Capacity-building’ and ‘Financial mechanisms’ to accommodate the lack of information and of initial investment capital are of utmost importance.

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10. For this report there is a merit to look at (some of) the past and present initiatives of the United Nations Framework Convention on Climate Change (UNFCCC) and of international organizations, including the United Nations Environment Programme (UNEP) and others (GEF, UNDP …).
11. It can be observed that some projects have been started in different countries, but that they are limited in time, scale and region.

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12. The selection of developing countries with a significant technology transfer potential for reducing the carbon footprint through the deployment and diffusion of solar dryers for cash crops started with the identification of the major exporters of developing countries for coffee, tea and rice.

13. In order not to re-invent the wheel when setting up partnerships, it has been recommended to work with existing institutional infrastructure such as the National Cleaner Production Centers and other initiatives supported by the UN-system and/or the European Commission.

14. By doing so, it could be concluded that there are merits with considerable potentials to work towards partnerships with and in Brazil, India, Sri Lanka and Viet Nam. In order to respect the criterion of equitable distribution of efforts, it has been suggested to identify African countries. Following the same approach Uganda and Kenya could be identified.

15. Furthermore, because of several reasons, including similar projects in the past, the authors of this study highlighted the importance for and the potential of Indonesia, Ghana and Nicaragua.

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16. It is clear that is up to UNEP-DTIE to approve this proposal. Based on this decision, the relevant stakeholders can be contacted, including the engagement of NCPC and other UN-initiatives and the stakeholders of the respective value chain (related to the selected countries). Partners already working in the field, institutions with the appropriate knowledge, organizations having a network already in place, etc. should be working together under one (regional/country) umbrella.

17. The aim is to launch as soon as possible a comprehensive process to enable the full, effective and sustained implementation through long-term cooperative action. The ultimate objective is the deployment and the diffusion of these environmental sound technologies (i.e. solar dryer technologies in food processing) now, up to and beyond 2012 in order to make use of its full potential. A road map for setting-up partnerships is proposed.

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1. Introduction

Objectives of the assignment

19. UNEP DTIE has commissioned the consultancy in October 2008 with the aim to carry out a small scale funding project on 'Technology Transfer for reducing the carbon footprint. The example of cleaner technologies for food processing.' This assignment is in line with the activities agreed on in the Grant signed between UNEP and the European Commission and in relation to UNEP's work on Sustainable Innovation.

20. The Terms of Reference for this assignment are stipulating as "The main objective of this study is hence to analyze in depth the feasibility for the introduction of drying technologies based on solar energy that are more environmentally friendly than conventional ones understanding what the obstacles are in some specific contexts, establishing first contacts for partnerships or other cooperation forms and learning what policy measures could be beneficial in such cases."

21. The rational and overall objectives are explained as follows:

    - "Feasibility analysis for the introduction of drying technologies based on solar energy and other renewables if applicable in different developing countries and in relevant food industries, including assessments of the carbon footprint in particular in the coffee supply chain, addressing the advantages related to it and justifying its choice, and including the exploration of other food chains (e.g. tea, rice) to which the concept is applicable and the assessment of conventional and cleaner food processing technologies impacts and benefits
    - Development of partnerships and cooperation with development agencies industry and development agencies in the selected developing countries
    - Understanding of current barriers preventing the transfer or increased uptake of such cleaner technologies and of identification of beneficial policy measures that could be implemented
    - Feasibility assessment for the introduction of such technologies in the selected countries
    - Next steps (e.g. possible demonstration plants, partnerships etc.)"

22. Specific objectives and main activities in the Terms of Reference are further detailing the ration and overall objectives, introduced by the following text: "The feasibility study shall focus on an adequate number of food crops, in particular coffee, solar energy technologies and geographical settings."

Background

23. Policy-making on sustainable development at the international level (UN-CSD, UNEP-DTIE, EC-DG ENV …) has been stressing the importance of linking production with consumption. Food has been identified as one of the categories of products with the biggest environmental impact over its life cycle (EC-JRC, 2006). Both in developed and developing countries the food and drink industry generates economic growth on the one hand and environmental impacts on the other. Global efforts are made to reform food production and tools promoting a fair trade and sustainable consumption become widespread. However, particularly the food processing segment has a significant potential for innovative technologies. Different renewable energy technologies, such as solar energy, energy from waste (using by-products), wind energy and geothermal heat, can be used for various processes, including grain and leaf drying, grain milling, juice extraction, distillation, fermentation and oil pressing .

24. The integration of clean technologies concepts in food processing is widely recognized as a win-win approach that increases overall efficiency while sustaining economic growth and minimizing environmental impacts, in particular through the reduction of the carbon footprint.

2. Context

The life cycle of goods and services

25. In Chapter 4 - Changing consumption patterns of Agenda 21 the world was called to "… develop criteria and methodologies for the assessment of environmental impacts and resource requirements throughout the full life cycle of products and processes." At the same time, at the end of the 1980's and in the beginning of the 1990's, the Society for Environmental Toxicology and Chemistry (SETAC) supported different efforts in order to generate documents, including the initial LCA Code of Practice, which promoted consistency and awareness of best practices in environmental LCA.

26. Later on, 'Life Cycle Thinking' - essential to sustainable consumption and production - made its way to the highest levels of decision-making. UNEP explained that "*It is about going beyond the traditional focus on production sites and manufacturing processes so that the environmental, social, and economic impact of a product over its entire life cycle, including the consumption and end of use phase, is taken into account.*"[1] Well-known is the promotion of this approach through the UNEP/ SETAC Life Cycle Initiative.

27. Life Cycle Assessment (LCA) can inform production and consumption choices because they assess the impacts of goods and services. The last 15 years LCA methodologies have been deepened. Environmental, social and socio-economic Life Cycle Assessment are complementary techniques, each offering their perspective of the products' life cycle impacts. Life Cycle Costing, in addition, gives information on the internalized costs throughout the life cycle of a product. They are all methodologies of a wider sustainability tool box that differ based on their scope (life cycle) and their product focus.

28. Part of the life cycle of a product is in the value chain, which is composed by the activities that generate profits on products or services and primarily comprehends of: inbound logistics, operations, outbound logistics, marketing and sales and services supported by the organization's infrastructure, human resource management, technology development and procurement (Porter M., 1985). It is important for the value chain to evaluate what are the possible environmental ameliorations.

29. Life Cycle Thinking is also reflected in the concept of the Ecological Footprint. This concept allows the measurement of the impacts given by a population/city/household on environment and is represented as the area (in ha) necessary to sustain the resource consumption and the waste discharge (Wackernagel and Rees, 1996).

30. Because in recent years, climate change became more and more important for decision-makers, the focus of 'footprint' (including the Life Cycle Thinking) has been laid on the 'discharge' of carbon. The purpose is to look from the cradle to the grave to the greenhouse gas emissions from the product-system (Carbon Trust, 2007). It can be expressed as kg CO_2-equivalent per functional unit of the product.

The development and transfer of environmental sound technologies

31. Within the context of the UN Framework Convention on Climate Change (UNFCCC), the development and transfer of environmental sound technologies (EST's) - in short 'development and transfer of technology' (DTT) – is regarded as an umbrella concept. In fact 5 development stages of technology (research, development, demonstration, deployment and

1 See for more information: http://www.unep.fr/scp/lifecycle.

diffusion) and 5 key themes for policy-making (technology needs and needs assessment, technology information, enabling environments, capacity building, financial and institutional mechanisms) can be distinguished. It is clear that this should be a country-driven process with attention to the stakeholders and the local communities. It is also acknowledged that there are important endogenous technologies. And South-South cooperation needs to be recognized.

32. Since the entry into force of the UNFCCC, DTT has always been on the political agenda, going through 5 different phases:

    - 1994-1998 - a turbulent period: various issues (projects inventory, financing, network centers, adaptation technologies) were discussed during the period of the Berlin mandate;
    - 1998-2002 - a consultative round: as a result of the Buenos Aires Plan of Action regional workshops (Asia, Africa, Latin America and the Caribbean) were organized as part of a consultative process;
    - 2002-2008 - a common understanding: the Marrakech Accords led for the first time to a common vision on how to deal with this commitment;
    - 2008-2012 - an acceleration on the implementation: the knowledge and the experience gained in the previous period lead to complementing the vision;
    - Post-2012 - a period with a wider scope: it can be understood from the Bali Road Map that more attention will be paid to the development and transfer of technologies under the different agenda items of the Conference of the Parties.

33. Implementing agencies of the UN system (UNEP, UNDP, UNIDO …) and the financial mechanism (GEF[2]) have al the time been working in close cooperation with the UNFCCC.

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34. The multilateral negotiations at COP 13 (Bali, Indonesia) in 2007 decided "…to launch a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012 …" One of the aims of the so-called UNFCCC Bali Action Plan is an agreement on the 'full potential of technology' at COP 15 (Copenhagen, 2009). However, because they feel not much has been done since 1992 (cf. the 5 different phases), developing countries[3] are expecting the 'long-term cooperative action now, up to …' is rewarded.

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35. Linking the carbon footprint of consumption with the GHG emissions in production is an opportunity to get higher societal and political support for measures along the life cycle of (food) products. It is within this context that this project under the set of *'Sustainable Innovation and Technology Transfer Industrial Sector Studies'* should be seen.

3. Cash crops and food processing

Introduction

36. By 2050, world population is projected to increase to more than 9 billion and current food production will have to increase around 1,5 % per year as shown in the United Nations projections (FAO, 2002). The increase of this production - to supply the demand of the increasing population - will also result in environmental impacts (climate change, water pollution, deforestation …) all over the life cycle. An example can be seen in the case of soybeans production either for food or for biodiesel. Although soybean is the 9th main crop produced in 2006, it is the 4th more land demanding crop (FAOSTAT, 2008). In Brazil, this

[2] GEF (Global Environmental Facility) is a global partnership and is currently the largest funding organization to improve the global environment (GEF, 2008).
[3] Developing countries definition according to the UN.

has resulted in the expansion to cattle areas, which in turn are moving to the Amazon Forest (Milani et al., 2008). The production increased from 35 million tons in 1990 to almost 60 million tons in 2008 (IBGE, 2008). Even though the productivity increased from around 1,8 tons/ha to 2,7 tons/ha during the same period, it was necessary an additional land of almost 3 million ha.

37. Although there is an expectation to increase the demand of cereals (which is the world's most important sources of food) in the upcoming years, some developing countries depend in terms of mass (tones) on the exportation of one or a few commodities such as coffee, tea, rice, cocoa, sugar, natural rubber and tropical fruits. Therefore 'export' figures[4] might be a better basis for this feasibility study than 'production': see Box 1.

Box 1

'Production' versus 'export'

FAOSTAT (see http://faostat.fao.org/site/375/default.aspx) defines production as "Figures relate to the total domestic production whether inside or outside the agricultural sector, i.e. it includes non-commercial production and production from kitchen gardens. Unless otherwise indicated, production is reported at the farm level for crop and livestock products (i.e. in the case of crops, excluding harvesting losses) …"

And furthermore "Crop production data refer to the actual harvested production from the field or orchard and gardens, excluding harvesting and threshing losses and that part of crop not harvested for any reason. Production therefore includes the quantities of the commodity sold in the market (marketed production) and the quantities consumed or used by the producers (auto-consumption). …"

In order to understand the most significant crop and the potential for carbon footprint reduction, different criteria – implicitly referred to in the ToR - need to be taken into account. In the ToR there is a reference to 1) linking production and consumption, 2) value chain and 3) developing countries. From this, it can be concluded that in terms of the characteristics of the development and transfer of technologies, the immediate and financial potential can be observed from export data. Take e.g. note of the (public/private) partnerships to be set up.

38. The rationale and the overall objective of this study (cf. Terms of Reference) are stating: "Feasibility analysis for the introduction of drying technologies based on solar energy and other renewables … in particular in the coffee supply chain, addressing the advantages related to it and justifying its choice, and including the exploration of other food chains (e.g. tea, rice) …" Therefore this report will lay the focus on the coffee value chain with references to other food chains (e.g. tea, rice, nuts, etc.), if relevant.

39. In 2006, sugar cane was the most produced crop in terms of mass, followed by rice, cassava, maize and wheat, nevertheless among the 10 main crops and livestock, in terms of export values, in Landlocked developing countries (LLDC), Small Island Developing States (SIDS) and Least Developed Countries (LDC) only sugar has major importance, as shown in Table 1 (FAOSTAT, 2008).

40. The 10 main crops and livestock in 2006 represented 46% of the total export value, from which more than half are crops (sugar, coffee, sesame seed, wheat and soybeans): see Table 1.

[4] Note that export is expressed by FAOSTAT in terms of weight (tonnes) or currency (in thousand US dollars).

Table 1 - World's total export values of crops and livestock in 2006 (FAOSTAT, 2008)

Crops and livestock	1000 $	% of the total
Cotton lint	3.615.843	14%
Tobacco, unmanufactured	2.060.028	8%
Sugar Raw Centrifugal	1.593.185	6%
Coffee, green	1.094.401	4%
Bever. Dist.Alc	1.041.039	4%
Coffee Husks and Skins	711.744	3%
Sesame seed	615.177	2%
Wheat	593.985	2%
Soybeans	479.095	2%
Meat-CattleBoneless (Beef&Veal)	457.172	2%

41. The main food crop identified in 2006 was sugar raw centrifugal, which accounted for 6% of the exported values of the countries groups mentioned above. From all the sugar produced in the world in 2006, 86% was produced from sugar cane and the remaining from sugar beet. 75% of the former was produced in developing countries (Table 2). By that time 60% of the total world production was produced by only three countries (FAOSTAT, 2008).

Table 2 - Major world producers of sugarcane (FAOSTAT, 2008)

Country	Sugarcane
Brazil	33%
India	20%
China	7%
Mexico	4%
Thailand	3%
Pakistan	3%
Colombia	3%
Australia	3%
United States of America	2%
Indonesia	2%

Legend: ☐ Developing Countries

42. The second most important crop in 2006 was green coffee, mainly produced in developing countries, as shown in Table 3. These countries accounted for 74% of the total world production and the three main big producers were responsible for 50% of the world production (FAOSTAT, 2008). Green coffee contributed with 4% of the exported values of the LLDC, SIDS and LDC countries.

Table 3 - Major world producers of green coffee (FAOSTAT, 2008)

Country	Coffee, green
Brazil	26%
Colombia	13%
Viet Nam	11%
Germany	6%
Indonesia	5%
Peru	5%
Guatemala	4%
Honduras	4%
India	3%
Mexico	3%

Legend: ☐ Developing Countries

43. In 2006, all 10 main producers of sesame seed are developing countries, from which the three biggest producers accounted for 56% of the world production (FAOSTAT, 2008): see Table 4.

Table 4 - Major world producers of sesame seed (FAOSTAT, 2008)

Country	Sesame seed
China	20%
India	18%
Myanmar	18%
Sudan	6%
Uganda	5%
Ethiopia	5%
Nigeria	3%
Bangladesh	2%
Paraguay	2%
Tanzania, United Republic of	1%

Legend: ☐ Developing Countries

44. On the other hand, from the 10 main producers of wheat, mostly were developed countries, which summed in 2006, 72% of the total world production (cf. Table 5).

Table 5 - Major world producers of wheat (FAOSTAT, 2008)

Country	Wheat
United States of America	19%
Canada	15%
France	13%
Australia	12%
Russian Federation	8%
Argentina	8%
Germany	5%
Ukraine	4%
Kazakhstan	3%
United Kingdom	2%

Legend: ☐ Developing Countries

45. Soybean production is more concentrated. Only 8 countries summed up 98% of the world production, from which the developing countries contributed with more than half of it (FAOSTAT, 2008): see Table 6.

Table 6 - Major world producers of soybeans (FAOSTAT, 2008)

Country	Soybean
United States of America	43%
Brazil	35%
Argentina	11%
Paraguay	3%
Canada	3%
Netherlands	2%
China	1%
Uruguay	1%

Legend: ☐ Developing Countries

46. Already now it can be noted that solar drying technologies (cf. ToR) are not used in all life cycles of these most important exported crops and livestock.

About quality, health and safety

47. Crops can be regarded as important for the export of developing countries. The price on world market is influenced – inter alia - by the quality. As for cash crops (coffee, tea, rice, nuts …), this quality is influenced by contamination with e.g. stones and excremental of animals and with fungi. The latter is due to the moisture content when preserving the cash crops and leads to a loss of parts of the cash crops. But it can even be worse. Cash crops can be affected by fungi producing mycotoxins (aflatoxins, zearalenones, trichothecenes, and ochratoxin). These fungi are causing mycotoxicosis by animals and humans (FAO, 1989). Box 2 is focusing on the mycotoxin in coffee.

Box 2

Ochratoxin A (OTA)

This fungi is the most important and toxic one, if looking at coffee. Half of the nineties, it has been found out that the main reason for this intoxication is due to bad circumstances when preserving the green beans. It was also analyzed that a decrease in the moisture content up to 12 % could help to prevent from contamination. Furthermore, it has been stressed that the roasting process in coffee production is not (always) ruling out the contamination.

Therefore FAO (2006) "*has developed good hygiene practices for coffee producers aimed at reducing contamination of raw beans by a potent fungal toxin …*". The main recommendation of preventing mould formation and OTA contamination regards "*to ensure a safe moisture content level as quickly as possible and prevent rewetting. Tests confirmed that the ICO's existing recommendation for maximum moisture content in green coffee (12,5%) is consistent with prevention of growth of OTA producers.*"

It can be concluded that economical (quality, loss of cash crops) and social (health) reasons are laying at the basis for an increased attention to the drying processes in the value chains of cash crops.

About environmental concerns

48. The specific objectives of the ToR of this assignment are requiring looking at the environmental concerns "… mainly regarding GHG emissions - associated to conventional food drying technologies…". "…and identification of its less sustainable processes (e.g. drying, roasting etc.) of current conventional food processing technologies which could be improved through the application of cleaner technologies".

49. In the few LCA studies of cash crops available, the main focus is on farming and on that part of the life cycle which is lying in industrialized countries. It is the observation from the literature review that the food processing in developing countries most of the time is not assessed in detail.

50. As mentioned before the ToR are requiring looking in particular at 'coffee'. Therefore Figure 1 gives – as an example - an overview of the life cycle of coffee. Apart from the environmental problems related to the coffee roasting and packing and to the use of phase – those phases of the life cycle taking place in developed countries (e.g. EU Member States) - the main problems are related to the coffee cultivation (i.e. farming) and the coffee processing (from berry to green bean).

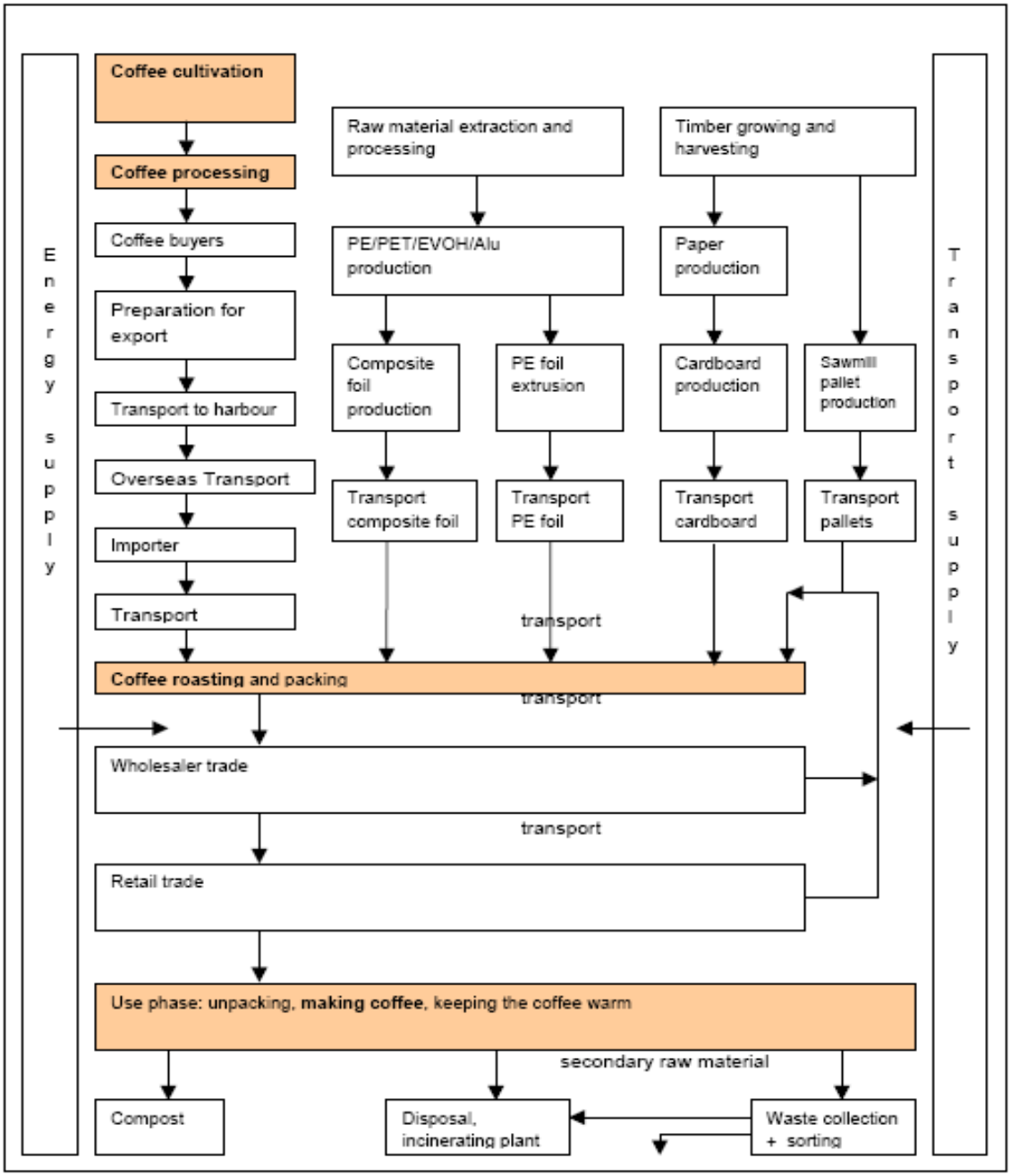

Figure 1 - Life cycle of coffee (Mazijn B., 2004)

51. Different LCA studies are confirming that these phases of the life cycle of coffee do have the major environmental burdens (ICO, 2001; Coltro L. et al., 2006; Vierre T., 2007; Büsser S. et al., 2008).

Box 3

Types of coffee processing

After picking the cherries of the coffee plan, during coffee processing they are converted into green beans, by removing the pulp. A distinction can be made between wet and (semi-)dry process.

At the global level more than 40 % is produced through wet processing. It can also be observed that Robusta coffee is mainly processed using the dry method, while Arabica coffee is going through the wet process.

It has been reported (see http://www.coffeeresearch.org/) that "*The dry-process is often used in countries where rainfall is scarce and long periods of sunshine are available to dry the coffee properly. Most coffees from Indonesia, Ethiopia, Brazil, and Yemen are dry-processed.*" Furthermore: "*Wet-processing coffees is a relatively new method of removing the four layers surrounding the coffee bean. This process results in a coffee that is cleaner, brighter, and fruitier. Most countries with coffee valued for its perceived acidity, will process their coffee using the wet-process.*"

The environmental problems are mainly related to wet processing: effluents from washing stations, by-products of coffee, greenhouse gas emissions from combustion, deforestation from the use of fire wood, etc.)

Focus on climate change, in particular during coffee production and consumption

52. As an important item, the focus in this report is on 'climate change', relating it to the consumption of coffee. Below some figures from the literature[5], reflecting the carbon footprint of coffee production, are extrapolated and related in particular to production and export.

53. World wide 400 billion cups[6] are consumed each year. Although the differences between and within continents are high, most of the coffee is consumed in the developed countries. As an example, two of the most important coffee drinkers in the world are Belgium and the Netherlands, which have respectively 10,5 and 16,375 million inhabitants. Considering that in these countries an average person drinks 600 big cups per year, the following calculations can be made:

54. When using references in the literature for the whole life cycle of coffee: 'from the berry to the cup', i.e. most of the life cycle, the following can be observed:

    - Narang S. (2007) has reported that Starbucks are emitting about two ounces of carbon per cup[7] they are selling. Therefore, world wide coffee consumption would be responsible for 84 million tons of CO_2 of which all Belgians together would emitting 1,323 million ton CO_2 and all Dutch people together 2,063 million ton CO_2;
    - Salomone R. (2003) however has been calculating a figure which is three times higher: 675 g of CO_2 emitted when drinking a big cup. The world CO_2 emissions related to coffee consumption would then be at the level of 270 million tons of which all Belgians together, would emitting 4,25 to 5,3 million ton CO_2 and all Dutch people together, 6,628 to 8,2655 million ton CO_2;

[5] An important source of data is the International Coffee Organization: see www.ico.org.
[6] Each big cup contains approximately 250 ml.
[7] I.e. 210 g of CO_2 are emitted by big cup

55. For the last decade, on average 114 million bags[8] of green beans are produced yearly of which 91 million bags are exported. The total value of this export product increase from 5,81 billion USD in 2000/01 (i.e. a crop year) to 13,22 billion USD last crop year. Other references in the literature are referring to the part of the life cycle of coffee 'from the berry to the green bean'

    - Coltro L. et al. (2006) numbers showed that just the diesel consumed in Brazil for coffee production is responsible for 292,3 kg CO_2/ton green coffee (mass based) or 281,2 kg CO_2/ton green coffee (up to 4 920 kg CO_2/ton green coffee) (energy based). Considering all the exports, this would mean a total of CO_2 emissions world wide of more than 1,5 million ton. When looking at the partner countries (within the context of development corporation) of Belgium, it would imply that the exportation of 1.419.443 ton green coffee, is summing up to 407.000 ton CO_2 emissions and for The Netherlands, 809.240 ton CO_2.

56. When looking at figures of energy use by conventional dryers, it can be concluded that 231,8 kWh and 8,3 m³ fire wood are necessary to produce 1 ton of green coffee (Trubey R., 2004).

57. If we consider that 1 kWh from fossil fuel is responsible for 0,2470 kg of CO_2, as 10,5 kWh is necessary to produce 45,3 kg of coffee with conventional dryers (Trubey, 2004), it means that 57,25 kg CO_2 is emitted for each ton of green coffee. Relating these figures to the total export, the total figure is more than 300 000 ton CO_2 world wide, of which the partner countries of Belgium and The Netherlands, are/could be responsible for respectively up to 81.250 ton CO_2 and 161.500 ton CO_2.

58. In addition to these figures, this would also mean that – related to the export figures - more than 45 million m³ of firewood is used world wide. The partner countries of Belgium and The Netherlands are using respectively up to 12 million m³ and 24 million m³ firewood. It is known that 10 m³ to 50 m³ (in some cases up to 100 m³) of firewood per hectare of forest can be harvested.[9] It means that at least 1 million (up to several millions) of hectares forest is needed for drying the green beans. Throughout Central America, an estimated 16,086 acres (i.e. more than 6 500 ha) of forest are cut to supply the firewood used to dry the coffee production each harvest.[10]

59. All in all, these numbers represent respectively 1,5 and 4% of Belgium and The Netherlands greenhouse gas emissions.

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60. Similar figures for energy use and CO_2 emissions for drying can be obtained for other important exported food crops, such as tea. In a GEF project in India, in which 170 SME's are producing 75 million kg tea, 150 million kg firewood is used, accountable for 0,27 million ton of CO_2; the world tea production is 3,2 million ton a year, i.e. more than 40 times; the GEF project highlighted that "the specific thermal energy consumption for drying is about is about 75-85% of the total thermal energy requirement and about 50-75% of total energy, depending of the type of tea produced." (GEF, 2004). It is argued that a reduction of 30% fuel (incl. fire wood) and carbon emission reduction can be obtained through solar heating with energy efficient furnace. These figures are confirmed by another GEF project in Africa (GEF, 2005).

61. Box 4 exemplifies that there are different major environmental concerns described for other food crops.

[8] Each bag contains 60 kg of green beans.
[9] See – inter alia - http://www.funaguas.org.br/.
[10] See http://energy.caeds.eng.uml.edu/coffee.html.

Box 4

Environmental concerns related to other food crops

Sugarcane

The system of the life cycle of sugarcane performed in Mauritius included cane cultivation and harvest, cane burning, transportation, fertilizer and biocide manufacture and sugar processing and electricity generation. The results of this study showed that most of the greenhouse gases were emitted during the manufacture of fertilizers and biocides (Ranjeawon, T., 2004).

Although Brazil is the main sugarcane producer, no life cycle study has already been performed. On the other hand, there are studies of the ethanol life cycle, which has some processes that are similar to sugar production.

There are two types of harvesting practices with burning or non-burning field practices. In Sao Paulo, with more than 50% of the production in 2005 (Ministerio da Agricultura, 2005), 75% of the fields are burned (Ometto, A., 2005), different situation than in Mauritius, where this practice only accounted for 2,3% in the country (Ranjeawon, T., 2004).

A study performed in a region that produces ethanol in Sao Paulo, Brazil took into account 9 processes: soil preparation, planting, cultivation, harvesting, processing, cogeneration, fertilization and irrigation, distribution and use (Ometto, A., 2005).

The results showed that the agriculture phase was responsible for most of the greenhouse gases emissions of the life cycle of ethanol, due to the field burning (102,94 g/km, even though it was not taken into account CO2 emission) followed by the usage phase (42,28 g/km). In the life cycle of sugarcane, this process could contribute even more with the greenhouse gases emitted, as there is no combustion during the usage phase, although it should also be included the amount of energy necessary to dry the sugar.

Soybeans

So far there is no life cycle of soybeans for food, nevertheless there are already life cycle studies for soy biodiesel. Even for food, soybeans are consumed directly or indirectly by human beings as it is used to feed animals.

Soybeans demand large amount of land. In the USA and Brazil, the two main producers, the average yield is respectively 2,7 and 2,4 t/ha. The agricultural phase is also responsible for biodiversity loss (Fearnside, 2001) and climate change (Ernsting, A. et al., 2007).

The impact on climate change of soya biodiesel is mainly in the agricultural phase. In Brazil and Argentina the contribution of this phase was respectively 83% and 80%, mainly caused by land transformation11 followed by the emission of nitrous oxides due to the use of fertilizers, which was also the main cause of greenhouse gases emissions in the USA (Panichelli, L. et al., 2008).

Rice

[11] The conversion of grassland to produce crops can release 300 t/ha, and conversion of forest land, 600 to 1.000 t/ha (FAO, 2008 apud Fargione et al., 2008; The Royal Society, 2008; Searchinger, 2008). Ernsting, A. et al. (2007) also mentioned, based on the Stern Review, that from the 8 billion tons of anthropogenic greenhouse gases emitted every year, 1,3 billions are due to the ecosystem destruction.

A study performed in Italy took into account the following processes: agricultural (seed production, field operations, fertilizer, pesticides, irrigation and field emissions), drying and storing and refining and packaging, capital goods and transportation for 1 kg of delivered refined rice. Data varied from 1990 to 2007. The results showed that the field cultivation is the life cycle step which contributes the most for greenhouse gases, summing up 68% of the total emissions of exported white milled rice (Blengini, G.A. and Busto, M, 2008). Field cultivation is followed by fertilizers consumption, transportation, refining and packing, field operations (machinery) and drying and storing, respectively accounting to 9,2%, 6,1%, 4,7%, 3,6% and 3,2% of the rice greenhouse gases emissions. It was also showed that organic rice emits more greenhouse gases than other types of rice (white milled, parboiled or upland rice), which was caused due to the lower production yield. The upland rice (reduced water regime) resulted in the smallest emission, mainly with the application of furrow irrigation.

The field emissions were obtained from Regione Piemont (2005) (48 g of CH4 / kg of paddy rice and 0,2 g N2O / kg of paddy rice). Schütz et al. (1989) apud Blengini, G.A. and Busto, M (2008) showed however that the CH4 field emissions varied from 25,7 to 101,1 g/kg of paddy rice in northern Italy.

These figures are even higher for the field emissions in other regions as, differently than in the coffee life cycle, the drying process of rice is usually with sun energy (FAO, 1998) whereas in Italy light fuel oil and electricity is used (Blengini, G.A. and Busto, M, 2008). However, it must be highlighted that to reduce the productivity losses, even though more expensive, there is an undergoing movement to change traditional use of sun energy by other forms of fuels in the Philippines (FAO, 1998).

The emissions of CH4 are mainly due to the cultivation process; Harada, H. et al. (2007) studied the amount of greenhouse gases (CO2, CH4 and N2O) during the flooded rice cultivation in Japan in three different cases: puddling, no-puddling and no-tilling. In this study, the authors considered the fuel consumption for the herbicide application (no tilling case), tilling, clod breaking, puddling, transplanting, manufacturing materials and the emissions from paddy fields. The latter was responsible for around 97%, of the greenhouse gases emissions independent of the case. Nevertheless, no tilling was the one with least emissions, accounting with 2.430,5 kg CO2/ha, whereas puddling emitted 4.290,6 kg CO2/ha and no-puddling, 4.414,1 kg CO2/ha.

Although cultivation is the main source of greenhouse gases emissions, China, the main rice producer developed an aerobic rice, which does not demand wetlands and keeping the yield (IRRI, 2008).

4. Identification of the cleaner drying technologies

Types and sizes of the technologies

62. Drying of cash crops such as green beans of coffee can been done in different ways:

    - ‘Sun drying’: the green beans are spread out in a patio and the direct sun radiation is used to decrease the moisture content till approximately 15 %; the greens beans can be laid on a floor (in concrete, wood, …) or an tables;
    - ‘Mechanical drying’: a conventional method based on fossil fuel and/or fire word is used to decrease the moisture content up to approximately 12 %
    - ‘Solar drying’: this environmentally sound technology12 is used in the same way of the ‘mechanical drying’; the application depends on the geographical location, crop type, size of operation and government policy.

63. Solar driers can be designed to use the sun radiation in a direct or indirect way. When it comes to the indirect way, air is heated to flow through the green beans in order to remove the

[12] These EST’s can be developed for single or multi product purposes.

moisture to an acceptable level (< 12 %). The hot air can flow passively or actively. The latter is referring to the use of fans or blowers.

64. Furthermore, according to the experiences of UNEP-AREED, three categories of solar driers suitable for different product types can be distinguished (Arfaoui Y., n.a.): see Table 7.

Table 7 - Solar dryer types and its suitability to different product types and end-users (adapted from Arfaoui Y., n.a., and Mulato S., 2004)

Solar Dryer Type	End-User Level	Product Type
Small size (up to 500 kg) Low Cost	Small scale farmers	Fruits Vegetables Cash crops Food crops Fish and meat
Medium size PV- powered	Medium size farmers	Fruits Vegetables Cash crops Food crops Fish and meat
Large size (up to 5000 kg) AC- powered[13]	Enterprises and timber trader	Fruits Vegetables Cash crops Food crops Fish and meat Timber and tobacco

65. From the literature, it can be noted that there is a discussion going on if solar driers can be developed for an industrial scale. Specialists from the side of the solar panel technology (Solar Trade Corporation, n.a.) are stating that "… *these air-based systems are not scalable to dry industrial quantities.*", while experts in drying technology (Solar Dryers Australia, n.a.) are presenting a container to dry 14 tons of nuts (and other crops and wood), mentioning "*Indirect gas fired, but able to be coupled to a solar module* …".

Costs and pay-back

66. Overall solar driers are regarded to have a higher investment cost than conventional dryers. Interesting is to look at the example provided by Solar Trade Corporation: see Table 8.

Table 8 – Investments and costs for different drying possibilities (Solar Trade Corporation)

	Solar	**Mechanical**	**Patio**
Capital Investment	248 798 USD	190 000 USD	160 304 USD
Energy costs (first year)	1 700 USD	20 400 USD	/
Labor costs (first year)	6 385 USD	5 490 USD	29 500 USD
Life Cycle Cost: 10 years	181 317 USD	427 744 USD	290 388 USD

[13] PV is producing electricity in a DC mode. If e.g. you want to produce electricity for the grid or for powerful machines (like vans etc.) one need to convert into AC.

67. From other references in the literature (Martinéz-Sosa M.C., 2006; Chandak A., 2006), it can be learned that small scale solar dryers can be build for a couple of hundreds of Euro to a couple of thousands of USD.

68. In terms of pay-back, when comparing with mechanical dryers, it can be observed that the time is shorter when the fuel prices are higher. The example of the Caribbean has been given (Arfaoui, n.a.), where in the Bahamas the payback time would be 2,26 years, while in the oil and gas producing country Trinidad and Tobago it would have been 35,6 years. Examples in India (Chandak A., 2006; Sreekumar A. et al., 2008) for drying tea leaves counts with less than 4 years of pay back time.

69. In 2005, Purohit P. et al. developed a framework for financial evaluation to compare solar drying versus sun drying in India. They have been calculating different financial parameters for a small size solar dryer with a 100 kg capacity and for a range of products. Depending on the increase in the selling price of the product due to improved quality the payback period for coffee and tea varied from less than two years up to respectively 4.40 and 3.66 years. The concluding remarks were formulated as follows: "*Solar drying of agricultural products appears to be financially quite attractive for cash crops (such as tea, cardamom, etc.) and it may even be possible to justify the use of high cost solar drying systems in their case.*"

70. An example from Ghana (UNEP-RISO, 2002) learned that the payback for a large size solar dryer for pepper and maize was less than 2 years.

Box 5

Renewable energy and employment
The case of solar air dryers

In the literature a difference is made between employment related to the drying process and employment linked to the sectoral activities.

From Table 2, it can be observed that the labor costs - and ditto full-time equivalent (FTE) employees - are more or less the same when it comes to mechanical or solar dryers. In a project executive sheet of the GEF (2005), in relation to mechanical dryers, it has been stated: "*Fuel wood plantations have the additional benefit of providing local employment.*" Overall the introduction of a 'technology' means far less employment (up to 80 %) than the traditional sun drying. Referring to "*Heating energy needs of factories are generally met using fuel wood from well managed plantations.*" (GEF, 2005), the question remains if 'well managed' is equal to 'sustainable'.

In the literature of different projects (Arfaoui, n.a.; WISIONS, n.a.) often employment opportunities are linked to the quality requirements of the product, in particular coming from small and medium enterprises. In other words, if a solar air dryer is used to dry agricultural products in a proper way, the quality will meet the standards for increased commercialization and trade, because (Arfaoui, n.a.) : "*The farmer has the freedom to decide the price, compared to before where they are forced to sell because of the lifetime of the product. The agricultural production attract more people increased employment and benefit.*" And furthermore (WISIONS, n.a.): "*The potential impact of solar food processing and conservation includes: … create local income and employment opportunities …*"

In conclusion for now: employment seems to shift from labor to get fire wood and to turn the cash crops for sun drying into labor needed for increased turn-over and higher prices due to improved quality of the product.

5. Barriers to the implementation

71. The ToR say "The identification, based on work done related to the previous points, of the barriers to the implementation of the cleaner technologies identified in the selected developing

countries (touching on the similar relevant issues in other developing/developed countries and in the food industry as a whole)". A possible selection of countries is discussed in the next chapter, but it can be observed that no country specific studies are available regarding the barriers to the implementation of specific EST's (e.g. solar drying technologies).

72. However when "…touching on the similar relevant issues in other developing/developed countries …" it is possible to discuss in the next paragraphs the enabling environments focussing on some of the selected countries (cf. AREED; cf. Box 5; etc.).

73. Removing barriers for the implementation of the full potential of these EST's (see Box 6), means working on each of the five key themes for the development and transfer of technologies (see Chapter 1). Within the context of the technology transfer framework of the UNFCCC, the synthesized objectives per key theme have been formulated in the past: see Annex 1.

74. Before identifying the barriers to the implementation of EST's, in casu solar dryers, by comparing with the synthesized objectives for DTT, in the next paragraphs barriers will be mentioned from reports available with a specific section for that item.

75. UNEP-AREED listed in their report the following major barriers and risks "*for penetration of the solar dryer among farmers in Africa*":

    - no established effective trade payment systems …
    - unavailable initial investment capital or loan facilities
    - limited production capacity
    - poor marketing
    - poor information dissemination
    - poor training of local entrepreneurs and technicians

76. Related to UNEP-AREED, the UNEP Collaborating Centre on Energy and Environment (UNEP-RISO) together with the Kumasi Institute of Technology and Environment (KITE) made a Ghana Country Report on the '*Implementation of Renewable Energy Technologies – Opportunities and Barriers*'. The most important barriers in relation to solar dryer technologies mentioned in the report are:

    - Socio-technical: the lack of interface between R&D and implementation;
    - Economic: weak market due to high capital costs and no commercial financing;
    - Cross-cutting: lack of information and capacity-building, limited policy support.

Box 6

Full potential for solar drying technologies

The literature review has shown that the solar drying technology – at least up to the size of 'large scale' (cf. the remark on 'industrial scale') – is now already in the demonstration phase of the development of technology and should move towards the deployment and diffusion phase (of the innovation chain) in order to use the full potential of these EST's.

Note that it has been estimated (Solar Trade Corporation, n.a.) that there is world wide market for drying coffee beans through solar energy of 60 000 installations with a total investment of 2,5 billion USD. Annually the international coffee market represents a turn over of 70 billion USD of which 6 billion is spend in developing countries.

From this review, the following three main barriers can be listed:

- Lack of knowledge about problems and possible solutions
- Lack of initial investment capital
- Lack of government support

77. It can be observed that the barriers in the specific reports are related to each of the five key themes. Each of the key themes will be discussed. However, right from the beginning, it should be noted that 'no one size fits all'. Pending on the region and the technology, the underlying reasons for barriers and the way of how remove them will be different.

Removing barriers by working with the DTT key themes

Technology Needs and Needs Assessment

78. Authors from developing countries have been identifying the need for solar dryer technologies. This is in line with the observation of the UNFCCC Secretariat in its 'Synthesis report on technology needs identified by Parties not included in Annex I to the Convention' (UNFCCC, 2006a). TNA's from African countries were listing these technologies.

Technology Information

79. In the different specific reports lack of information has been flagged. A search by the authors of this report in the databases van Intergovernmental Organizations (GEF, UNEP, UNDP, FAO, UNIDO …) and the UNFCCC confirmed this.

Enabling Environments

80. It can be observed that barriers in the specific reports related to enabling environments are focussing on strengthening regulatory frameworks, including the utilization of tax preferences, as a key role in stimulating the market for EST's, in particular solar dryer technologies.

81. Furthermore, the call for (joined) R&D to adapt these EST's to local/regional circumstances can not be denied.

Capacity-building

82. To make use of the full potential of these EST's, long experience under the UNFCCC with the development and transfer of technology, has shown that in order to come quickly to financial closure, most of the project proposals are not presented using the right format and lacking a good presentation. Looking for capacity-building in that field has repeatedly been mentioned in the specific reports.

83. To bridge the gap between project developers in the field and potential investors (public as well as private, or a combination of both), 'A guidebook on preparing technology transfer projects for financing' (UNFCCC, 2006b) has been developed.

84. In the guidebook, it is stressed that the project proposal should consist of a plan to do something, combined with a request for resources. Seven core questions need to be answered:

    - "*What is being proposed? → The core concept*
    - *Where will the proposal be implemented? → The setting*
    - *Who will champion the proposal and see it to completion, and who else must be involved? → The team*
    - *How will the proposal be implemented? → Implementation plans*
    - *Why is the proposal important and why should it be supported? → Expectations*
    - *What if things do not go as planned? → Contingencies*
    - *To who is the proposal addressed? → The audience*"

Financial mechanisms

85. The lack of initial investment capital has been mentioned in the specific reports, despite the fact that different financial mechanisms – but mostly limited in volume, time and region – have been set up to accommodate the lack of investment capital, inter alea, in solar dryers. The role of GEF, UNEP (e.g. A-REED, Aceh …) and UNDP (SGP …) have been mentioned.

86. Under the UNFCCC, in general the financial mechanisms have been considered by developing countries as not really meeting the needs. Responding to the call at COP 13, a decision was

adopted at COP 14 called the 'Poznan Strategic Programme on Technology Transfer', proposed by GEF with UNDP and UNEP as implementing agencies (UNFCCC, 2008b).

87. Three windows are proposed of which 'Window 2 – Piloting Priority Technology Projects Linked to TNA's' and 'Window 3: Dissemination of GEF Experience and Successfully Demonstrated EST's' are close to the possibilities of solar dryer technologies. For the latter window, five to ten EST's will be considered. In the annex to the decision it is stated: "*These technologies should have great potential for wide application in many developing countries that will lead to significant GHG emissions reductions while contributing to the development objectives of the countries.*" Although GEF supported the technology of solar dryers before in coffee and tea processing (Nicaragua and India), the problem could be that this technology is not mentioned explicitly in the 'Annex 2 – Overview of GEF-Financed Projects and Technologies'.

88. Another new possibility, complementing the previous one, is the Global Energy Efficiency and Renewable Energy Fund (GEEREF). It is a public-private partnership, offering risk sharing and co-funding opportunities for commercial investors and public investors, in particular in small and medium-sized regional projects and enterprises: see http://www.eif.org/about/geeref.htm. A special emphasis will be given to serving the needs of the ACP, a group of 79 African, Caribbean and Pacific developing countries. It can also support regional funding in Latin America, Asia and neighboring states to the EU.

89. Note that there might be opportunities for investors from developed countries to participate and – by doing so – make use of the UNFCCC Clean Development Mechanism. In the first place, this could be a focus for medium size or large size projects of solar dryer(s).

Linking with the full potential of technologies

90. The process leading to use the full potential of environmental sound technologies, such as solar drying technologies, is following the so-called S-curve going through 5 different stages: research, development, demonstration, deployment and diffusion. From past experiences it can be observed that the time needed between the initial concept (research) and the market penetration (diffusion) often takes decades before near by 100 % of the potential users effectively are applying the new technology. The same time-lag can be observed when it comes to the application of environmental sound technologies, products, processes or services (renewable energy sources, sustainable building …).

91. This is due to different barriers as described in the previous section (market failures; values, attitudes, …; high costs; knowledge)[14]. Expertise and experience from different fields will be needed to overcome these barriers when setting up partnerships. How it can be done will depend on the stage of the development of the technology: see Figure 2. The role and involvement of the different stakeholders will also differ as outlined in the figure.

[14] Different authors (Moreiro J.R., 2002; Vladu F., 2006; …) have been flagging these examples for 'mitigation' technologies to climate change.

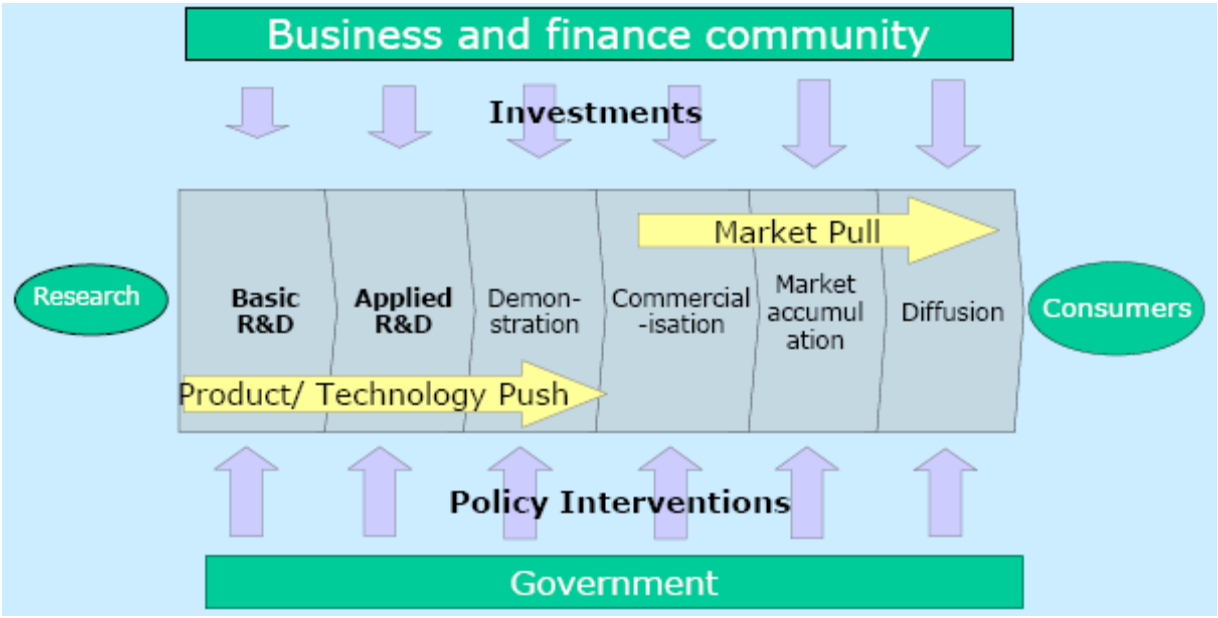

Figure 2 – The main steps in the development of EST's[15]

6. Past and present initiatives of international organizations

Global Environment Facility (GEF)

92. Within the UN-system the Global Environment Facility (GEF) is regarded as the designated financial mechanism for a number of multilateral environmental agreements or conventions, including the United Nations Framework Convention on Climate Change (UNFCCC). Although the GEF is an independent financial entity, it is implementing its projects and programs through the different agencies, including the United Nations Environment Facility (UNEP) and others (UNDP, UNIDO, FAO and World Bank). For this report there is a merit to look at (some of) the past and present initiatives of these international organizations.

93. In the Project Database of the GEF (see http://gefonline.org/home.cfm) one can find the following projects related to food crops and to solar dryers: see Table 9.

Table 9 – GEF projects related to food crops and solar dryers

	Approved Projects	**Projects with drying technology**	**Implementing Agency**
Coffee	5	1 (Nicaragua, 1999)	World Bank - IBRD
Tea	6	2 (India, 2004; East-Africa, 2005)	UNDP; UNEP
Rice	1	/	
Nuts	/	/	

94. The two projects with drying technologies for tea will be discussed in the sections below. The project in Nicaragua was implemented as a GEF medium size project by the IBRD in collaboration with the Mesoamerican Development Institute (MDI) under the title 'Renewable Energy and Forest Conservation: Sustainable Harvest and Processing of Coffee and Allspice'.

[15] Stern, N., (2006), *Stern Review: The Economics of Climate Change*, Cambridge en New York, Cambridge University Press. Cited from: Grubb, M., (2004), Technology innovation and climate change policy: an overview of issues and options. Keio Economic Studies. Vol.XLI. no.2. available from http://www.econ.cam.ac.uk/faculty/grubb/publications/J38.pdf

95. The environmental gains are estimated as follows (GEF, 2000): "Over life of project, the combined drying capacity represents estimated savings of 222 hectares of clear-cut forest over conventional dryers, with a corresponding 80 994 MTons reduction of CO2 emissions."

96. Unfortunately an evaluation upon the completion of the project is not publicly available, but information can be found in the 'Project Brief', the document describing the approach when proposing the project to the GEF.

United Nations Environmental Programme (UNEP)

97. A couple of years ago UNEP started REED, Rural Energy Enterprise Development Initiative, in Africa, Brazil and China. At present, according to information from UNEP-DTIE, B-REED (Brazil) and C-REED (China) have been completed. 'Solar dryer technologies' have never been an issue in these initiatives. A-REED (Africa) is still moving on and the commercialization of solar dryers for agricultural products have been a point of attention (Arfaoui Y., n.a.).

98. Entrepreneurs from 5 African countries (Mali, Ghana, Tanzania, Senegal and Zambia) can get support from A-REED for enterprise development services and start-up financing. As mentioned before, it seems that the focus on solar dryers for food crops has gained attention in the first place in Ghana (Danish Technological Institute, 2001 & 2002; UNEP-RISO, 2002). However there is no information of a follow-up to date.

99. The GEF project in East-Africa, mentioned above, is focussing on greening the tea industry. In the Project Brief (GEF, 2005) not much attention is paid to solar energy. On the contrary, it is stated: "*Solar thermal energy is considered to be limited in its ability to meet the needs of tea factories* …" This is in contrast to a similar GEF/UNDP project: see below.

100. More recently, as part of reconstruction efforts after the devastating tsunami in 2004, UNEP-DTIE started in collaboration with the German Ministry of Environment the 'Aceh Solar Energy Technology Loan Programme'. The objective is "*…to overcome limited access to credit from local banks, providing targeted end-user credit or loans to entrepreneurs investing in commercial solar energy applications, particular solar dryers.*" The motivation is that "The Aceh region of Indonesia was chosen because solar drying of crops and fish is economically and technologically viable, with a significant potential to create social benefits.[16]

101. It is a programme running "… from 2008-2010, with external support mechanisms such as interest rate reductions and credit guarantees phased out progressively as banks increase their confidence to lend for solar technologies." UNEP-DTIE in collaboration with UNEP-RISO and Khaula, a local organization, is guiding the whole process of entrepreneurs choosing for a solar dryer (for coffee, cocoa, betel nut, fish), including preserving the quality of the technologies offered by vendors.

United Nations Development Programme (UNDP)

102. The Small Grants Programme (SGP) is funded by the Global Environment Facility (GEF) as a corporate programme, is implemented by the United Nations Development Programme (UNDP) and is executed by the United Nations Office for Project Services (UNOPS). It supports activities of non-governmental and community-based organizations in developing countries towards – inter alea - climate change abatement.

103. The SGP project database (see http://sgp.undp.org/) contains 35 projects in which solar dryers are playing a central role. Up to 40 % of the projects are situated in Thailand; the others are located in countries in Asia and Africa. All these projects are executed within the context of the GEF Operational Programme 'Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs'

[16] It can be noted that the locally produced coffee, known as Gayo Coffee, is sold to speciality markets, including Starbucks.

104. The other GEF medium size project, mentioned above, is implemented by UNDP in collaboration with the Ministry of Environment and Forests of India, focussing on 'Energy Conservation in small sector tea processing units in South India'.

105. The objective is to pre-heat through solar energy the air for tea drying. Targeting 30 small factories producing 200 million kg of tea annually, it is stated (GEF, 2004) that "*The total direct CO2 emission reduction is estimated to be 56 925 tones.*" by eliminating the use of firewood in tea drying and saving an estimated 1 200 tons of fuel per factory per annum. Furthermore, it is estimated that the emission reduction through the replication effect would result in indirect CO2 reduction of 170 775 tones.

International Energy Agency (IEA)

106. Under the umbrella of the IEA Solar Heating & Cooling Programme (SHC), more than 40 different task forces have been established of which Task 29 – Solar Crop Drying (see http://www.iea-shc.org/task29) running from 2000-2006. In the IEA-SHC newsletter (2002), a study from 1999, jointly produced by Canada and the Netherlands, was quoted: "*The potential amount of energy that could be displaced using solar in this market (i.e. 'drying of agricultural products') was estimated to be between 657 PJ and 1530 PJ.*"

107. The Task 29 has been focussing on the segment of the market drying crops at temperatures less than 50 °C, setting up pilot projects in 5 different countries:

- Panama – coffee
- Costa Rica – coffee
- India – coir pith
- China – moyu
- Zimbabwe - tobacco

108. From the experiences with these projects, the group concluded that "Solar crop drying can be feasible in many large scale applications" and "Solar wall panels are capable of supplying heat to drying process as predicted in the feasibility studies". A long list of recommendations is phrased for setting up similar projects. The main barriers identified are similar to the ones formulated earlier: the lack of awareness, good technical information and good local practical experience.

UNEP/Wuppertal Institute Collaborating SCP Centre - WISIONS

109. The UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production (CSCP) provides scientific support to activities undertaken by UNEP and other organizations in the field of SCP. This support includes the development, testing, implementation and monitoring of concrete projects, especially in developing countries, which enables these countries to leapfrog to sustainable consumption and production patterns using life cycle thinking and resource efficiency as guiding principles.

110. WISIONS is an initiative of the Wuppertal Institute for Climate, Environment and Energy to foster practical sustainable energy projects. It provides consulting support to ensure the potential seen in visions of renewable energy and energy efficiency can become mature projects through its Sustainable Energy Project Support. In addition it also promotes good practice in resource efficiency through its publication of relevant successful projects in its Promotion of Resource Efficiency Projects.

111. WISIONS has been involved in the 'Solar Food Processing and Conservation', co-coordinated by the International Solar Energy Society (ISES).[17] It intends to establish a global network of interested parties, that will aim to gather, further develop and promote efficient methods of solar food processing and conservation, inter alia 'drying crops'.

[17] See http://cms.ises.org/solarfood/index.xsp.

7. An introduction to possible partnerships

112. Part of the overall objective of this assignment is "… establishing first contacts for partnerships or other cooperation forms …" The ToR further specify: "Identification of 2-3 developing countries with a significant technology transfer potential for the identified cleaner food processing technologies …". The criteria for selection are in line with the three pillars of sustainable development.

113. It can also be observed that the ToR started from the assumption that there were only a few demonstration projects in the world with only a few partners. However, research within the context of this report showed that over time (for some crops since the '80ties), initiatives have been taken, most of them without persisting in the implementation. Therefore the consultants focused primarily on mapping existing initiatives and discussing with different units within the UNEP-DTIE (involved in former initiatives) a possible selection of stakeholders to see how – after this feasibility study – the development and transfer of solar drying technologies might be organized (based on these former experiences) with a view of up-scaling.

114. As highlighted before, the focus should be on food crops, in particular coffee. In Table 10, the major exporters of developing countries for coffee, tea and rice (in term of volume[18]) are listed in order of importance.

Table 10 – Main commodity exporters (coffee green, tea, rice) in terms of volume of the developing countries (FAO, 2004)

	Coffee, green	**Tea**	**Rice[19]**
Export countries	Brazil, Viet Nam, Colombia, Indonesia, Guatemala, Peru, Uganda, Côte d'Ivoir, India, Ethiopia.	Sri Lanka, Kenya, India, Viet Nam, Indonesia, Argentina, Malawi, Uganda, Tanzania, United Arab Emirates	Thailand, India, Viet Nam, Pakistan, China

115. Developing countries with a large share in export of one of the selected commodities, i.e. food crops, do have a significant potential for using the full potential of solar dryer technologies. Those with a high ranking in more than one list have an additional advantage. This leads to a first preliminary conclusion that Viet Nam, India, Indonesia, Sri Lanka, Brazil and Thailand maybe interesting countries to work with. Except for Indonesia and Thailand, the other four countries do have a National Cleaner Production Centre (NCPC) working with UNIDO and UNEP. As capacity-building is a major barrier, this might be an advantage

116. Another criterion which was put forward during the interaction at the UNEP-DTIE Ad-hoc Sustainable Innovation Expert Meeting relates to 'at least one country from Africa'. In Table 3, it can be observed that Uganda (coffee and tea) and Kenya (2nd large exporter of tea) do have a significant potential. Both do have an NCPCP as well. However, it should be noted that for now those two countries are not belonging to the targeting countries by A-REED.

117. Furthermore, it can be noted that countries like Indonesia, Ghana and Nicaragua – as have been described above – do have already pilot/demonstration projects with solar dryers in their countries. While in terms of volume of food crop export as described, they are not belonging to the top list, when in comes to share of the total agriculture versus total exported

[18] The rational to list the major export countries by volume is related to the fact that energy use en CO2 emissions are related to volume and not to value in USD.

[19] For 'rice, only the 5 most important developing countries in terms of export are listed. Other developing countries have a market share of less than 3 %.

merchandise, Nicaragua and Ghana are respectively on 3rd (with 85 %) and 16th (with 52 %) place of the top 20 countries depending on agriculture.

118. It is clear that is up to UNEP-DTIE to discuss the final selection, but based on the above observations, the following road map can be suggested. However, in Annex 2 of this report, a possible road map is outlined. This includes a regional approach (Africa, Asia and Latin-America), the selection of countries, the engagement of NCPC and other UN-initiatives and the stakeholders of the respective value chain (related to the selected countries). The opportunities for capacity-building and of setting-up financial mechanisms will be crucial.

8. Conclusions

119. It is clear that the economical, social and environmental impact of using appropriate drying technology for cash crops is high and often underestimated. Furthermore it can be observed that quite some projects have been started in different countries, but that they are rather limited in time, scale and region.

120. However the solution is out. This solution should be a country or regional driven sustained process with attention to the stakeholders and the local communities. In some case existing endogenous technologies can be the solution. South-South cooperation can also play a role. In terms of the application of the solar dryer technology for food crops, it might be implemented as a hybrid system (i.e. a pre-heating system).

121. In those cases where medium scale or large scale solutions are preferred and in order to make use of the full potential of this kind of technology, there is a need for scaling up the investments, making use of existing tools (for capacity-building), while updating information. Initiatives along the whole chain of innovation (research, development, demonstration, deployment and diffusion) are needed.

122. Partners already working in the field, institutions with the appropriate knowledge, organizations having a network already in place, etc. should be working together under one (regional/country) umbrella.

123. The effort should be focused on a single issue (‘reduction of carbon footprint in food processing’) for reasons of public attention, communication, etc. though without denying other sustainability problems in this phase of the value chain and with a spin-off of this kind of technology to other (agricultural) processes.

124. A road map for setting-up partnerships on solar dryer technologies in food processing is proposed. If it is the intention to use the full potential of these environmental sound technologies through deployment and the diffusion - now, up to and beyond 2012 – there is an urgent need to call for a kick-off meeting with stakeholders in Spring 2009.

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Annex 1 - List of the synthesized objectives for development and transfer of environmental sound technologies under the UNFCCC

The synthesized objectives are derived from the technology transfer framework (see Document FCCC/SB/2008/INF.6).

For 'Technology needs and needs assessments':

- To undertake technology needs assessments (TNAs);
- To provide resources;
- To build capacity;
- To update and to disseminate the TNA handbook;
- To make available information on the TNAs;
- To implement the results of technology needs (identified in TNAs);
- To share lessons learned, success stories, good practices;
- To consider the synthesis report;
- To organize a meeting to identify TNA methodologies;
- To ensure that the Expert Group on Technology Transfer cooperates with the CGE.

For 'Technology information':

- To establish a technology transfer information clearing house (TT:CLEAR);
- To maintain, update and further develop TT:CLEAR;
- To network with technology information centers;
- To increase the number of users (of TT:CLEAR);
- To built capacity;
- To make available information through national communications.

For 'Enabling environments':

- To enhance legal systems (including those related to trade and intellectual property rights;
- To promote joint research and development;
- To promote transfer of publicly owned technologies;
- To strengthen regulatory frameworks;
- To utilize tax preferences;
- To integrate technology transfer into national policies;
- To create an environment conducive for investments;
- To explore preferential government procurement;
- To explore transparent and efficient approval procedures;
- To prepare technical studies for developing enhanced enabling environments;
- To cooperate closely with public and private partnerships.

For 'Capacity-building':

- To report on capacity-building needs and experiences for the development, deployment, diffusion and transfer of technologies of the developing country Parties;
- To implement/support capacity-building activities for the development and transfer of technologies (DTT) in developing country Parties;
- To establish/strengthen capacity for the DTT in institutions of developing country Parties;
- To increase/enhance/improve awareness/knowledge on environmentally sound technologies (ESTs) in developing country Parties;
- To provide training on ESTs in developing country Parties;
- To develop and implement standards and regulations for ESTs.

For 'Mechanisms': no synthesized objectives have been identified, but recently four different sub-themes have been formulated.

- Innovative options for financing the development and transfer of technologies
- Possible ways and means to enhance cooperation with relevant conventions and intergovernmental processes
- Promotion of endogenous development of technology through provision of financial resources and joint research and development (R&D)
- Promotion of collaborative R&D on technologies

Annex 2 – Using the full potential of EST's: road map for setting-up partnerships on solar dryer technologies in food processing

A proposal

A programme, under the name SOL-DRY-TECH (SOLar DRYer TECHnologies), is established. The aim is to launch as soon as possible a comprehensive process to enable the full, effective and sustained implementation of solar dryer technologies in food processing through long-term cooperative action. The ultimate objective is the deployment and the diffusion of these environmental sound technologies now, up to and beyond 2012 in order to make use of its full potential.

During the first period – now and up to 2012 – the selected countries will be targeted. In the table below an overview is given, incl. the important food crops exported and centres, organizations, initiatives … working in that domain.

Continent	***Country***	***Food crop***[20]	***NCPC***	***UNEP or other IGO***	***International organization***	***Financial initiative***
Africa	Ghana			UNEP Risoe Centre		GEEREF
	Kenya	T	*	A-REED		GEEREF
	Uganda	C	*	A-REED		GEEREF
Asia	India	C, T, R	*			
	Indonesia	C, T				
	Sri Lanka	T	*			
	Thailand	R				
	Viet Nam	C, T, R	*			
Latin-America	Brazil	C	*	B-REED		
	Nicaragua				Meso-American Institute	

WISIONS is invited to take the lead as a programme manager, on behalf of UNEP-DTIE, following the road map as outlined below. Note that each phase should be well-prepared.

Phase 0 – Kick-off Meeting (Spring 2009)

The following stakeholders are invited for a kick-off meeting, chaired by Mrs. Sylvie LEMMET, Director, and supported by the Chief Research Executive and the Business Manager of the Wuppertal Institute and WISIONS:

- UNEP-DTIE:
  - SCP Branche, incl. Programme Officer in charge of the NCPC's
  - Energy Branche, incl. UNEP Risoe Centre, and in particular REED
- IGO's: UNDP, UNIDO, …, UNESCO, UNITAR, FAO
- European Commission (DG ENV, DG Research, DG Development, EuroAID)
- Financial institutions: GEF, GEEREF
- International Coffee Organization

[20] C, T, R stand respectively for Coffee, Tea, Rice.

- International Tea Committee
- International Rice Research Institute
- World Fair Trade Organization, European Fair Trade Association
- The International Solar Energy Society
- International Chamber of Commerce, World Business Council for Sustainable Development
- …

The aim of the meeting is the preparation of regional meetings in Africa, Asia and Latin-America, targeting the most important stakeholders in the countries listed in the table below. At least the following agenda items are suggested:

- Presentation of the state of play on using solar dryer technologies for each of the food crops.
- Identification of important stakeholders at the (international and) regional level
- Preparation of a manual 'How to select the most adequate solar dryer technology?'
- Financial mechanisms for scaling-up the implementation of the solar dryer technology
- Capacity-building at the regional/national level (incl. the involvement of NCPC's and/or other national institutions.
- …

Phase 1 – Regional meetings (Fall 2009)

The aim of the regional meetings (preferable before UNFCCC COP 15 !) is to launch the process for scaling-up the implementation of solar dryer technologies. At least the following agenda items are suggested:

- Presentation of the state of play on using solar dryer technologies for each of the food crops.
- Identification of important stakeholders at the regional level
- Presentation of a draft manual 'How to select the most adequate solar dryer technology?'
- Regional financial mechanisms for scaling-up the implementation of the solar dryer technology
- Programme for capacity-building at the regional/national level (incl. the involvement of NCPC's and/or other national institutions.
- Identification of the particular needs: linking stages of development of the EST to each of the food crops.
- …

Phase 2 – Multiyear programme: up to 2012

The goal is using the full potential of dryer technologies in the indentified countries and for the selected food crops by the end of 2012. In addition, awareness-raising of the potential for other food crops (and in other sectors) in those countries.

Phase 3 – Beyond 2012: demonstration, deployment and diffusion in for other food crops, sectors and countries in the region

Beyond 2012, regional centres of expertise – a joined effort of involved stakeholders, building on existing and improved structures - should be able to share expertise and knowledge with other crops, sectors and countries in the respective regions.