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1. Executive Summary

The deliverable 7.3 reports an introduction on the Social Life Cycle Analysis (SLCA) as methodology for the estimation of a particular process/products on the society. It focuses on the differences between LCA and sLCA highlighting pro and cons of the methodology.

The report includes a goal and scope definition section, the analysis of the applied methodology and the description of the SLCA model developed, the results section and the conclusion section.

2. Introduction

WASTE2FUELS is a high impact project for the circular economy as it is hinged on using the suitable fractions of food waste for fuel production. The impact of this concept is by performing research work towards making this common-sense vision commercially viable in practice, and analysing the successful potential exploitation pathways. Indeed, the success of biorefineries will depend on their adaptation to international markets as well as the bulk chemical and fuel production being strongly driven by supply demand issues and "economies of scale". To be able to give a more comprehensive assessment of the sustainability of products, an expansion of the LCA framework to also include these product impacts on people, known as social impacts, has been going on for the last 10 years. The Social Life Cycle Assessment is needed in order to get a full coverage of the three pillars on which the concept of sustainable development rests upon. A social LCA could attempt to address the social issues such as, human rights, health and safety, working conditions, socio-economic repercussions, cultural heritage, equal opportunities, participation and influence, security, and corruption[1], that may be affected along a product's life cycle. SLCA can still be characterised as a methodology, or in other words some procedural steps, which if followed leads to an assessment of the social impacts of a product over its life cycle. As the SLCA is considered, in principle, a kind of parallel methodology to the LCA, where the difference simply is that SLCA assesses social impacts rather than environmental impacts, the SLCA is considered to include more or less the same procedural steps as an LCA, including:

1) A goal definition, which addresses what is to be assessed and why the assessment is performed.
2) A scope definition, which addresses the choices made in order to perform the assessment and the limitations of the assessment.
3) An inventory analysis which has the purpose to collect the data outlined through the goal and scope definition
4) An impact assessment, where the inventory data is through models 'translated' into impacts.
5) An interpretation, where the outcome of the previous phases is analysed in accordance with the goal definition of the study

Up to this day, there exists no standard or internationally recognised code of practice for social assessment similar to, for example, the environmental LCA standards of ISO 14040 (2006) and ISO 14044 (2006). It could be seen as pieces of methodological suggestions with the overall goal of assessing social impacts related to product life cycles. As an important step towards a standardization of SLCA, the 'Guidelines to SLCA'[2] should be mentioned.

There are two very important differences between LCA and SLCA, which will affect significantly the usability of SLCA. The first difference relates the way in which we can get data about the process, for instance, environmental impacts depend by the nature of the process, while social impacts depend on the conduct of the company. A reasonably accurate LCA only needs to know the types of the processes involved in the life cycle and their environmental flows (often available in databases). A rough overview of the processes involved in a product can be gained simply by dismantling the product and weighing the components. However, if the same approach is used in SLCA, the accuracy of the assessment will be drastically lowered, simply because of the low causal relationship between process and social impacts. The other main difference between LCA and SLCA is the need for assessing both the impacts of producing/using/discarding and of not producing/using/discarding in SLCA when it is to be used for decision support. From an overall perspective, LCA can be used to make prospective assessments. For instance, an assessment of the environmental impacts that are expected from a particular product which is maybe not yet in production. This assessment can be possible and it is viable only because we assume the causal link between process and environmental impact. In other words, the future environmental impacts can be estimated because it is already now the processes that are going to be included in the product system that we intend to develop. However, if there is no or very weak link between process and impact, as is the case for social impacts, the prospective assessment could have only a very limited accuracy. Furthermore, the very weak link among impacts and processes will impede in case of sLCA the chance for reaching an assessment of a product family with a reasonable degree of accuracy.

3. Biofuels SLCA literature

In conjunction with the triple dimensions of sustainability (environmental, economic, and social), recent strengths are undergoing to broaden existing impact assessment studies to account more criteria relevant to the three Pillars of Sustainability—prosperity, people, and planet. This implies the importance of evaluating the social and economic impacts in addition to environmental impact studies[3,4]. Guidelines in performing a socio-economic life cycle assessment (S-LCA) as a supplement to environmental LCA within the context of sustainable development of the product/service have been published by the United Nations Environment Programme[5]. Despite the environmental impacts, many social impact indicators are not easily quantifiable. Thus, one way to develop the social impact criteria is well described by Benoit et al 2010. They suggest to conduct stakeholders' analysis at local, national, and global levels and, then, employing a scoring system to help facilitate the assessment interpretation, relating the information to performance reference points. However, efforts are underway to provide global database that eases the data collection burden in social life cycle assessment (SLCA) studies.

The first question to address what social impacts a product or service has throughout its entire life cycle. But then, how is a social impact defined. The practitioners of the methodology for social impact assessment (SIA), which is used to analyse any intended or unintended social impacts of a planned policy, program or project, have their definition on what a social impact is: “By ‘social impacts’ we mean the consequences to human populations...”

The Interorganizational Committee on Guidelines and Principles (ICGP) defines social impacts as “all social and cultural consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society.” (1994)

The UNEP/SETAC life cycle initiative attempts in their definition to add another dimension; that is, the role of the stakeholder, and they also relate the concept of social impacts to the product’s life cycle. They define of social impacts as follows: Consequences of social relations (interactions) weaved in the context of an activity (production, consumption or disposal) and/or engendered by it and/ or by preventive or reinforcing actions taken by stakeholders (ex. enforcing safety measures in a facility). Therefore, social impacts are dimensions of stakeholders relations affected positively or negatively by one of the stages in the life cycle of a product.

Well-being and health are generally agreed upon as social impacts, cited by many authors[6,7], but consensus has not yet been reached on other impact categories. Often, researchers do not have at their disposal the full chain of calculations needed for the assessment of the target social impact. Because of this limitation, they stop the calculation at a mid-point, such as the change in job opportunities, which could lead to further important social impacts[8–10], income, land occupation and so on. To acknowledge our inability to calculate the end-point, at this stage, of social impacts we will discuss, in the next paragraphs which could be the ‘social effect’ of the butanol production from agro-food wastes in Europe. Social impacts are important, because employing biomass for energy provides opportunities also for supporting welfare and employment. So far, most of the empirical research examining the bioenergy industry has only touched on the social aspects of energy production. Mbohwa and Myaka[11] found that the main critical hotspots for biodiesel in South Africa are social conditions of farm workers and the exploitation of immigrants. Manik et al[12] studied the social effects of palm oil in Indonesia and they found the most important aspect is the negative impact on the well-being of local/tribal communities. Macombe et al[10] analyzed the social implication of biodiesel on three different levels: company, region, and state.

4. Potential social effect of second-generation biobutanol: discussion

At this stage, we decided to follow the approach proposed by Macombe et al.[10] in order to qualitatively discuss the social concerns related to the installation of a second generation biorefinery in Europe. The examples of production processes are connected to an European country, but it must be stressed that these different production routes are hypothetical scenarios and not directly related to the actual situation in the country. The raw materials considered in the biobutanol production are Corn Stover and Agro-food wastes. Biobutanol production which uses Corn stover is taken as a reference scenario (scenario A) while the Butanol production from agro-food wastes options represent alternatives that could replace conventional biofuels production in the future. Here, we do not try to address the social performance of a certain production system (as it could be done for benchmarking purposes, for instance).

According to Figure 1a, the cultivation, processing, and production of corn stover residues are considered as a global process involving suppliers outside of European country. In addition, the infrastructure, auxiliary materials, electricity, heat, and diesel inputs are assumed to be global for the same reasons. After production of corn, the residues of corn production are treated with fertilizer and they are transported to Europe by ship. The biobutanol refining process is considered local, the biofuels factory being located near the sea. The phases of storage, distribution, and combustion are also assumed to be local, furthermore, the produced biobutanol is assumed to be consumed in local markets as transportation fuel. The phases of storage, distribution, and combustion are identical for both butanol productions, regardless of the origin of the raw material. Therefore, these steps of the chain can be excluded from the analysis. A key difference in comparison to Fig. 1 is that the raw material's production is based local processes instead of imported raw material (as shown in figure 1b). At the company level, the company especially worries about the occupational health in own country, which may influence production chains. For example, the fertilisers used for the treatment of corn stover may be harmful and collecting agro-food wastes with modern machines may be less dangerous than shipping corn stover in precarious conditions among countries.

The company might want to increase its social performances with choosing suppliers that respect the human rights of their workers, that provide transparent document on environmental performance of the product and so on. The choice of certain suppliers over others may present an opportunity for the company to have positive social impacts. For instance, in the case of corn stover production, purchasing the row material in large quantities from certain developing countries could assist in their development and result in the improvement of their inhabitants' health, which would make it worthwhile to include these countries in the calculations. These aspects and in particular, the health of foreign populations is especially important in the cases of large multinational companies, whose size allow them to influence people's lives as the state does. For both current and second-generation biofuels, there are opportunities for new jobs along the entire chain, from biomass production or collection, to biomass transport, biomass handling, conversion and finally product distribution. For dedicated energy crops (including first-generation feedstocks), feedstock production involves an agricultural workforce for soil preparation, cultivation, harvesting, on-field transport, etc. In case of second-generation biofuels collection of residues after the harvest of the main product could extend seasonal occupation and improve job opportunities at least in manual harvesting systems. Downstream processes like biomass transport and biomass conversion may offer more jobs considering the increased biomass demand of scaled-up second-generation facilities, but would also require more qualified workers given the complexity of second-generation biofuel technologies. According to Figure 1a, all the processes related to the stover production, harvesting and transportation creates new job opportunities globally delocalized, while AFWs production are based on local processes. New job opportunities ideally cover both unskilled/cheap labour force and skilled engineers to manage plant operations. It is almost clear from Figure 1b that, on regional level the Butanol production from AFWs could create job opportunities in collection, transportation and other sectors within the delimited region.

In terms of income creation, adding value to residues could increase and diversify rural incomes, while providing added value to the local agri-food sector. Use of these residues for second-generation biofuels could be one option to create additional market opportunities in perspective of circular economy and to achieve this diversification. Depending on the type of residues there is an income increase in different parts of the chain. In particular, farmers can profit from selling primary residues, while plant operators profit from increasing demand for processing residues. In the long term, additional income means more flow money into the region, therefore more indirect and induced jobs would be created, investment in other areas such as welfare and infrastructure would be reinforced and the region could witness economic growth[13]. On the other hand, it should be considered, that increasing opportunity costs for agri-food residues could lead to relative income losses for traditional buyers of these residues.

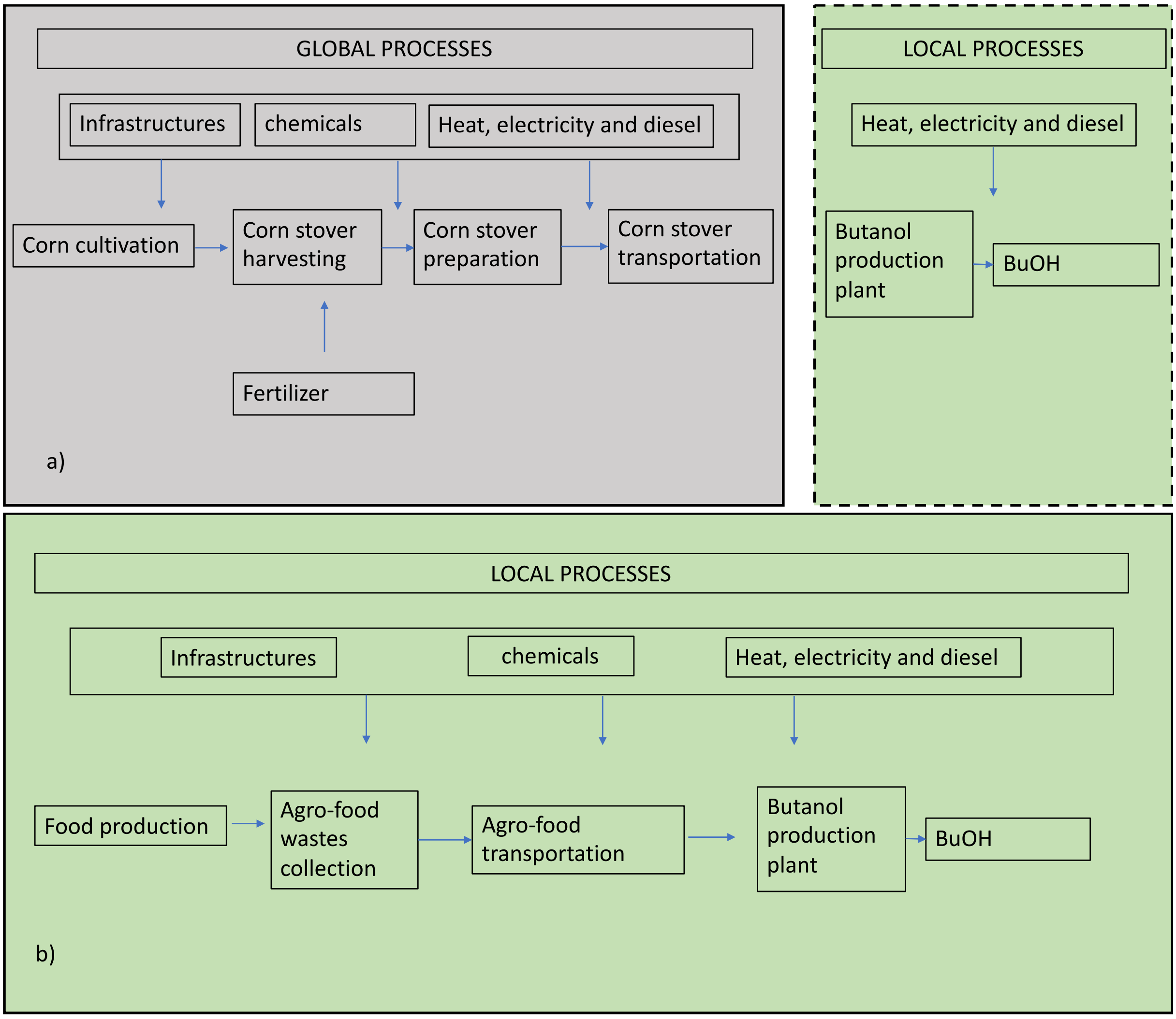

Figure 1 – Scheme of the System Boundary.

Typically, a second-generation biofuels production factory for a large commercial plant needs around 350000-600000 ton/year of lignocellulosic biomass[14], due to lower yields per hectare and the lower density of the feedstock compared to first generation biofuels larger areas would be required and would make supply logistics more challenging.

One of the most controversial subjects in generation of biofuels is the land occupation. Potential development of the biofuel sector could lead to increased demand for land and competition among actors, such as food or crop competition. This applies to both first- and second-generation biofuels that are based on crop feedstock that requires land for cultivation. If second-generation biofuels use agricultural residues as feedstock, land-competition is less of an issue. It is therefore important to include which could be the social consequences this. First of all, in case of firs generation of biofuels it is necessary to investigate whether there is enough arable land available for food and feedstock production, and whether that land could be used sustainably in terms of soil conservation and water consumption. Expansion of current biofuel production could have a critic effect especially in countries where food security is precarious since it is believed that biofuel production aggravates competition about limited land resources[15]. One more aspect that need to be counted is that large-scale production of current generation feedstock is often criticised for depriving small farmers of their properties. This is basically true also if dedicated energy crops are grown for second-generation biofuel production. The effect of large-scale feedstock plantations could be that workers have to work under worse conditions than on farms due to unsecured labour rights and the need to produce low-cost feedstock.

Second-generation biofuels produced from agri-food residues do not require cultivation of additional land. Thus, feedstock production for second generation biofuels may reduce competition on the level of land. However, the utilisation of residues may compete with traditional uses of the biomass (animal feed, fertilizer, etc.). This should carefully be considered, since their competition may imply changes in agricultural production, markets and uses, and even lead to additional land demand to produce animal feed or fertilizer.

The issue of food security represents another point of criticism associated to the production of biofuels and it should be examined for each country individually. Generally, in countries where food supply is not secured, competition between food crops and crops for biofuel production on arable land can further weaken food security causing serious social impacts. Considering that cultivation of energy crops for second-generation biofuels could be more profitable, farmers may opt for growing a biofuel feedstock instead of growing food for the national market. On the other hand, if agri-food residues would be used as feedstock for second-generation biofuel, this could increase the profitability of the crop cultivation and create a further income for the farmer. Moreover, residues from food sector do not compete with food crops and would also help to lower the amount of wastes that, to date, almost 80% goes to incineration or landfill. In a social perspective it is widely accepted that integration of local farmers into the overall scheme with contractual agreements, securing farmers from the potential failure of biofuel projects and allowing them to stop living under uncertain land-tenure condition, would be beneficial for all parties involved[16]. This integration should aim make them not only part of biomass production, but also allow farmers and their families to enjoy benefits from the entire value chain (e.g. jobs in the downstream industry, free use of the product, exploitation of by-products), increasing the interest and willingness to engage in second-generation biofuel projects.

For second generation plants, economies of scale and economic viability of facilities require scaled up plant sizes and large annual biomass demands (up to 600 000 t/yr). This make more challenging the integration of small producers and smallholders, since individual production outputs cannot cover the large feedstock demand of a biofuels production plant. This point can be faced by creating larger cooperatives among smallholders and, from a logistic point of view, for example, by establishing several collections points and gathering the feedstock in the plant area. However, this would imply a great investment for reliable transport and infrastructure network.

The potential effects of biofuel production on women will depend upon the social status and the rights of women in a specific country and in the agricultural context, and not upon a specific biofuel pathway. Since women are more vulnerable as a result of systematic discrimination, gender-specific impacts can also be observed in the biofuel industry but will not necessarily differ between first- and second-generation biofuel production[17].

5. Theoretical discussion

Few information about public acceptance in terms of public knowledge and public awareness of biofuels in European countries can be found in the literature. According to Balogh et al.[18] conducted and analysed several surveys about Hungarian consumers' knowledge concerning biofuels. The authors reported a lack of knowledge of consumers on the field. The study was conducted over 386 respondents and the majority of the respondents, around 206 people, support biofuels. The report concluded that consumers look positively biofuels introduction, however, it is recommended to further increase the available information and knowledge about the topic.

Assefa and Frostell[19] discusses the importance of assessing social indicators when implementing new technical/technological systems. Social indicators refer different factors of public acceptance and give a critical summary of existing social research on the acceptance of renewable energy technologies, such as biotechnology. Electra et al.[20] shows that in Greece, a very few people prefer to use biofuels in their transportation compared with other renewable energy sources, mainly because of significant lack of information about biofuels. The study of Giraldo et al.[21] shows that the diesel car owners' willingness to pay for biodiesel, but the biggest disagreement between the car owners' regarding advantages and disadvantages of biodiesel was about its direct effect on food prices. Issues such as change of land use and food versus fuel have emerged as a strong barrier for biofuel development[22]. Moula et al.[23] analysed the public's awareness and knowledge about biofuels in Finland on about 90 respondents of different ages and social classes. It can be said that all the respondents had environmental awareness and were willing to choose renewable fuels for their vehicles in the future. However, the consumption of biofuels was rather low mainly because of a significant percentage (60%) of the respondents were lacking information about them and would require further knowledge to move towards utilization of biofuels. 50% study respondents would not buy biofuels based on food-crops, as it would result in increased food prices. 60% respondents would like see governments leading steps in promoting and supporting people in shifting from fuels to biofuels direction. On the other hand, the study also shows that on average the respondents were willing to pay more for biofuels as compared to conventional fuels.

6. Proposed questionnaire to be submitted

It is clear from the previous paragraphs that biofuels con offer a valid solution to the increasing environmental pollution, but at the same time it is unclear the real role of biofuels, and in particular bio-butanol, from a social prospective. For this reason, we truly believe that it is necessary to understand more about what European societies knows about bio-butanol production from agro-food wastes and to make them part of the project. We propose a survey questionnaire that may be used in future work on bio-butanol production. It was designed in a way that the answers are only dependent on personal viewpoint and experience, in other words there are no correct or incorrect answers. The goal of the survey is to assess the public's opinion and knowledge about the use of biofuels, and in particular bio-butanol, in transportation. It was also intended to identify the driving factor to a possible shift towards bio-butanol. The questionnaire schedule for the survey participants has been prepared to include four parts, which covered various issues that can be seen from the previous sections. The purpose of part one was to gather background information about the interviewee such as, age, educational level and gender. This was to make sure to collect information from a variety of people. Part two, social perspective, was attempted to measure the respondents' knowledge about the European Union's targets regarding biofuels, and to survey what would motivate them to choose biofuels. Part three, com- munity perspective, was intended to study the respondents' opinion about the importance of environmental issues. Finally, part four, the market perspective, was designed to investigate each respondent's fuel consumption pattern; and their current and future vehicle choice with regards to its type of fuel consumption. Other important question was whether they think there is a connection between the production of biofuels and increasing food prices

Background respondent information

Gender

a) Female
b) Male
c) x

Age

a) below 18
b) 19-28
c) 29-39
d) 40-50
e) 51-60
f) Above 61

Educational level

a) Elementary school
b) High school
c) Bachelor degree
d) Master degree
e) Doctorate

Where do you live (nation)?

Community perspective

Do you care about environmental issues?

a) Yes
b) No

Do you know what is a biofuel?
c) Yes
d) No

Do you know the difference between biofuel and fossil fuels?
a) Yes
b) No

Do you know about environmental issues related to biofuel?
a) Yes
b) No

If yes what are the most relevant issues related to them? (up 3 answers)
a) Air pollution
b) Global warming
c) Waste generation
d) Acidification
e) Water pollution
f) Deforestation
g) Food security
h) Land use change
i) Loss of biodiversity

Do you know the difference between first generation and advanced biofuels?
a) Yes
b) No

Should food-crop be used for biofuels generation?
a) Yes
b) No

Would you buy biofuel produced from food-crop?
a) Yes
b) No

Are you willing to pay more for biofuels?
a) Yes
b) No

If yes, how much more would you pay?
a) Max 5% more
b) Max 10% more
c) Max 20% more
d) Other

Do you know butanol as biofuel?
a) Yes
b) No

If No, are you interested to know more regarding it?
a) Yes
b) No

Social perspective

Do you know about European directive related to transport fuel, up to 20% of fuels from renewable sources?
e) Yes
f) No

Do you believe that biofuel can play a role to reach the EU target?

g) Yes
h) No

Do you believe that EU should treat biofuel from food-crop and from no food crop (wastes) differently?

c) Yes
d) No

If yes, how?

a) Increasing tax biofuels from food crop
b) Forbid biofuels from food crop
c) Supporting and incentivize biofuels from wastes
d) Other (write your idea)

Would you change to use biofuels?

a) Yes
b) no

If not, what would motivate you to change?

a) Price
b) Availability
c) Reliability
d) performance

7. Conclusions

In conclusion, the findings suggest that the SLCA is still an early stage methodology that need further research to become standardized as for LCA. However, the analysis has pointed some social effects related to the biobutanol production from agro-food wastes. In particular, new job opportunities on regional level, new income creating additional market and additional valuable chains. On the other hand, the high amount of feedstock needed for a large production plant would make supply logistics more challenging. Furthermore, other aspects that need to be counted are land occupation and income losses for traditional buyers of these residues. The next step could aim to translate these social effects (blue rectangle) in impacts (red rectangle) as shown in Figure 2.

It must be also stressed that the valorisation of the residues perfectly fit with European directive (directive UE 2018/851) aimed to lower the number of residues to be sent in landfill or incineration and to create a new valuable and economic profitable chain. The key argument is that of employment and rural development, but additional supporting arguments include the prevention of soil erosion, the possibility of intercropping, the provision of animal fodder, the use of parts of plants for building.

The aim of future studies is to have an overview of what the potential customers of biofuels think about its sustainability and what would motivate them to change their consumer behaviour in favor of biofuels. Those results can help to find a new door to measure energy policy related to the public acceptance of biofuels for transportation.

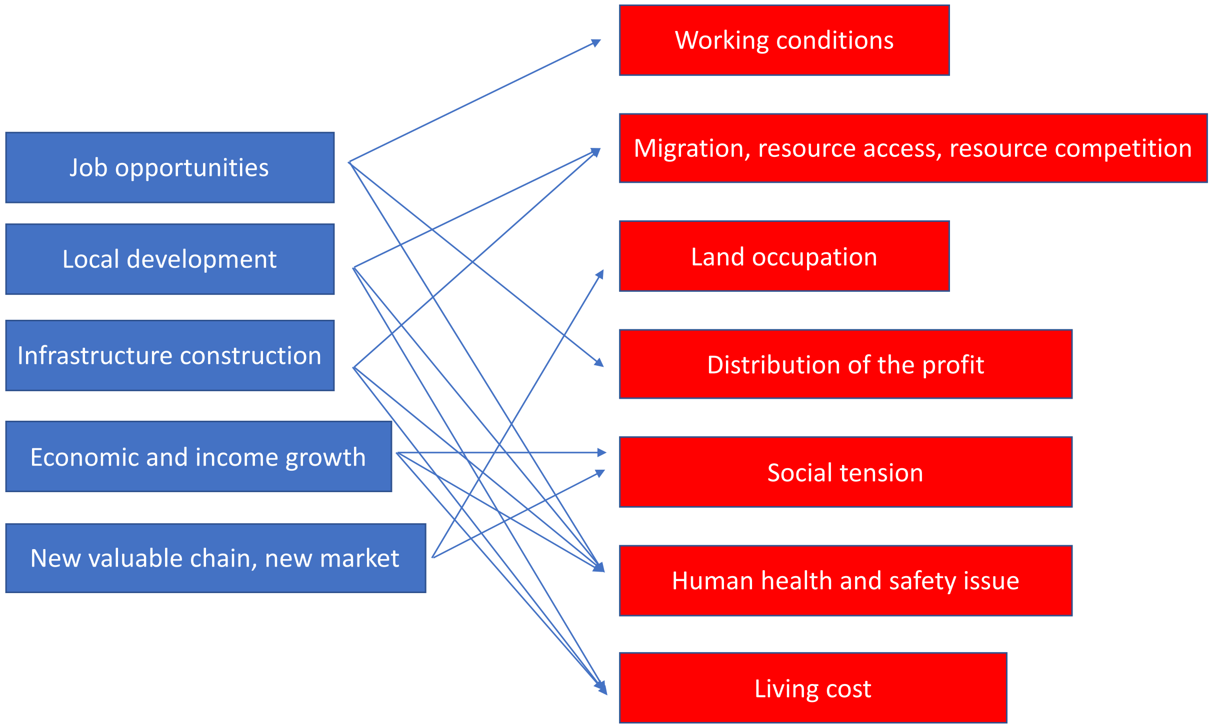

Figure 2 Conceptual representation of the relation between social effects and social impacts

Despite the remaining challenges in developing an SLCA approach, the survey questionnaire designed for the context-specific of biofuels in European countries is a starting point for answering the following questions: (i) what people from different countries, age and social class knows about biofuels; (ii) public's awareness and knowledge about biofuels; (iii) how to move forward to make the shift to biofuels happen. It would create an European map that will provide information on public acceptance and social issues related to biofuels in different countries and from different perspectives.

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