ACADÉMIE d'AGRICULTURE de FRANCE
AGRICULTURE ■ ALIMENTATION ■ ENVIRONNEMENT

ACADÉMIE POUR UN PROGRÈS RAISONNÉ CHOISI PARTAGÉ DES TECHNOLOGIES

Special interacademic group

« covid-19 crisis »

Subgroup n°4

« Using the sustainable development goals to restart while ensuring sustainability and resiliency »

Notes written by the group members

May 2021

Notes I-1 and I-2 of this booklet were approved by the Working group and were then endorsed by the National Academy of Technologies of France and the French Academy of Agriculture in a statement entitled « Les Objectifs de développement durable, un référentiel pour l'analyse des politiques publiques ».

The other notes in this booklet were discussed by the Working group but reflect the opinion of their respective authors only.

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Preamble

In the context of the Covid-19 pandemic, the National Academy of Technologies of France has been steering since April 2020 an inter-academic Working Group dedicated to "Using the SDGs to restart while ensuring sustainability and resiliency ». This group involves participants from the Academy of Technologies, the Academy of Agriculture and the Academy of Sciences, since April 2020.

The health crisis has highlighted deep weaknesses. The cascading social, economic, financial, food-related and educational effects, and the concomitant economic and geopolitical crises jeopardise the achievement of major goals in France and around the world, particularly the Sustainable Development Goals and the strengthening of resilience expected from the Sendai Framework for Disaster Risk Reduction.

In the context of growing emerging risks concerning sustainable development issues, due to climate change, pressures on ecosystems that threatens biodiversity, and their interactions with inequalities and with changes in international relations, crisis management and a strategic vision for building a way out of the crisis require in-depth reflection. This is to ensure that this recovery is done in a sustainable and resilient manner, reducing future risks for the younger generations and contributing positively to major global goals.

As France and its allies for multilateralism stated on 20 April 2020, in our efforts to "heal faster", our common roadmap remains Agenda 2030 and its 17 sustainable development goals, as well as the Paris Agreement. The Sustainable Development Goals (SDG) provide an overall perspective and a framework for analysing the contributions, co-benefits or risks of adverse effects associated with each policy option.

Our Working Group has analysed the actual or potential impacts of the current crises on the actions taken towards the SDGs and the associated global and French goals. Its work on the systemic and balanced nature of SDGs has led it to recommend the use of SDGs as a systemic reference frame to guide choices in terms of public action for the reconstruction of the country, in particular concerning the investments of the recovery plans. The group also analysed the methodologies for evaluating the impacts of public actions on SDG targets. All these elements have been transmitted to the Minister in charge of ensuring the integration of Sustainable Development Goals in the development and implementation of all policies conducted by the Government. They were made public by the Academy of Technologies in a notice dedicated to the SDGs on 3 December 2020. They were included in the statement by the three Academies entitled « Les Objectifs de développement durable, un référentiel pour l'analyse des politiques publiques ».

The members of the Working Group have also decided to reflect on specific SDG targets and on topics related to a systemic approach. The Working Group has chosen to specifically address issues related to sustainable consumption and production, air quality, land-use planning, the food system and decision-making in the face of uncertainty, in order to complement other analyses such as those of the French High Council for Climate, which focuses on greenhouse gas emissions.

These thematic reflections have led to the thematic notes gathered in this booklet. They reflect the complexity of the issues at stake and the relevance of combining different perspectives. This is particularly true for the evolution of the food system, which is at the crossroads of challenges pertaining to public health prevention and food and nutrition security, and which must be transformed for environmental reasons.

The authors of these thematic notes have submitted them for discussion within the group, but the group decided to present them as they stand, despite their possible differences, in order to highlight the relevance of the SDG analysis grid in seeking a balance between human well-being, social and economic prosperity, and the preservation of the environment.

This booklet makes the group's work public and is an intermediary step in an ongoing reflection process.

It was set up and formatted by Boris Bourdoncle, secretary to this group co-managed by Valérie Masson-Delmotte and Gérard Payen.

General

Notes

Impacts of the Covid-19 pandemic, crisis management and cascading effects on the achievement of the SDGs; benefits of efforts to achieve the SDGs for risk management in such a pandemic

Valérie Masson-Delmotte (National Academy of Technologies of France)

Abstract. *The Sustainable Development Goals are interconnected and the achievement of these goals aims to build a better and more sustainable future for all, leaving no one behind, while addressing global challenges, including those related to poverty, inequality, climate change, prosperity, peace and justice, and building resilience to risks. This note aims to analyse the health and cascading effects of the COVID-19 pandemic and crisis management (containment) from the standpoint of the SDG indicators.*

The Sustainable Development Goals are interconnected and the achievement of these goals aims to build a better and more sustainable future for all, leaving no one behind, while addressing global challenges, including those related to poverty, inequality, climate change, prosperity, peace and justice1 and building resilience to risks.

This note aims to analyse the health and cascading effects of the COVID-19 pandemic and crisis management (containment) through the lens of SDG indicators.

1. International context

At the global level, the 17 SDGs and their 169 targets are associated with 232 indicators. The main indicators from the international dashboard are used below to operationalise the targets.

The SDSN 2020 report provides indicators and monitoring tables for each country and analyses the implementation of the SDGs in the form of 6 major transformations, and has conducted a specific analysis related to the COVID-19 pandemic[1]. It highlights that:

- COVID-19 will have major negative effects on the achievement of most of the SDGs worldwide, especially for the poorest countries and for the most vulnerable populations, with major uncertainty about the long-term consequences of the pandemic.
- All countries, even those in high-income countries that were previously perceived to be best prepared, need to strengthen the resilience of their health and prevention systems (SDG3), and remain vulnerable to further resurgence.

[1] https://sdgindex.org/reports/sustainable-development-report-2020/

- The COVID-19 pandemic alarmingly amplifies many inequalities and it is important to place the SDGs at the heart of decision-making for recovery plans.

- Asian countries have made the most progress towards the SDGs since the goals were adopted in 2015 and have also responded most effectively to the emergence of COVID-19.

- Solidarity and partnerships are critical to addressing and preventing health, economic and humanitarian crises. International cooperation can accelerate the identification of solutions and the sharing of best practices, and help prevent future shocks. Ongoing crises reinforce the need for support to the most vulnerable countries.

- Real-time information is crucial in crisis situations, especially for early warning systems. This is also the case for many of the SDG indicators, where rapid access to information is essential for effective governance, saving lives and ecosystems. Given the timeframe for data analysis, it is not possible in June 2020 to assess the full impact of the COVID-19 pandemic on the SDGs. Major efforts are needed to improve data accessibility and reduce delays in sharing official statistics, making better use of data from other sources, such as from the scientific community and the private sector.

2. French context

The same difficulty in accessing real time data exists for the specific French context.

The analysis in this note focuses on the main indicators of the French SDG dashboard[2] by identifying, on the basis of information available through the media, points of attention jeopardizing the achievement of the goals (temporary or long-term effects); potentially positive temporary effects for a given indicator; and the importance of making progress on specific indicators to reduce vulnerabilities in order to guard against another such pandemic. In the tables below, the effects of the epidemic on the SDGs that require attention are shown in red in the Impacts column and the positive effects are shown in green in the same column. The reductions in vulnerabilities that can be expected from achieving the SDG targets are shown in green in the second column. Items requiring further research are shown in black italics.

[2] https://insee.fr/fr/statistiques/2654942?sommaire=2654964

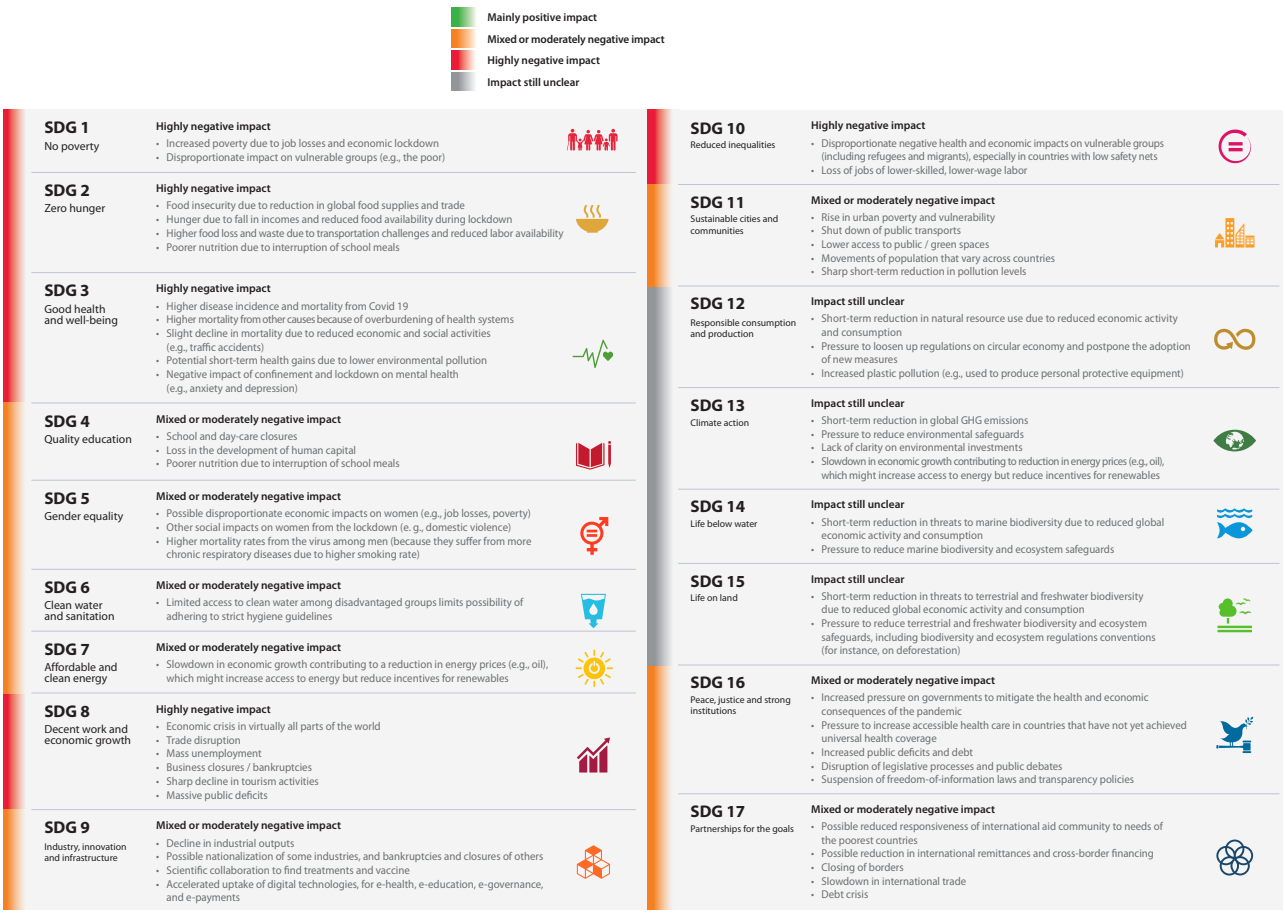

Figure I.1.1. Short-term impacts of the Covid-19 pandemic on the SDGs worldwide (SDSN 2020 Report)

SDG and French indicators	Impact of the Covid-19 epidemic on achieving the SDG	Benefits of achieving the SDG for reducing vulnerabilities to Covid-19-like epidemics
1. Poverty 1.i1 Monetary poverty rate 1.i2 Poverty rate based on living standards	Very worrying (employment, income of the most precarious populations, access to drinking water and other public services)	Yes (ability to implement protective measures, reduce vulnerabilities)

2. Hunger 2.i1 Proportion of households that cannot afford to eat protein at least every other day* 2.i2 Prevalence of overweight and obesity 2.i3 Average arable crop diversity 2.i4 Proportion of agricultural area for organic agriculture and high environmental value (HVE) farms 2.i5 Animal level exposure to antimicrobials 2.i6 Consomption of plant protection products 2.i7 Proportion of local breeds at risk of extinction **As it stands this indicator is very imperfect with regards to nutritional security and does not take into account the many potential sources of protein.*	Very worrying (income, employment and poverty, lack of access to school and university cafeterias) *Analysis of the effects of lockdown on food and nutrition practices and health to be conducted.*	Yes (ability to maintain food and nutrition security in crisis situations) Obesity as a major comorbidity factor
3. Health 3.i1 Healthy life expectancy 3.i2 Number of new HIV cases 3.i3 Suicides 3.i4 Life satisfaction 3.i5 At-risk alcohol consumption 3.i6 Fatalities per road accident 3.i7 Rate of forgone healthcare for financial reasons 3.i8 Daily tobacco use	Very worrying (direct health impacts and delays in access to care, lack of physical activity, screen time) Temporary reduction in car accidents	Yes (better access to care and better health status reduce vulnerabilities to health crises) Vigilance on vaccine mistrust Importance of R&D on "one health" and R&D for sustainability
4. Education 4.i1 Proficiency in reading and mathematics for young people in grade "CM1" and at age 15 4.i2 Participation of youth and adults in education and training in the previous 12 months 4.i3 Digital skills 4.i4 Early school leavers	Very worrying (increasing inequalities, digital divide, school drop-out, major impacts on apprenticeship, internships, work-linked training and certain vocational courses)	Yes (importance of a better skills base to better understand health crisis situations, their causes, behaviours to adopt; ability to bounce back in one's career path even in a crisis situation) Major benefit to strengthening digital skills for continued access to education

5. Gender equality 5.i1 Gender pay gap 5.i2 Proportion of women in scientific discipline at university 5.i3 Victims of domestic physical and/or sexual violence 5.i4 Victims of non-domestic physical and/or sexual violences 5.i5 Proportion of women in managerial positions	Very worrying (childcare during lockdown, domestic violence, access to family planning during lockdown)	
6. Water 6.i1 Proportion of the population served by non-compliant water 6.i2 Proportion of water bodies ambient water quality 6.i3 Compliance rate of sanitation systems 6.i4 Efficiency of drinking water networks	Difficulties in accessing drinking water and sanitation due to lockdown Efforts to ensure permanent access to water for vulnerable populations Major difficulties for sanitary measures in case of lack of access to water at home (need to move around despite lockdown, difficulties in washing hands, access to drinking water and showers for the homeless) *Unassessed risk related to the presence of viruses in wastewater for sanitation professionals, stop of the spreading of unhygienised sewage sludge in agriculture*	Yes (importance of access to safe water for protective measures and importance of sanitation and of monitoring the prevalence of an epidemic through wastewater testing)
7. Clean and affordable energy 7.i1 Proportion of people affected by energy poverty 7.i2 Share of renewable energy in final energy consumption 7.i3 Primary energy consumption by type of raw material 7.i4 Energy intensity measured in terms of primary energy and GDP	Risk of increasing fuel poverty in relation to employment and poverty Temporary reduction in greenhouse gas emissions	Yes (importance of living conditions in housing for health and in lockdown situations; importance of improving air quality; resilience of energy systems in crisis situations)

8. Decent work and economic growth 8.i1 Annual growth rate of real GDP per capita 8.i2 Employment rate 8.i3 Underemployment rate 8.i4 Proportion of youth not in education, employment or training 8.i5 Work-related accident 8.i6 Proportion of adults holding an account in a bank or making use of mobile monetary services 8.i7 Share of subsidised jobs in youth employment	Very worrying (in particular for youth employment)	Yes (improving working conditions is important to prevent the emergence of clusters; access to employment for young people allows them to become independent and avoid overcrowding in housing)
9. Resilient infrastructures and innovation 9.i1 Public passenger transport (excluding air) and freight transport 9.i2 Acceptance rate for credit applications from very small businesses (VSEs) 9.i3 CO_2 emissions per unit of added value 9.i4 Research staff 9.i5 Research effort 9.i6 Government budget allocations for R&D per socio-economic objective	Worrying (R&D capacity of companies) Very worrying (VSE) *Analysis of the effects of lockdown on travel practices and public transport to be conducted*	Yes (ability to quickly redirect R&D efforts to provide solutions to new crisis situations; resilience of infrastructure; ability of public transport to ensure health security; importance of active mobility infrastructure) Importance of R&D on "one health" and R&D for sustainability
10. Reducing inequalities 10.i1 Growth rate of available income 10.i2 Income inequalities 10.i3 Wealth inequalities (Gini index) 10.i4 Broadband internet at home 10.i5 People who have logged onto the internet in the last three months	Very worrying (increased inequalities during lockdown)	Yes (benefits for SDGs 1, 2, 3; importance of bridging the digital divide for access to education and telemedicine)

11. Sustainable cities and settlements 11.i1 Housing overcrowding rate 11.i2 Artificialisation of land 11.i3 Waste collected by municipalities 11.i4 Annual mean level of fine particulate (PM 10) in cities	**Contrasting effects** Warning concerning the evolution of choices in terms of living space following the lockdown that can increase the pressure on artificialisation (displacement from the city centre to the suburbs facilitated by teleworking) Temporary improvement in several aspects of air quality (due to reduced transport) during lockdown (on other indicators) *Uncertainties about airborne contamination from ventilation/ air conditioning systems*	Yes (better air quality improves respiratory health; reduced overcrowding allows better implementation of protective measures)
12. Responsible consumption and production 12.i1 National material consumption 12.i2 Material footprint 12.i3 Food losses and waste along the food chain 12.i4 Hazardous waste 12.i5 Annual tonnage of waste recycled/recovered 12.i6 Jobs in the circular economy 12.i7 Industrial and territorial ecology projects	**Contrasting effects** *Need for analyses of the effects of lockdown and post-lockwdown on consumption and production and losses and waste.* Large increase in waste related to the use of single-use protective equipment Development of local food network	Yes (reduction of vulnerabilities in crisis situations through strengthening of circular economy; reduction of zoonosis enabling factors)
13. Climate 13.i1 Number of very serious natural events 13.i2 Municipalities with an approved natural risk prevention plan 13.i3 Carbon footprint 13.i4 GHG emissions 13.i5 Compensation paid out for natural disasters	No direct link Temporary reduction in greenhouse gas emissions mais very high risk of rebound effect	Yes (potential for reducing cross risks e.g. from extreme events through ambitious adaptation and mitigation action)

14. Aquatic life 14.i1 Ecological status of coastal water bodies 14.i2 Percentage of Northern Fulmars found dead with plastic in their stomachs in the Channel 14.i3 Annual assessment of the main nutrient flows from watersheds 14.i4 Number of 'Polrep' reports 14.i5 Coral reefs status 14.i6 Progress made with an ecosystem approach 14.i7 Marine protected areas	*Need for analysis of temporary effects of reduced maritime traffic*	
15. Terrestrial life 15.i1 Afforestation rate 15.i2 Conservation status of natural habitats 15.i3 Proportion of Metropolitan France covered by ecosystems with little human impact 15.i4 Sites with polluted soils 15.i5 Protected terrestrial areas 15.i6 Trends for specialist common bird populations 15.i7 Trend in the number of invasive alien species in France	*Need for analysis of temporary effects of lockdown*	Yes (reducing pressures on natural ecosystems should reduce the risk of zoonosis emergence)
16. Peace, justice and effective institutions 16.i1 Homicides 16.i2 Victims of physical and/or sexual violences 16.i3 Unsentenced detainees as a proportion of overall prison population 16.i4 Public trust in institutions	Worrying (domestic violence, distrust in institutions, delays in the functioning of the judicial system due to lockdown) *Functioning of scientific bodies and science-society relationship to be analysed in depth (scientific deontology)*	Yes (importance of early warning systems, preparation for crisis management, participation of everyone in risk management)
17. Partnerships 17.i1 Official development assistance 17.i2 Bilateral official development assistance 17.i3 Public debt 17.i4 Private debt 17.i5 Financial soundness	Worrying (international cooperation, public and private debt) *Open questions on the implications of increased household savings (rebound effects)*	Yes (importance of international cooperation, importance of reducing vulnerabilities and zoonosis enabling factors)

A similar analysis of the French roadmap is presented below. Three points identified in this roadmap are particularly relevant but, to our knowledge, have not yet been implemented in a way that would have a visible impact:

- building levers for integrating the SDGs into state action;
- taking the SDGs into account in legislative and budgetary work;
- developing science for the SDGs;
- building educational pathways and systems, including teacher training.

French roadmap	**Impact of the Covid-19 epidemic on the French roadmap**	**Benefits of achieving the priority goal for reducing vulnerabilities to Covid-19-like epidemics**
Priority 1: Act for a fair transition, by fighting all types of discrimination and inequality and guaranteeing the same rights, opportunities and freedoms for everyone. **Priority 1.1** Leave no one behind **Priority 1.2** Fight discriminations, with a focus on gender discrimination **Priority 1.3** Better distribute wealth	Very worrying (increase in inequalities during lockdown and due to potential cascading social and economic consequences)	Yes The four ambitions of Priority 1 goes in the direction of SDGs 5 and 10 and targets 1.4, 1.6.1 and 11.1 of reducing inequalities Achieving the ambition of universal access to safe drinking water and sanitation services, particularly in the overseas territories, will make the French people more resilient to epidemics
Priority 2: transform society models by implementing low-carbon strategies and conserving natural resources, to act for the climate, planet and its biodiversity **Priority 2.1** Low-carbon strategies and climate change adaptation **Priority 2.2** Resource-efficient and sustainable production and consumption models **Priority 2.3** Recover biodiversity	Temporary effects due to lockdown, major impact of the choices made in recovery plans Worrying effects concerning the use of single-use protective equipment Warning on the evolution of housing choices (new pressure to urban sprawl in contradiction with the desire to limit artificialisation)	Yes By improving the quality of housing (poorly insulated dwellings), by reducing the conditions for the emergence of zoonoses (e.g. imported deforestation) and by strengthening the resilience of supply (more local circuits) Warning concerning the need to reconcile the ambition of zero net artificialisation of land with the constraints of public transport in dense areas and those of dense housing in periods of lockdown

Priority 3: Focus on lifelong education and training to change behaviour and lifestyles that are adapted to our future world and sustainable development challenges **Priority 3.1** Sustainable development education **Priority 3.2** Behaviour change **Priority 3.3** Educate and train so as to "leave no one behind"	Very worrying (digital divide, school dropouts, conditions for higher education success for 2020 high school graduates)	Yes, in particular the strengthening of digital skills (continuity of access to education and information, development of teleworking) and of the place of life and earth sciences (major issue of understanding and critical thinking) will promote sustainable behaviour
Priority 4: Act for the health and well-being of all, with a focus on healthful and sustainable food and agriculture **Priority 4.1** Access to facilitated and structured healthcare **Priority 4.2** Health-environment: safe, secure and sustainable agriculture and food	Very worrying This priority explicitly emphasises in its wording: "In the field of health, the environmental risk factor - epidemics and pollution - is growing, particularly with the increasing degradation of water, air, soil and biodiversity. The State and economic actors are aware of this interaction between health, environment and climate change."	Yes The 5 ambitions of priority 4 go in the direction of SDG 3. A better focus on SDG target 3.3 on transmissible disease control would help limit epidemics. Major issues to act on for nutritional health (healthy and environmentally friendly food; education; accessibility to low-income people), for access to water and sanitation and for improve air quality
Priority 5: Make citizen participation effective to achieve SDGs, and truly transform practices by increasing trial projects and local innovation **Priority 5.1** Promote local projects and innovations **Priority 5.2** Reduce the territorial divide **Priority 5.3** Get citizens involved in public action	Hard to evaluate However most French citizens participated in the fight against the epidemic through protective measures and, for many, through solidarity actions, thus contributing to SDG target 3.3 of fighting transmissible diseases	Yes (including citizen participation for taking into account the SDGs in the development of crisis management and recovery plans) The participation of citizens in the choice of actions and investments in the field of recovery can only favour their effective implementation
Priority 6: Work at a European and international level for the sustainable transformation of societies, peace and solidarity **Priority 6.1** Promote sustainable development **Priority 6.2** Overhaul development and international solidarity policy	Worrying (lack of cooperation at the beginning of the crisis) The crisis has led to international declarations by France in favour of the implementation of the SDGs	Yes (major solidarity issues to manage the risk of a pandemic)

3. Reflections on current indicators and their relevance for the vulnerabilities highlighted by the Covid-19 pandemic

The Covid-19 epidemic has shown that the current SDG indicators for France (the 98 national dashboard indicators and the 232 UN indicators) do not take into account the following points:

- monitoring of people in extreme poverty who are unable to implement pandemic barrier actions or social distancing (e.g. lack of a national indicator of lack of access to running water for homeless people, invisible in INSEE surveys);
- characterisation of health issues linked to the precariousness of certain working conditions (e.g. seasonal agricultural workers, slaughterhouses);
- lack of spacial disaggregation of indicators measuring vulnerability and exposure to different types of risk (health, climate, etc.);
- Relevant indicators for the cross-cutting issues of air quality and health (beyond the PM10 indicator alone);
- monitoring domestic violence (violence against minors);
- monitoring of physical activity and active mobility (important in terms of public health);
- indicators dedicated to nutritional and food security issues;
- indicators specific to factors contributing to the emergence of zoonoses in the world (e.g. imported deforestation).

Using the SDG framework as a guide for decision-making for public choices and policies
Methodological analysis

Gérard Payen (National Academy of Technologies of France)

Summary. *Using the 2030 Agenda and the Sustainable Development Goals (SDGs) as a reference framework for choosing action or investment options requires the use of a rigorous methodology to analyse the impacts of each action option "on the SDGs", i.e. on the 169 SDG targets.*

This note aims to identify the desirable characteristics of methods for assessing the impacts of an action, project or policy on the SDGs and to explore existing methodologies.

Desirable characteristics of the impact assessment method

The 2030 Agenda is a coherent whole, with all targets to be achieved simultaneously. In order to respect its systemic character, the methods for assessing the impacts on the SDGs should lead to an assessment on all the SDGs and not on a particular SDG or a selected set of SDGs.

An assessment of the impacts of an action, project or policy on the SDGs should ideally be able to highlight its main positive impacts as well as its possible undesirable effects on each of the targets of the different SDGs.

In practice, this means assessing the impacts on a large number of issues, as many of the 169 targets combine several different objectives. The method should therefore ideally be able to assess impacts on more than 250 subjects, bearing in mind that some are measurable and others are not. It should therefore combine quantitative criteria with qualitative assessments.

To avoid excessive complexity, simplified methodologies can be envisaged, provided that they do not oversimplify the richness of the subject. In particular, this simplification must:

- *not lead to "false positives", i.e. to qualify projects positively without reservation despite their obvious negative impacts on the objectives targeted by the SDGs. Such a situation could occur if these objectives are not properly integrated into the simplified representation of the SDGs used;*
- *not qualify a project neutrally or unfavourably because the simplifications of the method would render invisible the clear progress made by this project towards a part of a SDG target.*

These two conditions mean that reducing the analysis to the project's contribution to the 232 official UN indicators and the 98 national indicators for France would be an oversimplification. Indeed, the high number of targeted objectives that are not the subject of measurable and measured indicators and the large number of impacts that are known to be difficult to quantify would very likely create "false positives" and "false neutrals".

These conditions also make it necessary to be wary of any simplified method consisting solely of a list of closed questions. Assessors should be able to mention a positive or negative impact that the method used would not make visible.

Thus, the impact analysis method should:

- *combine quantitative assessments and qualitative evaluations on all the SDG targets,*
- *not be based solely on the SDG indicators, but be able to assess the impacts on the targets that do not have indicators or whose impacts on these indicators are not yet precisely known*
- *not be too simplified in order to limit the risks of 'false positives' and 'false neutrals'.*

1. <u>Levels of analysis and aggregation of results</u>

The 169 SDG targets are grouped into 17 categories called SDGs. The labels of the 17 SDGs are those of the themes, but they do not indicate anything specific. The objectives to be achieved are those of the "targets". The method of analysis used must therefore be able to take account of the impacts on the various targets.

This does not prevent the results of the analysis from being presented SDG by SDG by grouping the impacts on the different targets of each SDG. This aggregation should not, however, obscure the negative impacts on any particular target, as this is important for detecting the need for compensatory measures.

Aggregating the results for each individual SDG into a single overall assessment na only be considered if each SDG is given the same weight. This is what the SDG Index of the SDSN does. The 2030 Agenda is indeed a coherent whole where all targets are to be achieved simultaneously. It does not give more weight to one SDG than another.

2. <u>Review of existing methods</u>

Several global or European reports use exclusively statistical indicators. They are useful to shed light on the subject but insufficient to constitute in themselves impact assessments on the SDGs.

At this stage, the main global reports identified that aim to assess impacts on the entirety of the SDGs without relying on indicators are:

- *The Swiss CDE blog detailing the interactions between SDG targets, which is associated with the 2019 Global Sustainability Report (GSDR 2019),*
- *The IPCC +1.5°C report which qualitatively assesses the impacts of different mitigation measures on each of the 16 SDGs other than SDG13 with positive or negative scores on a scale of 1 to 3.*

In France, the Agence Française pour le Développement (AFD) analyses the impacts of its projects on Sustainable Development (SD), which differs from the impacts on the SDGs, in particular because the targets considered are much more imprecise. Its open-ended questions are however interesting.

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1. Subject

Most public policies contribute de facto directly or indirectly to at least one 'target' of the Sustainable Development Goals (SDGs). More and more public policies explicitly refer to the SDGs by indicating qualitatively and/or quantitatively their contributions to one or more sectoral SDG 'targets'. However, this is not enough to consider the 2030 Agenda as one of their reference frameworks, as this Agenda is systemic and this essential characteristic disappears when only a limited number of SDG targets are considered.

The purpose of this note is to explore and specify the methodological characteristics necessary for ex ante assessments of impact on the Sustainable Development Goals (SDGs) of proposed public policies or structuring investment options.

In other words, it is a question of specifying how to use all the SDGs and not only certain SDGs as a reference in the process of choosing public policies or investments.

This note does not deal with the full desirable content of organisations' SDG strategies, of which impact assessments are only one element.

2. Context

The Inter-Academic Group "Using the SDGs to restart while ensuring sustainability and resiliency" worked from April to July 2020 on the consequences of the Covid-19 epidemic and on the modalities for restarting the country with the following objectives:

- the qualification of certain action options by showing their potential, their limits, their co-benefits or, conversely, their collateral damage in the various dimensions of sustainability
- the choices to be made and the pitfalls to be avoided in restarting the economy and life in society in order to make progress towards the achievement of the SDGs and the associated objectives.

The work of this group has led it to consider that the Sustainable Development Goals [SDGs] provide a framework for analysing the contributions, co-benefits or risks of undesirable effects associated with each action option.

It recommends the SDGs and associated global goals as a benchmark for analysing policy options to recover from Covid-19 crisis.

Whether for each of these goals or for recommending the use of the SDGs as a benchmark, a rigorous methodology is needed. Such a methodology is not obvious, however, as the value of the SDGs lies in their systemic and holistic nature, which makes it impossible to be satisfied with progress towards a particular target without checking that the whole is making progress. Many targets are difficult to reconcile and accompanying measures are often needed.

This note explores the possibilities and pitfalls to be avoided in such a methodology for what amounts to an impact assessment.

3. Purposes of an analysis of the potential impacts of a public policy on the SDGs

“SDG impact assessments" are used to evaluate the relevance of an action option (a project, an investment, a policy, etc.) in relation to the 2030 Agenda and its 169 SDG targets. Before going into methodological detail, it is worth clarifying their scope, what they are intended to analyse and the types of conclusions that are expected.

3.1. Taking into account the systemic nature of the SDGs

It is clear that most public policies have a main policy area for which there is at least 1 SDG. Analysing and measuring the contributions of each policy option to that SDG is useful but not sufficient to constitute an "SDG impact assessment". Indeed, the systemic aspect of the SDGs makes it necessary to detect the main positive and/or negative impacts on the totality of the 2030 Agenda goals in order to get an overall view and, in particular, not to hide an undesirable impact on an SDG target that would be far from the natural scope of the action option.

There are many such targets, with the 169 SDGs ‘targets’, plus the more detailed associated Sendai, Aichi and Paris targets, and the key principles of the 2030 Agenda of 'leaving no one behind' and 'not working in silos'.

3.2. Positive contribution to expected progress

Most public policies make a fairly direct and obvious contribution to an SDG target, a Sendai or Paris goal or one of the main principles of the 2030 Agenda. This is often obvious. But progress does not mean success in reaching the target in 2030. Small steps can be far too small for that.

For example, at the current global pace, universal access to safe drinking water would only be achieved by the end of the 22nd century instead of 2030.

Thus, a merely positive contribution deserves to be differentiated from a significant contribution, and the latter from a contribution that is large enough to be in line with achieving the target in 2030. Therefore the degree of positivity of a contribution needs to be identified.

3.3. Positive contributions to other objectives

In many cases, a public policy aimed at one main goal can have positive spillover effects in other areas. Thus, identifying progress towards 1 SDG target is not enough. It is necessary to identify the direct or indirect progress that will result from the new policy across the whole 2030 Agenda.

Example: Supplying a slum with drinking water clearly contributes to the MDG target 6.1 of universal access to drinking water, but it also has a positive impact on targets 1.4 of access to essential services for the poor, 3.9 of the fight against communicable diseases, 11.1 of the fight against substandard housing, 5.1 of the fight against discrimination against women and girls (water collection, schooling), etc.

3.4. Collateral damage

A public action may generate significant progress towards one target while hindering another target or, worse, moving away from the objective of another target.

Examples: supporting airlines may work against limiting GHG emissions; taxing fossil fuels may increase the cost of living and increase poverty; not taxing them may delay the introduction of renewable energy; changing production or consumption patterns may make certain jobs disappear; etc.

Using the SDGs as a benchmark therefore requires identifying these collateral damages.

Then, accompanying, mitigating or compensatory measures may be possible, in which case they should be incorporated into the new policy in order to reduce or even eliminate the collateral damage.

3.5. The complexity of the SDGs

The large number of targets in the 2030 Agenda is not easy to grasp by the human mind, which tends to find them "complex". As a result, many authors and institutions have tried to simplify them by rewriting them differently. In addition, many try to prioritise them in order to consider only a part of them.

However, this apparent complexity is only a consequence of the systemic nature of the SDGs, which aim to tackle all the major challenges facing mankind. Ignoring one part of them inevitably leads to significant action deficiencies. Our inter-academic group considers that a good methodology must be able to take this complexity into account.

3.6. Priorities for action and reconciling objectives

Of course, at a given time and place, society and public authorities may set priorities for action. This does not detract from the existence of many SDG targets, all of which are desirable and even necessary, even if progress towards them does not proceed at the same speed. Establishing a hierarchy of priorities between targets does not comply with the spirit of the SDGs.

Thus, the choice of priorities for action, or even for goals, is a political decision. This political nature of any priority, either upstream to frame an impact assessment or downstream to prioritise its conclusions, is not the responsibility of the drafters of the impact assessment. This has several consequences.

On the one hand, if the impact assessment must take into account such priorities from the outset, which structure its analysis, it is normal for it to specify that it is not an "impact assessment on the SDGs" but an "impact assessment according to the objectives linked to the SDGs considered to be priorities by the country".

On the other hand, the positive and negative impacts identified by the study cannot be prioritised by the authors of the study if they fall into different thematic areas. For example, if a policy option reduces GHG emissions but also reduces employment, the authors should make these impacts visible without considering that climate trumps employment or that employment trumps climate, as these choices are political decisions.

Moreover, several of the SDG targets are difficult or impossible to reconcile with standard practices. They require new and proactive approaches to be reconciled. It is therefore normal that the impact assessment makes visible in the most objective way possible the impacts of the considered option for action on these different targets that are apparently difficult to reconcile.

The conclusions of an "SDG impact assessment" cannot therefore be summarised in the form of an overall score or a simplistic global assessment. Taking into account the complexity of the 2030 Agenda, the difficulties of reconciling certain targets and the political nature of the choice of priorities, in most cases a serious impact assessment has to present several impacts simultaneously without artificially aggregating them into a global assessment.

3.7. Aims of an ideal impact assessment

Table 1 - Aims of an ideal methodology

⇨ Thus, a good methodology for assessing the impacts of a policy option on the SDGs should ideally:

a. assess the impacts on all the targets of the 17 goals and not only on a particular target or goal,

b. detect, analyse and assess both positive and negative impacts

c. make visible in its conclusions the main positive and negative impacts without proceeding to an oversimplifying aggregation that would obscure them,

d. not prioritise between thematic areas except where priorities have been defined by the institutions (in which case the title should explicitly state this).

4. Methodological details and constraints

4.1. Taking into account the different objectives and their different statuses

The requirement to assess the impacts of a policy on all of the Agenda's goals implies being able to estimate impacts on goals of at least 4 different natures or statuses.

Indeed, there are 169 separate global SDG targets and 232 SDG indicators. While almost all of the 232 indicators measure progress towards their targets, many measure only partial progress. In addition, many targets have 'drawers', i.e. they are actually a collage of different targets. Thus the evaluation methodology should distinguish at least the following 4 categories of targets:

a. The 2 main general principles of the 2030 Agenda of "leaving no one behind" and "not working in silos

b. SDG targets (or parts of targets) with indicators of progress towards their achievement

c. SDG targets (or parts of targets) with insufficient indicators of progress towards them

d. SDG targets (or parts of targets) that do not have indicators of progress

In practice, this leads to assessing impacts on a large number of issues, knowing that some are measurable and others are not. The methodology must therefore combine quantitative criteria and qualitative assessments.

Official monitoring indicators are the most suitable tools for quantitative assessments. They can, of course, be reinforced by additional indicators. However, they only cover objective b and say nothing about objectives of types a, c and d. Moreover, even where indicators exist, the impact of the project may be difficult to assess in a detailed and quantitative way.

For objectives a, c and d, qualitative assessments are needed. For example, 3-level assessments such as 'low impact', 'significant impact', 'major impact'.

4.2. Diversity of situations.

Diversity of territorial situations. Because of the diversity of local situations, an action may have a strong positive impact on one part of the national territory and no impact or a negative impact on another. For example, there may be differences between rural and urban areas, between metropolitan France and the overseas territories, between the warmer Mediterranean regions and the north of metropolitan France, etc. A good methodology of assessment of impact on the SDGs must be able to detect the strongly differentiated impacts according to territories, if any, without hiding them in an average.

France versus abroad. Studies of the "impact on the SDGs" of an action option or a French policy option aim first of all to establish whether this option contributes positively to the achievement of the SDGs in France and, possibly, to improve the values of the UN statistical indicators for France. However, some actions that are beneficial for these indicators in France may have adverse consequences for the indicators in other countries, making it more difficult for them to achieve their share of the goals. As the SDGs are collective goals of the international community, such undesirable spillover effects outside the country of origin should be detected by the impact assessment in order to study possible corrective processes.

4.3. Nuances of assessing a particular impact

To assess the impact of the policy option on a particular target, the simplest case is, of course, one in which an impact on a relevant indicator can be measured. This indicator then provides a scale for assessing the significance of the impact.

In other cases, the evaluation is necessarily qualitative. The evaluator then estimates a degree of impact according to a scale inherent to the methodology. In order to allow for a minimum differentiation of projects, it is desirable that this scale includes at least three positive and two negative bars.

4.4. Uncertainties about developments over the long term of the SDGs

SDGs are long-term issues, at least 2030. The public policies of post-Covid-19 "restart" and their recovery plans are also long-term issues. They will structure part of the functioning of a specific

country over a generation. However, the future is uncertain and the crises of 2020 have increased the degree of uncertainty. The assessment of the impacts of an action option on an SDG target must take into account that the trajectory towards this target is largely unknown and that the most likely scenario may be strongly modified by subsequent changes in the context.

Table 2 - Modalities of an ideal methodology

⇨ Thus, ideally, a methodology for analysing impacts on the SDGs should be able to :

e. combine quantitative and qualitative analyses to take into account all the objectives of the 169 SDG targets and the principles of the 2030 Agenda,

f. make visible, if necessary, the strong differences in impacts according to the territories,

g. If necessary, make visible the undesirable or positive spillover effects on foreign countries,

h. qualify the impacts on at least 3 positive and 2 negative levels,

i. integrate the wide range of possible scenarios over the period up to 2030 or even beyond.

5. Conditions for possible simplifications

Given the number of distinct parts of the SDG targets, which is at least 200, an ideal methodology in the sense of the two summary tables 1 and 2 above leads to asking several questions for at least 200 topics. Assessing the impacts of a policy on all the SDGs may therefore require the collective work of specialists from several disciplines.

An "ideal" methodology is thus a very heavy and extensive task. It is legitimate to try to build simplified methodologies. However, these simplifications should not be excessive in order to respect the systemic spirit of the SDGs.

5.1. Avoiding "false positives" and "false neutrals"

The main risk of a simplified methodology is to be too crude and to be able to declare :

- that an action option has only positive impacts when it has significant negative impacts that are mechanically hidden. This can be described as a "false positive",
- that an option for action has no impact on a subject even though it contributes significantly to it. This could be called a 'false neutral'.

Examples:

- if the methodology only refers to the wording of the SDGs without taking into account the precise wording of their targets, an evaluator could declare positive a water supply project established against the opinion of the population concerned;

- if the methodology only looks at wastewater management from the point of view of the treatment of its pollution, and remains under the influence of the only SDG indicator 6.3.1 which measures these treatment rates, a project to recycle wastewater in agriculture may be declared as not being of interest to the SDGs, even though the recycling of wastewater is an explicit element of the SDG 6.3 target.

5.2. Including 'open-ended' questions

One way to simplify the process is to replace a battery of specific questions on a range of topics with open-ended questions such as "are there negative impacts in this thematic area? "This allows an experienced evaluator to avoid ignoring impacts that are significant.

For example, as was done in the IPCC +1.5°C report, target-by-target questions can be replaced by open-ended questions about a large SDG as a whole, which makes it possible not to hide possible impacts on any of its targets. However, such simplification should not lead to losing sight of the objectives of each target, as they are much more precise - and ambitious - than what can be deduced from the imprecise wording of the SDG. The evaluator should therefore be familiar with the targets in the area concerned.

Open-ended questions on possible territorial differences make it possible to avoid the trap of national averages that may hide strong local difficulties.

Obviously, open questions have a counterpart in terms of drafting. They imply that the evaluator must write an explanation and a summary justification of the positive or negative impact that he/she feels should be retained.

5.3. Presentation of results

Whatever the level of detail of the analysis, the results are necessarily presented to decision-makers in a synthetic manner. Trying to present all the impacts in detail can be ineffective if this presentation is too complex. Conversely, aggregating all the impacts into a single impact score combining all the targets would be oversimplified because the weighting of the different objectives is a matter of political choice and is outside the scope of the evaluator.

The optimum of the synthetic presentation is probably somewhere towards a differentiated assessment according to the 17 impacted SDGs with for each, if necessary, positive and negative elements. Such a presentation allows the systemic nature of the SDGs to be respected.

5.4. Summary of conditions for simplifications

Table 3 - conditions for a simplified methodology

⇨ Thus, an SDG impact analysis methodology should :

j. be able to avoid "false positives" and "false neutrals

k. include open-ended questions that enable the evaluator to make visible :

- impacts on any of the SDG targets

- impacts on a part of the national territory that differs from the national average
- impacts on foreign countries

l. present the results in a way that does not hide negative impacts and at least details the effects for each of the 17 impacted SDGs.

6. Desirable features of the methodology of an SDG impact assessment

As the ideal methodology is unlikely to be achieved, it is useful to draw together the desirable elements of a good simplified methodology. Table 4 summarises these elements.

Table 4 - Desirable features of a methodology for analysing the impacts of an action option on the SDGs

An SDG impact analysis methodology should:

a. assess impacts on all targets of the 17 goals and not just on a particular target or goal.

b. detect, analyse and assess both positive and negative impacts

c. make visible in its conclusions the main positive and negative impacts without over-simplifying aggregation that would obscure them. At the very least, present the effects for each of the 17 impacted SDGs.

d. Do not prioritise between thematic areas except in cases of priorities defined by the institutions (in which case the title of the assessment report should explicitly mention this context).

e. combine quantitative and qualitative analyses to take into account all the objectives of the 169 SDG targets and the principles of the 2030 Agenda

f. make visible, if necessary, the strong differences in impacts according to the territories

g. make visible, if necessary, the undesirable or positive spillover effects on foreign countries

h. qualify the impacts on at least 3 positive and 2 negative levels

i. integrate the wide range of possible scenarios for the period up to 2030 and beyond

j. avoid "false positives" and "false neutrals

k. include open-ended questions that enable the evaluator to make visible :

k.1.impacts on any of the SDG targets

k.2.impacts on a part of the national territory that differs from the national average

k.3.impacts on foreign countries

7. Existing methodologies approaching the subject

It is useful to analyse the different exercises already carried out to assess the impacts of existing policies on the SDGs and to compare their characteristics with those in Table 4.

7.1. Work by the impact assessment community

The International Association for Impact Assessment[3] (IAIA) brings together impact assessment experts at the international level, with probably an over-representation of the Anglo-Saxon community. It defines itself as "the leading global network on impact assessment", defining impact assessment as the process of identifying the future consequences of a current or proposed action[4].

This global association is relevant to the subject of this paper. Several articles discuss SDG Impact Assessment. However, they recognise that the association's membership community brings together distinct disciplines and that the 'SDG Impact Assessment' does not yet exist either as an operational procedure or as a professional discipline. Details are given in Annex 5.

7.2. Global and European level studies

Ex-post or ex-ante assessment of existing policy outcomes. Estimating in advance the impacts of a new public policy on the SDGs is quite similar to the ex-post assessment of the impacts of past policies on the SDGs. The main difference is that in assessing the results obtained, one does not need to consider different scenarios and the corresponding uncertainties. It is therefore a priori simpler.

The existing reports that seem closest to our topic are at the global and European levels:

A. The 'guide to SDG interactions' of the International Council for Science[5]

B. The 2019 Global Sustainable Development Report[6] and especially its reference blog[7] developed by the Swiss CDE which details the interactions between all the SDG targets

C. The Chapter 5 of the IPCC +1.5°C report[8]

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[3] https://www.iaia.org

[4] According to the IAIA website: "*Impact assessment, simply defined, is the process of identifying the future consequences of a current or proposed action*"

[5] https://council.science/wp-content/uploads/2017/05/SDGs-Guide-to-Interactions.pdf

[6] https://sustainabledevelopment.un.org/content/documents/24797GSDR_report_2019.

[7] https://datablog.cde.unibe.ch/index.php/2019/08/29/sdg-interactions/

[8] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter5_Low_Res.pdf

D. The SDSN Global Sustainable Development Reports[9] and SDG dashboards (with Bertelsmann Stiftung)[10]

E. The SDSN and IIEP 2019 Europe Sustainable Development Report[11]

F. The SDSN SDG Index[12] (2019 and 2020 sustainability reports)

G. The 2019 OECD SDG report[13]

H. The EuroStat reports on progress towards the SDGs[14]

I. The GRI-Global Compact guide for reporting on corporate contributions to the SDGs[15]

J. The analysis of the impacts of the Common Agricultural Policy on the SDGs published in Science[16]

Note: The analysis of the interactions of SDGs 2 and 13 presented by the IPCC in Chapter 5 of its 2019 report on climate change and land is not an impact assessment but a study of statistical correlations between historical series of indicator pairs[17]. The correlations measured may give some clues but do not necessarily correspond to the situation of the policy or object of which an SDG impact assessment is desired.

Annex 2 presents the respective scopes of analysis of reports A to H. Annex 3 presents the types of impacts they assess.

These two annexes show the following points:

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[9] https://www.sustainabledevelopment.report/

[10] https://dashboards.sdgindex.org/#/

[11] https://s3.amazonaws.com/sustainabledevelopment.report/2019/2019_europe_sustainable_development_report.pdf

[12] https://github.com/sdsna/2018GlobalIndex/raw/master/2018GlobalIndexMethodology.pdf

[13] https://www.oecd.org/sdd/measuring-distance-to-the-sdg-targets-2019-a8caf3fa-en.htm

[14] https://ec.europa.eu/eurostat/documents/3217494/9940483/KS-02-19-165-EN-N.pdf/1965d8f5-4532-49f9-98ca-5334b0652820

[15] « Integrating the SDGs into Corporate Reporting: A Practical Guide », https://www.globalreporting.org/resourcelibrary/GRI_UNGC_Reporting-on-SDGs_Practical_Guide.pdf

[16] Guy Peer et al. (2019). « A greener path for the EU Common Agricultural Policy », *Science*, Vol. 365, Issue 6452, pp. 449-451, DOI: 10.1126/science.aax3146

[17] These correlations are described in Pradhan, P., L. Costa, D. Rybski, W. Lucht, and J.P. Kropp (2017). « A systematic study of Sustainable Development Goal (SDG) interactions », *Earth's Futur*, 5, 1169–1179, doi:10.1002/2017EF000632.

- The frames of reference considered by these studies are nested as shown in Annex 1. As shown in Annex 2, some consider indicators of progress towards targets, others the targets themselves and others the whole 2030 Agenda.
- There are 2 main types of methodologies:
  - those that refer to indicators of progress. They record positive and/or negative impacts on what is measured by these indicators;
  - those that refer to the content of the SDG targets by making qualitative (and quantitative where possible) analyses of positive and/or negative impacts (according to experts) on progress towards these targets.

7.2.1. Analyses using only indicators ("quantitative" studies)

The use of indicators alone provides interesting information on positive and negative impacts. This is done in Documents D, E, F, G and H.

However, these analyses are not exhaustive and may lead to "false positives" or "false neutrals". No existing methodology that uses only indicators can be used to judge the overall impact of a public policy on the 2030 Agenda because the indicators used only partially monitor this Agenda:

- because these indicators are too limited in number in the studied methodology, between 100 and 130, whereas there are 232 global SDG indicators,
- because some parts of the SDG targets have no indicators.

An interesting aspect of these quantitative analyses is that the scores on the different indicators open the way to weightings and an overall quantitative judgement (like the SDG Index of the SDSN). However, a good overall score may hide a significant flaw, while a very positive policy may go unnoticed.

As an example, Annex 4b shows the main differences between the characteristics of the SDSN SDG Index method and the desired characteristics.

7.2.2. Systematic searches for all possible impacts ("qualitative studies")

Studies that start from the content of the SDG targets by making qualitative (and quantitative where possible) analyses of positive and/or negative impacts on progress towards these targets better match the characteristics sought. This is the case for documents A, B, C, I and J.

Those that aim to identify the main positive and negative impacts on all the SDGs and not on a few (feature a in Table 4) respect the spirit and holistic nature of the 2030 Agenda.

The main disadvantage of these "qualitative" approaches is that they do not allow for the consolidation of all identified impacts into a simple aggregate view that allows for easy comparison of several options. However, these approaches can lead to estimates of impacts by SDG by grouping all the targets of a single SDG, which is often relevant even if it may obscure some negative impacts.

Study A. The 2017 ICSU report studies the impacts of actions towards 4 SDGs on the other 16 SDGs and then studies in more detail their impacts on the targets that appear to be most affected. Its methodology is thus quite comprehensive. The impacts are classified on a scale with 3 positive and 3 negative bars. The characteristics of this method are not far from the desired characteristics.

Study C. The IPCC +1.5°C report identifies the impacts of different greenhouse gas (GHG) mitigation actions on each of the SDGs by assigning them positive or negative scores on a 3 positive and 3 negative bar scale. Its characteristics are compared to the characteristics we are looking for in Annex 4c. They are quite close to the desired characteristics. The main difference is the analysis SDG by SDG and not SDG target by SDG target, which does not guarantee that the precise objectives of each target are considered.

Study B. The CDE Switzerland blog linked to the GSDR report indicates the potential impacts (positive and negative effects) of each SDG target on each of the other targets by documenting and referencing the identified impacts. It uses the elements of the IPCC +1.5¨C report for topics related to GHG emission limitation actions and scores each impact according to the ICSU scale. In total, it is very close to the desired characteristics and makes an effort to present the results by aggregating the impacts on each target of an SDG to estimate an overall impact on this SDG. The presentation of the results on the blog and in Figure 1.2 of the GSDR report is curious in its lack of neutral impact. Only positive and negative impacts are presented.

Study I. The methodology recommended by the Global Reporting Initiative (GRI) and the Global Compact for corporate SDG strategies includes several steps. The first one is to select SDG targets to focus on according to two criteria. One of these criteria is the significance of the impacts of the company's activity on people and the environment. The SDG targets to be chosen are those related to the highest impacts that are identified. The second step is to set objectives against these targets and select indicators to monitor progress. The third step is to report on these indicators. The SDG reports of companies that follow this methodology are thus "quantitative" ex post reports using indicators. They follow a thorough impact assessment, the methodology of which is not specified in the GRI-Global Compact documents.

Study J. The J study analysis qualitatively assesses the ex-post impacts of the EU's Common Agricultural Policy (CAP) on each of the SDG targets by ranking them on a positive scale of 1 to 4. Its characteristics are fairly close to those desired. However, the negative impacts are not obviously visible and the synthetic presentation by colours is less readable than a bar chart.

7.2.3. Consideration of future uncertainties

We have not found any international impact studies on the SDG targets that explicitly consider several scenarios for the changing context over time. This does not mean that the "qualitative" analyses listed above do not consider several possibilities for future developments or do not take into account the various existing prospective studies.

7.3. Existing impact assessment methodologies in some countries

Most countries regularly report their actions and progress towards the SDGs to the UN High-Level Political Forum on Sustainable Development (interim reports or ‘voluntary national reports’). More

and more countries are producing SDG reports internally. This is the case of France, which has decided in its Roadmap for the 2030 Agenda to report annually to Parliament on the progress of its implementation.

Beyond this "reporting", some countries have committed to using the SDGs as benchmarks for their political decisions and impose an ex-ante SDG impact assessment for any new law.

Germany uses a grid of 66 indicators - quite similar to the French national SDG scorecard of 98 indicators - and each bill sponsor must indicate the impacts of the future law on these indicators. It would be useful to know whether German impact assessments go beyond their 66 indicators and refer qualitatively to the content of all targets.

"All proposals for new laws and regulations are subject to a Sustainability Impact Assessment (SIA). The SIA is based on indicators, targets and management rules, which include intergenerational and transboundary dimensions. Since March 2018, laws and regulations can be checked against those through an online tool: www.enap.bund.de" (source: OECD[18]).

In **Finland**, impact assessments are also conducted and being improved:

"In its 2030 Agenda implementation plan, the government commits to explore the use of a sustainable development impact assessment tool to identify systematically the unintended effects of policies. The existing impact assessment process for bill drafting will be improved to ensure better alignment with the SDGs and to enhance coherence between actions undertaken at national and global levels." (Source: OECD[19])

In **Belgium**, as of 2017, the Walloon Government decided that each 'note to the Government', i.e. each administrative report proposing a new regulation, should indicate the contribution of the proposed decisions to the SDGs[20].

At the federal level since 2013, an impact assessment is required for most projects of new regulations. Called Regulatory Impact Assessment[21], it is "a prior assessment of the potential consequences (/ collateral impacts) of proposed regulations in an integrated manner in the economic, social, environmental and public authority fields". In practice, it is a questionnaire with one or more questions on 21 topics:

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[18] https://www.oecd.org/governance/pcsd/Country%20Profile%20Germany.pdf

[19] https://www.oecd.org/governance/pcsd/Country%20Profile%20Finland.pdf

[20] Source: communication du Secrétariat général de l'administration wallonne au Congrès de l'ASTEE à Liège le 7 juin 2017

[21] Cf. *Manuel pour la réalisation de l'analyse d'impact*, AIR : ria-air.fed.be/wp-content/uploads/2013/12/AIR-Manuel-FR-2014-01-02.pdf

1. Fighting poverty 2. Equal opportunities and social cohesion 3. Equality between women and men 4. Health 5. Employment 6. Consumption and production patterns 7. Economic development 8. Investments 9. Research and development 10. SME development 11. Administrative costs	12. Energy 13. Mobility 14. Food 15. Climate change 16. Natural resources 17. Indoor and outdoor air 18. Biodiversity 19. Nuisances (for the population) 20. Public authorities 21. Coherence of development policies (support to developing countries)

For most themes, the question is unique: is there a positive, negative or no impact? If there is an impact, the project leader has to explain the answer. It is therefore an 'open-ended' questionnaire that deals with many aspects of the SDGs. Unfortunately, it was designed before the adoption of the SDGs and does not refer to them at all. Some of the SDG targets are well covered, others are missing. This is the case, for example, with education issues. Several are aggregated in single questions which may lead to masking certain aspects. It should be noted that this procedure includes an examination of the impact on foreign countries (theme 21).

In **Denmark**, according to the OECD:

"As part of the national Action Plan, the government will assess the consequences of new legislation for the SDGs when considered relevant in the Danish context and if the impact is significant. The work to develop the specific concept and guidelines for the assessment is currently being finalised." (Source: OECD)

In **France**, the Agence Française pour le Développement (AFD) analyses the impacts of its projects on Sustainable Development (SD) according to a proven and codified methodology. It predates the adoption of the SDGs and was adjusted after their adoption, but its purpose is not to assess the impacts on the SDGs. The differences are mainly due to the fact that the goals considered are much more imprecise than the 169 SDG targets. Annex 4a compares its characteristics to the characteristics we are looking for.

The AFD methodology combines two approaches:

- a quantitative approach measuring the expected impacts of a project on indicators,
- a qualitative approach leading to positive or negative scores from -2 to +3 according to 6 dimensions established by AFD to group the different SD constituents.

The six dimensions are:

1. Sustainable growth and resilient economy (identified SDGs: 8, 9, 11, 12)
2. Social well-being and reduction of social imbalances (identified SDGs: 1, 3, 4, 6, 8, 11)
3. Gender equality (SDGs 5, 8, 16)

4. Preservation of biodiversity, management of natural environments and resources (SDGs 14 and 15)

5. Combating climate change and its effects (SDG 13 but also 7, 9, 11). This dimension is subdivided into "mitigation" and "resilience

6. Sustainability of project effects and governance framework (SDG16, 17)

The results of this qualitative part are presented to decision-makers in the form of a 6-bar horizontal diagram.

The AFD methodological guide includes "grids of correspondence between the SDGs and the sub-criteria of analysis" of the dimensions. In practice, these grids do indeed indicate correspondences, but without the full objectives of the targets mentioned being reflected in the AFD criteria. Moreover, more than 30% of the 169 SDG targets do not appear in these correspondence grids.

In total, this method does not make visible the potential positive contributions to all the SDG targets or parts of targets. It probably avoids omitting most, but not all, of the large collateral damages.

This methodology is however very interesting and useful as it includes many qualitative elements that cannot be measured.

All of this should be explored further. These methodologies from different countries are indeed very inspirational.

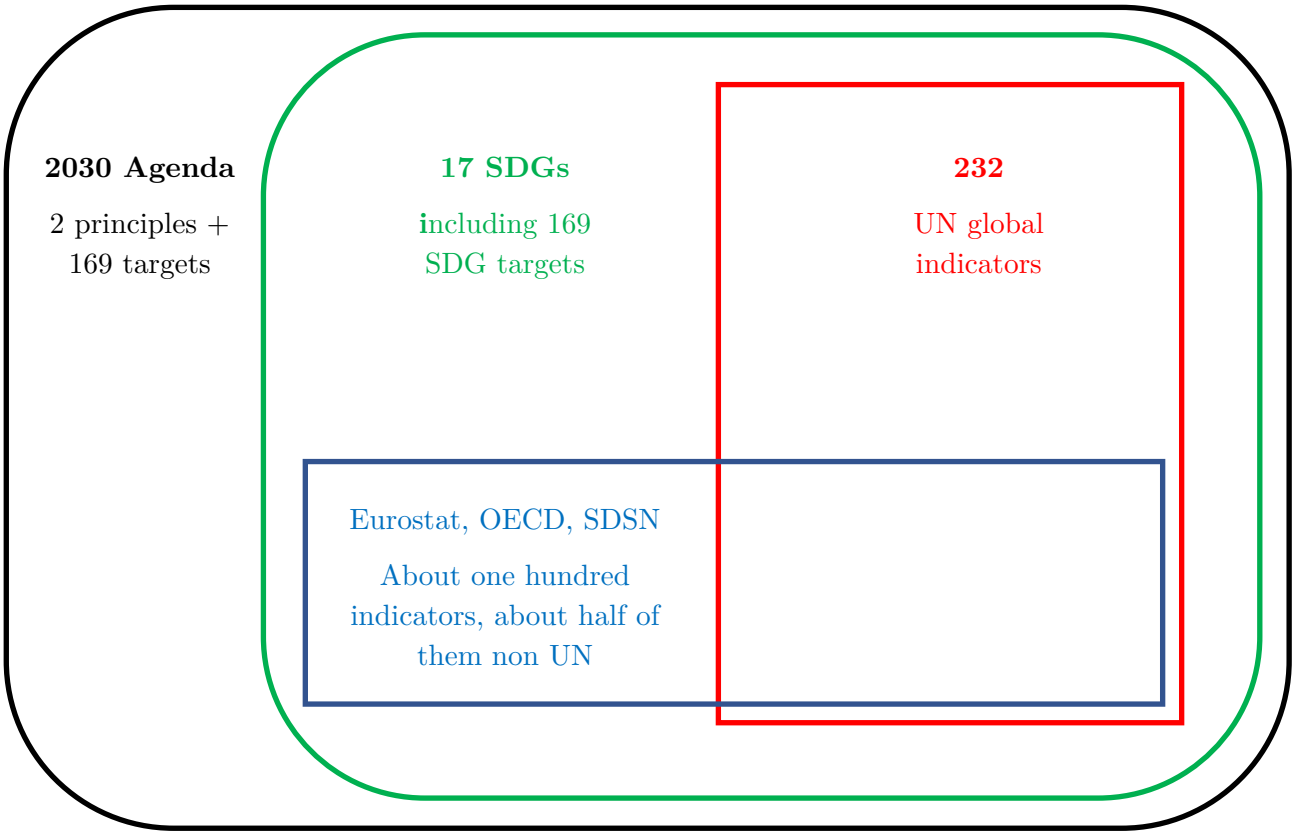
8. Conclusion

Using the SDGs as a benchmark to assess the relevance of various policy options requires analyses of their impacts on the SDGs that meet all the characteristics of Table 4 above.

Among these, the essential characteristics are to:

- refer to the SDG targets and not only to the Sustainable development themes,
- consider all the SDG targets and not just a few,
- asking "open-ended" questions for each target without limiting oneself to aspects measured by indicators,
- Look for both positive and negative impacts,
- consider possible spillover effects on other countries,
- give equal weight to each target (unless political priorities have already been set),
- present the results in a non-aggregated way but broken down at least by SDG.

Annex 1 — Nested reference fields



Annex 2 — Scope of the analysed international reports

		Scope of the reference frame used							
		Principles	Targets	Indicators					
		General principles	SDG Targets	Total	UN (SDGs)	EU	OECD	France (SDGs)	Others
Total number		2	169		232			98	
A	*Guide to SDG Interactions* by the International Council for Science (2017)		Targets of 11 SDGs						
B	2019 Global Sustainable Development Report (GSDR)		x						
C	IPCC +1.5ºC Report		x						
D	SDG dashboards by SDSN			109	65		6		38
E	IEEP-SDSN Europe SD report 2019	1		113	14	51	10		38
F	SDSN SDG Index			109	65		6		38
G	2019 OECD SDG report			132	43		89		
H	EuroStat reports on SDGs			100	53	47			

Annex 3 — Types of impacts studied by the analysed international reports

		Impacts studied for each objective					Impact aggregation	
		Progress towards objective		Variations in indicators	Positive effects	Collateral damages	By SDG	All SDGs combined
		By SDG	By target					
A	*Guide to SDG Interactions* by the International Council for Science (2017)		x		x	x		
B	2019 Global Sustainable Development Report (GSDR)		x		x	x		
C	IPCC +1.5ºC Report	x			x	x	x	
D	SDG dashboards by SDSN			x			x	
E	IEEP-SDSN Europe SD report 2019			x			x	x
F	SDSN SDG Index			x			x	x
G	2019 OECD SDG report			x			x	
H	EuroStat reports on SDGs		x	x			x	

Annex 4a — Methodology by AFD

Characteristics of the methodology for impact analysis	**Ideal characteristics**	**AFD's methodology**
Type of analysis *(ex post* or *ex ante)*	*ex ante*	*ex ante*

Scope and level of detail **Questioning and level of research**	Impacts ont the 17 SDGs analysed according to their targets + principles of Agenda 21	Impacts on sustainable development issues and not specifically on SDGs
Measures contributions to the scope based on indicators (if yes, number of indicators)	Yes	Yes
Qualitatively assesses the direct and indirect positive contributions to the scope (not measured by the indicators)	Yes	Yes
Avoid "false neutrals" by assessing positive contributions that are not precisely anticipated in the methodological framework	Yes	Yes
Identifies direct and indirect negative impacts (not measured by the indicators)	Yes	Yes
Avoids "false positives" by allowing the reporting of negative impacts not anticipated in the methodological framework	Yes	Yes
Allows for the measurement of positive and negative effects in foreign countries	Yes	?
Allows for taking into account territorial differences	Yes	Yes

Flexibility and systemicity		
Open method, excluding no subject	Yes	Yes
Takes into account future uncertainties		
Approach that aims at systemicity	Yes	Yes

Appreciation levels		
Number of grades on the positive rating scale	At least 3	3
Number of grades on the negative rating scale	At least 2	2
Justified appreciation	Yes	Yes

Synthetic presentation of the results		
For each SDG target	No	
For one or several specific SDG(s)	No	
For less than 17 SDGs	No	7
For each of the 17 SDGs	Yes	
In a way that aggregates all SDGs	Possibly	
Offering a global appreciation	Possibly	
In a way that allows at least a rough comparison between projects	Possibly	Yes

Insufficient in comparison with the ideal characteristics:

Annex 4b — Methodology of the SD report by SDSN

Characteristics of the methodology for impact analysis	**Ideal characteristics**	**SDSN's methodology**
Type of analysis *(ex post* or *ex ante)*	*ex ante*	e*x post*
Scope and level of detail **Questioning and level of research**	Impacts ont the 17 SDGs analysed according to their targets + principles of Agenda 21	Impacts on the 17 SDGs with analysis based on their wording
Measures contributions to the scope based on indicators (if yes, number of indicators)	Yes	Yes (about 105)
Qualitatively assesses the direct and indirect positive contributions to the scope (not measured by the indicators)	Yes	No
Avoid "false neutrals" by assessing positive contributions that are not precisely anticipated in the methodological framework	Yes	No
Identifies direct and indirect negative impacts (not measured by the indicators)	Yes	No
Avoids "false positives" by allowing the reporting of negative impacts not anticipated in the methodological framework	Yes	No
Allows for the measurement of positive and negative effects in foreign countries	Yes	Yes
Allows for taking into account territorial differences	Yes	No
Flexibility and systemicity		
Open method, excluding no subject	Yes	No
Takes into account future uncertainties		
Approach that aims at systemicity	Yes	No

Appreciation levels		
Number of grades on the positive rating scale	At least 3	99
Number of grades on the negative rating scale	At least 2	-
Justified appreciation	Yes	No

Synthetic presentation of the results		
For each SDG target	No	
For one or several specific SDG(s)	No	
For less than 17 SDGs	No	Diagramm
For each of the 17 SDGs	Yes	Diagramm
In a way that aggregates all SDGs	Possibly	Global score
Offering a global appreciation	Possibly	
In a way that allows at least a rough comparison between projects	Possibly	

Insufficient in comparison with the ideal characteristics:

Annex 4c — Methodology of the IPCC +1.5ºC report

Characteristics of the methodology for impact analysis	Ideal characteristics	IPCC's methodology
Type of analysis *(ex post* or *ex ante)*	*ex ante*	According to littérature
Scope and level of detail **Questioning and level of research**	Impacts ont the 17 SDGs analysed according to their targets + principles of Agenda 21	Impacts on 16 SDGs (all but nº13) with analysis based on the SDG wording but not detailed by their SDG targets
Measures contributions to the scope based on indicators (if yes, number of indicators)	Yes	No
Qualitatively assesses the direct and indirect positive contributions to the scope (not measured by the indicators)	Yes	Yes
Avoid "false neutrals" by assessing positive contributions that are not precisely anticipated in the methodological framework	Yes	Unsure
Identifies direct and indirect negative impacts (not measured by the indicators)	Yes	Yes
Avoids "false positives" by allowing the reporting of negative impacts not anticipated in the methodological framework	Yes	Unsure
Allows for the measurement of positive and negative effects in foreign countries	Yes	N.a.
Allows for taking into account territorial differences	Yes	N.a.
Flexibility and systemicity		
Open method, excluding no subject	Yes	Yes
Takes into account future uncertainties		
Approach that aims at systemicity	Yes	Yes

Appreciation levels		
Number of grades on the positive rating scale	At least 3	3
Number of grades on the negative rating scale	At least 2	3
Justified appreciation	Yes	Yes

Synthetic presentation of the results		
For each SDG target	No	
For one or several specific SDG(s)	No	
For less than 17 SDGs	No	
For each of the 17 SDGs	Yes	Diagramm
In a way that aggregates all SDGs	Possibly	No
Offering a global appreciation	Possibly	No
In a way that allows at least a rough comparison between projects	Possibly	

Insufficient in comparison with the ideal characteristics:

Annex 4d — Methodology of the Swiss CDE blog

Characteristics of the methodology for impact analysis	**Ideal characteristics**	**CDE's methodology**
Type of analysis *(ex post* or *ex ante)*	*ex ante*	According to litterature
Scope and level of detail **Questioning and level of research**	Impacts ont the 17 SDGs analysed according to their targets + principles of Agenda 21	Impacts on each 169 SDG Targets with analysis based on their wording and objectives
Measures contributions to the scope based on indicators (if yes, number of indicators)	Yes	No
Qualitatively assesses the direct and indirect positive contributions to the scope (not measured by the indicators)	Yes	Yes
Avoid "false neutrals" by assessing positive contributions that are not precisely anticipated in the methodological framework	Yes	A priori yes
Identifies direct and indirect negative impacts (not measured by the indicators)	Yes	Yes
Avoids "false positives" by allowing the reporting of negative impacts not anticipated in the methodological framework	Yes	A priori yes
Allows for the measurement of positive and negative effects in foreign countries	Yes	N.a.
Allows for taking into account territorial differences	Yes	N.a.
Flexibility and systemicity		
Open method, excluding no subject	Yes	Yes
Takes into account future uncertainties		
Approach that aims at systemicity	Yes	Yes

Appreciation levels		
Number of grades on the positive rating scale	At least 3	3
Number of grades on the negative rating scale	At least 2	3
Justified appreciation	Yes	Yes

Synthetic presentation of the results		
For each SDG target	No	
For one or several specific SDG(s)	No	
For less than 17 SDGs	No	
For each of the 17 SDGs	Yes	Diagramm
In a way that aggregates all SDGs	Possibly	No
Offering a global appreciation	Possibly	No
In a way that allows at least a rough comparison between projects	Possibly	

Insufficient in comparison with the ideal characteristics:

Annex 5 — The SDGs challenge the international community of impact assessment professionals

1. The IAIA

The International Association for Impact Assessment[22] (IAIA) brings together impact assessment experts at the international level. It defines itself as "the world's leading network on impact assessment", defining impact assessment as the identification of the future consequences of an ongoing or planned action[23]. It is funded by many institutions such as the multilateral development banks and companies. It has partner associations in 17 countries, including Germany and Italy but not France.

It publishes the journal "Impact Assessment and Project Appraisal" (IAPA), of which only 3 articles deal with impact studies on the SDGs as a whole. These are the editorial of June 2020, which gives a sort of state of the art of the subject, and two articles from 2018 and 2019:

- Article 1: Thomas B Fischer, Embedding the sustainable development goals (SDGs) in IAPA's remit[24], Editorial, IAPA, Volume 38, 2020, Issue 4, pages 269-271, published online: 10 Jun 2020
- Article 2: Angus Morrison-Saunders, Luis E. Sánchez, Francois Retief, John Sinclair, Meinhard Doelle, Megan Jones, Gearing up impact assessment as a vehicle for achieving the UN sustainable development goals[25], IAPA, Volume 38, Issue 2, Pages 113-117, Published online: 22 Oct 2019

  > "*the purpose of our paper is to consider how IA in its various forms might be utilised as an important vehicle for facilitating achievement of the Sustainable Development Goals (SDGs) established by the UN - United Nations (2015).*"

- Article 3: Theo Hacking, The SDGs and the sustainability assessment of private-sector projects: theoretical conceptualisation and comparison with current practice using the case study of the Asian Development Bank[26], IAPA, Volume 37, 2019 - Issue 1, Pages 2-16, published online: 03 Jun 2018

The issue of the SDGs is gradually emerging in the IAIA's discussions. Its internal newsletter published an article in May 2019 promoting the SDGs as a benchmark:

> *"For impact assessment (IA) in its multiple forms—such as EIA, SIA, SEA, HIA—the opportunities to play a crucial role in achieving the SDG targets are significantly greater than they were for the MDGs."*

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[22] www.iaia.org/

[23] According to the IAIA website: "Impact assessment, simply defined, is the process of identifying the future consequences of a current or proposed action"

[24] https://www.tandfonline.com/doi/full/10.1080/14615517.2020.1772474

[25] https://www.tandfonline.com/doi/full/10.1080/14615517.2019.1677089?src=recsys

[26] https://www.tandfonline.com/doi/full/10.1080/14615517.2018.1477469?src=recsys

"Support the adoption or adaptation of IA guidelines to incorporate SDG principles and concepts, develop sector-based IA guidelines aligned with the SDGs, and generate well-documented case studies that highlight the links between IA and the SDGs."

2. The current practice of impact assessment

From the many IAPA articles and the 3 articles above, it is clear that the IAIA brings together experts in impact assessments dealing with specific objectives:

- environmental impact assessments (EIA),
- social impact assessments (SIA),
- climate impact assessments,
- human rights impact assessments (HRIAs),
- gender impact assessments,
- poverty impact sssessments (PIA),
- economic impact assessments,
- health impact assessment (HIA).

Each of these specialities is now structured with recognised forms of impact analysis. It seems that environmental impact studies are the most numerous.

3. Sustainability or sustainable development studies

Hacking's article indicates that another form of study is developing, that of sustainability studies (SA). But it is a discipline that is gradually being built up, with the difficulty that sustainability has no precise definition.

"SA is still an emergent concept that may refer to ex post, ongoing or ex ante processes applied in various decision-making contexts, with varying sustainability ambitions."

The SDGs provide precise objectives that are likely to frame these sustainability studies (SA) by defining sustainability.

"By adding clarity to the meaning of sustainability, the SDGs have increased the feasibility of implementing SA, ..." (Hacking)

4. From sector studies to impact studies on all the SDGs

The authors referenced above recognise that the addition of traditional sectoral impact assessments is not sufficient to cover the scope of the SDGs for several reasons:

- The SDGs set broader directions than specific decisions.

> *"the SDGs have a scope that reaches beyond what IA can deliver, focused as it is on specific decisions."* (Morrison and al.)

- The SDGs interact with each other, which is not systematically explored in traditional sectoral impact assessments. There is a need for better "integration" of sector studies.

> *"Any thematic sub-division of the sustainability agenda risks the creation of 'silos'; hence from the inception of the SDGs it was emphasised that there are many cross-cutting elements and deep interconnections across the goals and targets (UN 2015). Elder et al. (2016) recommend that because the goals are interconnected, they should be implemented using an integrated approach that will help avoid costly trade-offs."* (Hacking)

- Conventional impact assessments are mainly used to detect undesirable effects. They are less useful in identifying positive impacts. This is particularly true of the 'safeguard clauses' of the international financial institutions.

> *"It is only possible to explore trade-offs if both positive and negative impacts are considered. In practice, impact assessments have tended to focus on the prediction and mitigation of negative impacts, driven by legal compliance and the potential for enhancement of positive impacts has been neglected (João et al. 2011; Esteves et al. 2012). "* (Hacking)

> *" The ADB's [Banque Asiatique de Développement] safeguard policies are 'generally understood to be operational policies that seek to avoid, minimise or mitigate adverse environmental and social impacts', which are determined via an EIA for Category A projects (ADB 2009, p. 4 emphasis added). In the SPS there are far fewer references to positive impacts than to adverse/negative impacts (ADB 2009). The SPS [Safeguard Policy Statement] Operations Manual makes no reference to positive impacts and reiterates that the goal of the Policy is to 'promote the sustainability of project outcomes by protecting the environment and people from potential adverse impacts of projects' (ADB 2013b, p. 1 emphasis added) "* (Hacking)

The authors conclude that the classic procedures are a conceptual foundation, but that they need to be brought together and fleshed out to encompass all the topics of the SDGs and to address both positive and negative effects.

> *" We conclude that 'geared up' IA might be used as a major vehicle to facilitate achievement of the SDGs. "* (Morrison et al.)

> *"In relation to the SDGs, however, it is clear that at the very least, IA must become more comprehensive and integrated, such that the full suite of SDGs and the relationships between*

them (including potential trade-offs) can be considered and debated in a transparent and inclusive way. " (Morrison et al.)

5. Why aren't impact assessments on the SDGs more developed?

The IAIA authors advocate for SDG impact assessments but find that their development is slow. They present several explanations for this.

5.1. Lack of interest - NIH syndrome

"It is somewhat surprising that the impact assessment community has been slow to adopt the SDGs, despite them receiving increasing attention in other quarters, including the private sector. This could be ascribed to a 'not invented here' mind set, since the SDGs were not developed within the impact assessment 'community' of practitioners and academics. Arguing that impact assessment has always supported sustainability will be insufficient – processes and techniques need to evolve to be explicitly supportive of the SDGs, since these are now widely regarded as setting the sustainability agenda. As governments and businesses increasingly commit to this agenda, it will be incongruous not to imbed the SDGs in assessment processes that support decision-making. It has been demonstrated that this can be achieved by refining the emergent SA concept." (Hacking)

5.2. Lack of human resources

However, there is a lack of human resources adapted to impact studies on the SDGs. Indeed, the SDGs require an integrated approach between all specialities, whereas current practices mobilise specialists in distinct disciplines.

"*The successful integration of different specialist studies remains a particular challenge in many jurisdictions such as South Africa (Retief 2010). In most cases this appears to be a reflection of weak scoping, lack of agreement around significance ratings and/or lack of skills and capacity to manage specialist inputs and deal with integrated thinking."* (Morrison et al.)

5.3. Lack of political will for evaluation

Integrating the SDGs into a policy does not necessarily imply an assessment of the policy's impact on the SDGs.

" For example, the South African government is actively in the process of aligning the most important overarching national development policy (i.e. the National Development Plan, NDP) with the SDGs. The NDP is broad ranging and could potentially incorporate all the SDGs. However, SEA has not yet been formally legislated, which means that the successful integration of the SDGs with the NDP will not necessarily be evaluated in South Africa. " (Morrison et al.)

Decision making and uncertainty

Claude Nahon (National Academy of Technologies of France)

Abstract. *The health crisis has highlighted the difficulty of making rapid decisions in the front of the knowledge uncertainty as well as the strong interactions between themes often treated separately. It showed new strengths and vulnerabilities in our societies (link between health and economy, resilience of public services, etc.). This note exposes the need to change the way we make decisions to take into account the multiple and long-term issues specific to sustainable development, and in a context of strong uncertainties related to climate change. In the face of unknown risks, prevention is no longer possible and precaution becomes essential.*

It is necessary to change the decision-making process, and even more visibly and consciously take in account uncertainties related to risk management into decision-making.

One of the challenges of sustainable development is to develop iterative decision-making processes that combine unknown and unknowable and allow the long term to be really taken into account. More systemic decision-making processes to take into account the interactions between the various sustainability issues (for example climate, water, biodiversity or "end of the world" and "end of the month").

In the case of cities: it is a matter of studying and accepting its vulnerabilities and adapting its infrastructures and management accordingly, reconsidering choices that have become mistakes (soils artificialization, heat islands, etc.). These are both organization and investment choices that must be made with population and infrastructure managers by redefining the commitments of public services. It means reviewing the decision-making and design methods.

We cannot use deterministic models that have become uncertain to support decisions, but methods with an uncertain future such as the tree of least regret.

This theme has been the subject of numerous studies after extreme events that have impacted communities, with feedback but also reflections on this articulation between strengthening infrastructure, construction, risk management but also responsibilities and cost.

An excellent publication[27] addresses all these subjects by asking the relevant questions on the articulation of decisions: the role of engineers, public decision-makers, climatologists. This quite clearly set the question of adaptation and the new world of uncertainty that will govern our decisions.

[27] Chester, M., Underwood, B.S. and Samaras, C (2020). "Maintaining the reliability of infrastructures in climatic uncertainty", Nat. Clim. Chang. 10, 488–490.

1. Climate change and adaptation

We make all kinds of decisions, and to do so we rely on our knowledge of the past to estimate the risks and negative impacts of these decisions.

The more complicated the decision and the more we use sophisticated models articulated with possible scenarios to develop these decisions.

We also rely on financial analyzes that favor the present over the future through discounting methods.

This starts from the idea that one can reasonably know what is possible.

Very often when working on adaptation to climate change, we realize that we cannot rely on short-term scenarios to envision the future. The downscaling of climate models is too imprecise: we know that it will rain more where it rains, but we do not know the form or the frequency of the rains. The instability of meteorology with the multiplication of extreme events further accentuates these uncertainties.

"*Infrastructure systems around the world face immediate crises and persistent long-term challenges ... system owners and managers must balance the need to repair and replace aging systems. and deteriorating already in place and transformative investments in deep decarbonization and climate adaptation [...]* "[28]

It is necessary to change the decision-making model, and even to integrate these uncertainties related to risk management into decision-making. This is obviously the case for the construction or maintenance of infrastructure.

"*Infrastructure design continues to allow past conditions to be predictors of the future despite growing evidence to the contrary.*"[29]

For example, a piano keys weir does not require the same knowledge about dimensioning flooding but simply allows to evacuate excess water arriving on a dam during a flood.

The inexorable rise of sea level makes border a particular place of vulnerability: physical under the violence of storms but also economic and human in determining what part of the coast can (and must at least temporarily) be protected. Many large metropolises are affected by the rising waters. The barrier installed to protect London on the Thames worked much more than expected. How do you decide what to protect? What tools do we have, do we have to protect everything?

Sea level rise can also be a drinking water issue because it can compromise groundwater: how to preserve them, should we invest in desalination?

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[28] Doss-Gollin, J. (2020). Sequential Adaptation by Predicting Structured Climate Risk, Columbia University.

[29] Chester, M., Underwood, B.S. and Samaras, C (2020), ibid.

We can also think of cities and territories: cities are obviously sensitive to variations in climate, whether they are the multiplication of extremes or deeper changes (such as the amount of water available). It is about thinking of them as more resilient, more adapted, not autonomous but in relation to their immediate environment.

It is a matter of accepting our vulnerabilities and adapting our infrastructure and management accordingly, reconsidering the choices that have become mistakes (artificialization of soils, dikes, heat islands, etc.). These are both organization and investment choices that must be made with the population and infrastructure managers by redefining the commitments of public services. It means reviewing the decision-making and design methods.

"*As such, cities, towns, regions, states have codified the level of risk that their infrastructure should be able to withstand ... it is not desirable that a single individual or a single form arbitrate the economic costs and social failure*"[30].

This raises the question of the law, responsibility and financing of these decisions.

2. Decision making: uncertainty and uncertainty

The pandemic we are going through has made many people realize that we are making decisions with little certainty: neither scientists nor decision-makers understand certain information about the epidemic, the virus and the risks. And yet politicians had to make decisions that impacted our health and our economy, each of us had to manage our own risk based on what is actually perceived and understood about the epidemic.

This understanding of uncertainty has been highlighted in several articles as genuinely resented by a large part of the population. Recognizing our lack of knowledge, admitting that we pilot on sight, is fairly new in public decision-making.

However, if we look at the environmental and social risks that are in front of us, even if we manage to identify them, their interactions, their effects are still unrecognized or even unrecognizable.

We have built decision-making processes that help us make long-term decisions by over-valuing short-term effects. One of the challenges of sustainable development is to take advantage of this conscience prize to develop iterative decision-making processes that combine the unknown and the unknowable and make it possible to really take the long term into account. More systemic decision-making processes to take into account the interactions between the different sustainability issues (for example climate water biodiversity or “end of the world” and “end of the month”).

3. Precaution/prevention

In a way, it is about moving from a preventive to a precautionary approach. In everyday language, we often act when faced with a risk as a precaution, or even in application of the precautionary

[30] Chester, M., Underwood, B.S. and Samaras, C (2020), ibid.

principle. In fact, it is very often also an abuse of language leading to confusion because precaution and prevention are necessary in front of the risks but very different.

Prevention is done in front of identified and known risks: the risks are known, their consequences, their probabilities, and prevention methods too, sometimes insufficient in view of the scale of the risk. These risks are analyzed and known prevention methods are applied. In the decisions, in the supporting mathematical models, the residual risks (the residuals of the models) are estimated to be negligible.

We size our houses to resist a wind identified through the history of winds in our region. If a storm occurs with more violent winds, the conversion of these speeds is evaluated to decide whether or not to reinforce the roof of the house. This is prevention. Climate change will upset these certainties.

Precaution is different from prevention: the risks are unknown, their probabilities and their consequences too, the methods of prevention are insufficient and sometimes ineffective. Methodologies must be developed to move forward in front of uncertainty. These methods must evolve as the threat evolves. Precaution does not only concern research, but all risk management, including the construction of infrastructure.

This does not mean that nothing can be done, but that one must act by accepting the uncertainties and the errors, by accepting the iteration and the change of decision. The approaches and responses will be different and evolving: they may use prevention methods.

We cannot use deterministic models that have become uncertain to support decisions, but methods with an uncertain future such as the tree of least regret. Precaution should not be a pretext for inaction or mediocrity: it is about inventing flexibility and resilience in the face of uncertain risks that we sometimes cannot imagine.

In the case of COVID 19, we moved from preventing influenza to precaution in front of a pandemic without really being aware of this move.

This is not to say that measures could not have been taken to protect against the risk of a pandemic, but that these measures should be systemic and flexible to adapt to the risk.

Thematic

Notes

Responsible consumption and production

Jean-Pierre Chevalier (National Academy of Technologies of France), Dominique Vernay (National Academy of Technologies of France)

Abstract. *This note concerns SDG n°12: "Ensure sustainable consumption and production patterns". It deals with non-food products and analyses their consumption and production. The concepts of domestic material consumption, material footprint and material productivity are described. It provides recommendations concerning training, research, repair, recycling and Industry 4.0.*

Preamble. The state's response to the crisis caused by the Covid-19 epidemic would seem to be articulated in several phases:

- rebound (very short term - a few months) - which was carried out through financial support to companies in order to best maintain jobs and safeguard industrial sectors,
- recovery (short term - several months to one or two years) - this is the purpose of the France Relance plan of 3 September 2020,
- transformation (medium term - a few years).

This text on responsible consumption and products is mainly aimed at the transformation phase.

Extract. *Progress towards the Sustainable Development Goals — Report of the Secretary-General* (High level political forum on sustainable development convened under the auspices of the United Nations Economic and Social Council, Juillet 2020) :

« *Goal 12. Ensure sustainable consumption and production patterns*

20. Worldwide consumption and production—a driving force of the global economy—rest on the use of the natural environment and resources in a model that continues to lead to destructive impacts on the planet. The COVID-19 pandemic offers countries an opportunity to build a recovery plan that will reverse current trends and change our consumption and production patterns towards a sustainable future.

- *As of 2019, 79 countries and the European Union reported on at least one national policy instrument that contributes to sustainable consumption and production (SCP) in their efforts in the implementation of the 10-Year Framework of Programmes on SCP.*
- *Global domestic material consumption (DMC) per capita rose by 7% from 10.8 metric tons per capita in 2010 to 11.7 metric tons in 2017, with increases in all regions, except North America and Africa. However, the DMC per capita in Europe and North America is still 40% higher than*

the global average, indicating the need to enhance resource efficiency and practices to reduce consumption in the future.

- *The global material footprint rose from 73.2 billion metric tons in 2010 to 85.9 billion metric tons in 2017, a 17.4% increase since 2010 and a 66.5% increase from 2000. The world's reliance on natural resources continued to accelerate in the last two decades.*
- *The Montreal Protocol on Substances that Deplete the Ozone Layer has been universally ratified by 198 parties and as a result of its implementation, the overall abundance of ozone- depleting substances in the atmosphere has decreased over the past two decades, with projections to return to 1980 values in the 2030s for Northern hemisphere mid-latitude ozone.*
- *Between 2010 and 2019, global e-waste generation grew continuously, from 5.3 kg per capita to 7.3 kg per capita, while the environmentally sound recycling of e-waste increased at a slower pace, from 0.8 kg per capita to 1.3 kg per capita.*
- *The global fossil fuel subsidies amounted to more than $400 billion in 2018. The continued prevalence of these subsidies, more than double the estimated subsidies to renewables, adversely affects the task of achieving an early peak in global CO2 emissions.* »

The French situation is presented in, for example, *2018-Point d'Etape, France's Progress Report on the Implementation of the Agenda 2030*[31]. Apparent Domestic Materials Consumption (DMC) per capita is 11.7 t/inhabitant in 2014. This indicator takes into account non-metallic minerals (construction and infrastructure materials) which are in the majority, followed by biomass, fossil fuels and finally metallic minerals. This indicator is statistically very reliable, as it is derived from customs data, but does not fully take into account the direct and above all indirect impact on the consumption of materials in products consumed in France. The material footprint would give more reliable indications, as it would take into account the material content of imported finished products. Indeed, the tendency to produce outside France in order to consume in France complicates the calculation of the true impact of our consumption. For example, a 170g smartphone requires a total of 70kg of minerals and raw materials (50% metals, 30% polymers and 20% glass and ceramics) - see *Material Footprint: an indicator reflecting actual consumption of raw materials*[32]. Moving from an internal consumption indicator to a material footprint is complicated and depends heavily on the nature of the products consumed, as well as the scope of the material flow analysis. The material footprint for France would be higher than the apparent domestic consumption by factors varying from 30% (reference cited immediately above) to 100% (2018-Point d'Etape). If the material footprint is taken into account, the French value, like those of other EU

[31] www.agenda-2030.fr

[32] https://www.statistiques.developpement-durable.gouv.fr/sites/default/files/2018-10/datalab-essentiel-142-empreinte-matiere-eng-avril2018b.pdf

countries, is significantly higher than the global average. Efforts should be made to reduce it, in absolute terms.

Another important aspect is the "material productivity", given by the ratio between GDP and internal material consumption. The aim is to create more wealth with less material. Here, the aim is to increase this indicator.

This note will address indicators 12.2 (sustainable management and sound use of natural resources), 12.4 (environmentally sound management of chemicals and all wastes throughout their life cycle and significantly reduce their release into air, water and soil), and 12.5 (significantly reduce waste generation through prevention, reduction, recycling and reuse). These indicators are in part common to some of SDO 8, notably 8.4.

Achieving these targets requires :

- an improvement in the performance of materials or material productivity ("materials efficiency") to enable needs to be met and wealth to be created with fewer raw materials.

- an overall reduction in the consumption of raw materials, particularly for manufactured products. This can be achieved by aiming to increase the life span of products.

- a reduction in the volume of waste, which will only be possible if products are designed from the outset to be deconstructed (ecodesign) and recycled or reused.

- the substitution of raw materials with a high environmental impact (either for extraction or for toxicity reasons) by others with a lower impact.

- the evolution of production methods and tools, including the supply chain, to reduce the carbon footprint.

The CO2 footprint of products as well as the production of waste must also be reduced.

1 - Consumption and non-food products

Today, growth is focused on the consumption of goods, products and services. The consumption of goods and products is very often based on the use of raw materials, water and energy. In this consumer based model, the most frequent possible renewal of products is sought, based on advertising, social pressures, the life span of products and a perception of innovation.

The dematerialisation of consumption, through digital services, e.g. streaming music and video, can reduce the consumption of raw materials and water, although the energy consumption of digital systems must be taken into account and is far from negligible. More generally, « live performance » (e.g. theatre and concerts) is low in input and energy consumption, but brings added value, and should be carefully considered in the context of a largely dematerialised economic growth.

As far as "material" goods and products are concerned, their production consumes raw materials, energy and water, and produces CO2 and pollutants (especially if mining production is included). Their use often requires (e.g. cars, household appliances...) energy with CO2 emissions and pollutants, but not always (e.g. furniture, bicycles...), see Figure 1.1.

Consumption can be simplistically categorised (more comprehensive analyses exist, see for example the "Maslow pyramid") into two categories, "needs" and "wants". There is some arbitrariness in this choice. As an example :

- Needs: products related to mobility (from train to bicycle, via the car), food (fridges, cooking, kitchen utensils), housing (heating, furniture), etc.
- Want: home furnishings, fashion, leisure facilities. The word « want » is a little pejorative, because they are components, a little less essential, of human nature. The "luxury" sector is an extreme example where the added value is very high in relation to the raw materials and energy consumed in manufacturing (the added value comes from the design, possible manual production, perceived quality and the symbolic value of the brand).

Often, needs-based products have a significant and unavoidable content of materials and energy. Their lifespan should be extended. For "want" products the added value of, for example, design is much higher and the "material" content lower. Nevertheless, the purchasing interval should be increased.

If consumption and products are to correspond to sustainable development objectives, the aim must be to maximise added value (or wealth creation) in relation to, for example, the consumption of energy and raw materials. This can be done by respecting a number of simple criteria:

- improving functionality (ergonomics and design) without sacrificing recycling possibilities.
- improving the durability of products (we know very well the modes of degradation, e.g. fatigue, corrosion for metals, ageing for polymers). The problem today is to design and manufacture as accurately as possible :
- designing products to allow for performance upgrades (retrofits) to increase their life span.
- foresee the repairability of products (dismantling, component replacement, etc.).
- reduce the speed of replacement of "desirable" products (effect of fashion and societal influence)

The aim is to produce less, but better designed, higher quality, higher value-added products, in production conditions that respect the environment and human rights, etc. The aim is to produce less, but better designed, higher quality, higher value-added products, in production conditions that respect the environment and human rights, etc. This approach applies to products almost indiscriminately in relation to various uses (sole ownership, shared use, reuse), because to allow these uses, products will have to be well designed, durable, repairable, etc.

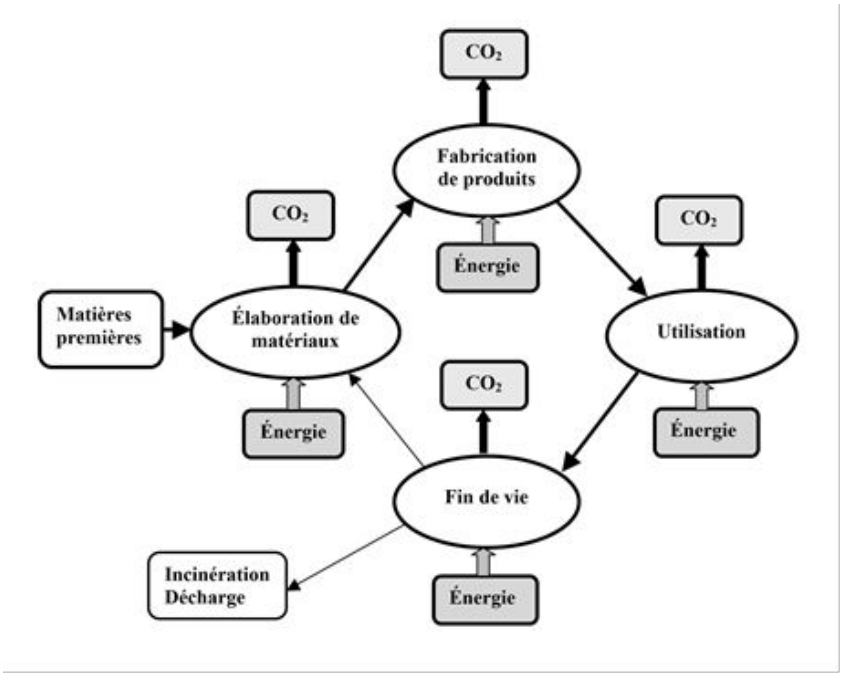

Figure II.1.1 Illustration of the share of energy (and CO2 emissions) in the product cycle[33]. Similar diagrams apply, with variations, for water consumption and for the production of pollutants.

With regard to end-of-life, products must be designed to be at least partially reusable (circular economy approach) and then easily dismantled to allow sorting and recycling of raw materials. This will require compromises, because while recycling of a car or an aircraft can be done under reasonable conditions, the same cannot be said for household appliances, and even less so for electronics (a modern smartphone contains about 60 items, 20 of which are considered rare and critical[34]). The recovery of all the elements contained in the phone is hardly conceivable today.

Special attention must be paid to the recycling of metal alloys and polymers. Steels can be easily recycled, as the treatments make it possible to eliminate almost all alloying elements (except accidental pollutants such as copper or lead). This is not the case for other alloys, e.g. aluminium. The situation for polymers is much more complicated, as they are almost all "formulated" with additives (plasticisers, stabilisers, mineral fillers, etc.) and rarely in a completely standardised manner. A minimum amount of standardisation work would be useful[35].

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[33] Based on M. F. Ashby, Cambridge University

[34] Based on J.-P. Raskin, Université de Louvain

[35] See e.g. pp 86-87 de *Global resources outlook 2019* — https://wedocs.unep.org/bitstream/handle/20.500.11822/27518/GRO_2019_SPM_EN.pdf

Proposals

Interdisciplinary skills are necessary to carry out life cycle analyses, material flow analyses, etc., which are essential to inform choices that are part of a sustainable development approach. The research and higher education system in France presents weaknesses for all interdisciplinary activities and it would be important to be at the level of the best international teams. It is also important that these approaches be part of scientific and engineering training courses.

Economic models corresponding to sustainability, product sharing or reuse are necessary. Interdisciplinary work between product designers/product manufacturers and economists is also necessary. The contribution of sociologists would also be necessary to better address the evolution of uses.

In order to make products truly more sustainable (whether for a single user, shared use or reuse) a system approach must be put in place, from design, to the possibility of repair, reuse and eventually recycling. In principle, today's product design is capable of taking these aspects into account. On the other hand, a repair system (with corresponding training) would have to be set up as well as systems to encourage reuse and facilitate recycling.

The generic way to make products and their consumption compatible with a sustainable development approach is to increase the legal guarantee period, gradually, up to probably about 10 years. This should increase the duration before replacement. To encourage repair, a tax incentive (reduced VAT) would give a clear direction. It would be interesting to apply it to all repairs and maintenance/maintenance operations (including automotive and industrial).

These points have been addressed in detail in a parliamentary report (Rapport du Gouvernement au Parlement on the advisability of extending the duration of the legal guarantee of conformity from two to five years, or even to ten years, for certain targeted categories of products. Pursuant to Article 70 of the Law of 17 August 2015 on the Energy Transition for Green Growth, April 2017), and includes tax incentives for the repair sector. It does not appear that this report has been followed by legislative measures to date.

In both cases, such measures could not be taken without European coordination.

2 - Production

Production processes, from the use of raw materials to production technologies and recycling channels are to be taken into account for today's industry, but also within the framework of post-Covid industrial recovery plans. Any industry that does not take into account environmental constraints and social requirements is doomed to failure in the long run. In order to maintain competitiveness, it is necessary to integrate the approaches of the Industry of the Future (or

"Industry 4.0"[36]). This would make it possible to manufacture quality products with high added value and therefore competitive. The "Industry of the Future" approach integrates the digital contribution of the complete manufacturing chain (from the design office to production) with the development of automation, the introduction of more robots, etc. The "Industry of the Future" approach is based on the use of digital technology in the production process. There is a broad consensus in France that this can only work on condition that the organisation of work and the place of operators are strongly revised. Environmental aspects are largely taken into account in the approach.

Environmental pressures lead to processes :

- which are energy-efficient and emit less CO2. This has a significant impact on a range of processes in many industrial sectors and can lead to :
  - heat treatments that lead to similar results with optimised time/temperature couples (e.g. metallurgy, electronics, etc.).
  - a change of heat source, e.g. from gas or fuel oil to electricity. This applies to all industries with firing or drying stages. Cement production is particularly affected by low-emission heating processes.
  - deeper changes, e.g. to produce steel without blast furnaces and coke or aluminium without graphite electrodes.

These orientations are part of the report of a group of experts under the direction of Benoit Potier[37]. It should be noted that the majority of the major industrial groups producing raw materials (e.g. metals, cement, glass, polymers, etc.) have undertaken to strongly reduce their CO2 emissions, or even to aim for zero CO2 in 2050.

- which are cleaner with the elimination of toxic products or by-products. This particularly applies to products affected by the REACH directive. Are particularly concerned:
  - surface treatment (elimination of Cr VI and Cd)
  - polymers with the elimination of certain additives and formulating agents.

Note: it is important that European standards are rigorously applied to imported products so as not to distort competition.

- which are less water consuming.

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[36] See Alliance Industrie du Futur — www.industrie-dufutur.org — and the report by the National Academy of Technologies of France *Industrie du Futur : du système technique 4.0 au système social*, November 2017.

[37] *Faire de la France une économie de rupture technologique*, DGE, DGRI et SGPI, 7 février 2020

- it should also be noted that many products are made from parts and sub-assemblies from many suppliers. The supply chain (logistic chain) becomes an important factor of performance, but also a source of CO2 emissions. An optimisation in terms of CO2 produced will prove necessary.

Economic factors (competitiveness and return on investment) must also be taken into account. The "Industry of the Future" or "Industry 4.0" approaches are well known and widely documented, but their application in the French industrial fabric is incomplete, particularly in SMEs[38]. For example, the rate of robotisation is much lower in France than in Germany or Italy. It would be advisable to continue to transform French industry by taking into account the digitisation of industry (and of process control with the introduction of sensors), an increased presence of robotisation, the renewal of production equipment and training at all levels of companies. One aspect that has now become very important is equipment maintenance, with a potentially high stake for preventive maintenance, based on sensors in a connected factory and the use of data analysis methods (big data applied to monitoring a machine fleet).

Initial experiences from the Covid-19 pandemic suggest that flexible factories that can quickly adapt to new products or new markets are an important asset for the future.

Although today the price of raw materials is generally low, due to low demand, this should not mask a long-term upward trend, with very strong price variations due to tensions between supply and demand. To varying degrees, this is true for almost all raw materials. It is a point of attention especially when developing new uses and products (e.g. batteries, wind turbines, electric motors...). From an industrial point of view, it is of course necessary to secure sources of supply, but also to improve the efficiency of materials use (materials efficiency) and possibly to look for substitutes.

Recycling is also important, both to reduce CO2 emissions and to free oneself in part from an excessive dependence on raw materials. For common metals (e.g. copper, steel, aluminium), recycling technologies are more or less in place. The recycling of rare earths is also well advanced. The key point is that recycling is no longer economically feasible when raw material prices are very low. The time constants between setting up an industrial recycling chain and fluctuating raw material prices are incompatible.

Recycling of glass is commonly carried out.

Polymer recycling deserves special attention. Although recycling of scrap in the factory is well under control, this is not the case for all polymers from products, with the exception of PET from bottles. In fact, additives are added to a large number of polymers to improve their formability (plasticisers), their UV resistance or their mechanical properties (mineral fillers). This formulation does not correspond to specific standards per polymer class and therefore makes recycling almost impossible. The introduction of European standards per polymer family would allow for greater

[38] See also *L'industrie du futur : du système technique 4.0 au système social* et *Industrie du futur : la montée en compétences technologiques des PME — Le cas des entreprises industrielles*, National Academy of technologies of France

recycling. Packaging deserves special attention and a search for new compromises guaranteeing sufficient food preservation and improved recycling possibilities.

Proposals

It is necessary to accelerate the implementation of the Industry of the Future (Industry 4.0) in all its dimensions:

- automation, robotisation, digital chain, logistics;
- work organisation, with better employee involvement;
- social and skills development;
- environmental (reduction of CO2 emissions, reduction of water consumption, elimination of pollutants and the use of toxic products) thanks to adapted processes.

Interactions with other SDGs

The production of products that have real intrinsic value (functionality, quality, durability) leads to a sense of pride in work "well done" (cf. the aeronautical or luxury industries - La Fabrique de l'Industrie/Académie des Technologies evening at the Collège des Bernardins). This restoration of the "meaning" of work has become a challenge for society. This has an impact on goals 3 and 13, and through the reduction of pollution on goals 14 and 15.

Housing and transportation: some people left behind

Jean-Pierre Chevalier (National Academy of Technologies of France), Bernard Tardieu (National Academy of Technologies of France)

Abstract. *This note deals with SDG n°11: "Make cities inclusive, safe, resilient and sustainable". It focuses on three aspects that have received little attention: housing for seasonal workers, transportation and teleworking, and mobility in highly rural areas. Recommendations concerning the need for further studies and potentiel actions are made for each of these aspects.*

Extract. *Progress towards the Sustainable Development Goals — Report of the Secretary-General* (High level political forum on sustainable development convened under the auspices of the United Nations Economic and Social Council, Juillet 2020) :

« Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

19. Rapid urbanization is resulting in a growing number of slum dwellers, inadequate and overburdened infrastructure and services, and worsening air pollution. The COVID-19 pandemic will hit hardest the more than one billion slum dwellers worldwide, who suffer from a lack of adequate housing, no running water at home, shared toilets, little or no waste management systems, overcrowded public transport and limited access to formal health care facilities. Many of these populations work in the informal sector and are at high risk of losing their livelihoods as cities shut down. Urgent response plans are needed to prepare for and respond to outbreaks in informal settlements and slums.

- *The number of slum dwellers reached over 1 billion in 2018, which represents 24% of the urban population, up slightly from 23% in 2014. Numbers of people living in urban slums are highest in Eastern and South-Eastern Asia (370 million), sub-Saharan Africa (238 million) and Central and Southern Asia (226 million).*

- *Access to adequate, reliable and safe public transport is an urban basic need. Per 2019 data from 610 cities from 95 countries, only half of the world's urban population had convenient access to public transport, defined as living within 500 meters walking distance of a low-capacity transport system (like a bus stop) and within 1,000 meters of a high-capacity transport system (like railway and/or ferry terminal).*

- *2019 data collected from a sample of 755 cities from 95 countries show that, through the 1990-2015 period, most urban areas recorded a general increase in the extent of built-up area (defined as the presence of buildings) per person. On average, all regions except sub-Saharan Africa and Eastern and South-Eastern Asia recorded a consistent increase in the built-up area per capita, with Australia and New Zealand recording the highest values. á Based on 2019 data from 610*

cities in 95 countries, the share of land allocated to streets and open spaces—critical to cities' productivity and social and health dimensions of their populations —averaged only about 16% globally. Of these, streets accounted for about three times as much urban land as open public spaces (e.g. parks, river-fronts). The share of population who could access open public spaces within 400 meters walking distance along a street network averaged 46.7%. »

This report focuses on points that are largely aimed at developing countries, although they also apply to many territories in France. These territories, characterised by high unemployment rates, high poverty and a low average level of education, correspond to territories heavily affected by the loss of industrial jobs. They have also often been strongly affected by the COVID-19 epidemic. This note focuses on three specific and often forgotten aspects.

1 - Housing for seasonal workers

The housing issue is very sensitive for seasonal workers, especially those working in the agricultural sector of fruit and vegetable picking. It can also concern certain types of livestock and fisheries that have seasonal cycles. The influx of seasonal workers begins in the spring and lasts until the fall. These workers are generally registered and come from all European countries, which sometimes serve as stopovers for workers from further afield, such as South America, Asia and Africa. Their economic contribution is crucial for the fields that employ them. The world of construction and public works has the practice of such temporary accommodation. On the other hand, there are no real good practices or recommendations in the field of food processing. In general, the employers themselves have modest incomes. It would therefore be counterproductive to establish binding regulations that would jeopardise these sectors (as is already the case for e.g. fruit picking). However, workers, rarely families, must be housed in comfortable and hygienic conditions. This is particularly sensitive in times of epidemics, including contagious diseases associated with these trades, because then promiscuity and lack of proper sanitation multiply the contagion and the development of clusters as has been observed in Germany (sometimes for non-seasonal activities). A particular approach is undoubtedly needed for cold chain workers, who seem to be very sensitive to various contagions.

Recommendations

Analyse in each region the seasonal population: number, gender, length of presence, average age, presence of children.

Analyse with employers and their representatives through the trade unions and chambers of agriculture in the region the specificities of the tasks and the housing capacities currently mobilised. Clarify the legal status of this housing. To hear seasonal workers and their point of view.

Set up a policy to improve this housing at regional or departmental level.

2 - Mobility and teleworking

Teleworking, by avoiding travel, makes it possible to achieve reductions in CO2 emissions, especially if the journeys are made in a car with a combustion engine. For example, in the case of a worker of any hierarchical level, employee or self-employed, who lives far from his or her place of work, regular teleworking for 2 days a week would reduce consumption and emissions by 40% for transport by car and bus with combustion engines. This emission saving can be valued according to the price of CO2 and its progressive increase. This saving in CO2 emissions therefore has a real economic value. This value is immediate and therefore precedes the emission savings of battery electric vehicles or hydrogen-powered heat pumps and the gradual change in urban sprawl. Teleworking can be more profitable for our country than installing photovoltaic panels on the roof or changing a boiler. It should therefore be accompanied by incentives.

It would also be interesting to develop teleworking in rural areas or quite remote areas around large cities and medium-sized towns. To this end, municipalities could set up "co-working" spaces, allowing teleworking in good conditions (ergonomics, high-speed internet, socialisation, etc.). This should reduce travel, revitalise areas of low activity and ensure decent working conditions.

Recommendations

Analyse the real impact of teleworking on GHG emissions, taking into account transport, changes in heating practices and building use, including less busy office buildings.

If the analysis is convincing, propose incentive schemes targeted at men, women and children who live far from their workplace or school and who are obliged to use vehicles that emit GHGs.

3 - Mobility in highly rural areas

These many and varied rural areas in France are living and working places for many French families. Very little, if any, public transport is actually available. In the mountain areas, the frequent practice is to use 4x4 diesel vehicles. In rural areas without frequent snow and steep gradients, the practice is to use small diesel vehicles. These vehicles are currently being discredited.

It would be incomprehensible to penalise these populations who watch over our national territory and give it life.

The need for autonomy is generally relatively modest and compatible with battery recharging. The habitat is frequently compatible with the installation of night-time recharging stations in residential areas. The adaptation of electric vehicles already in production to this particular demand deserves attention, both to solve a difficult problem for the inhabitants of rural areas and to disseminate new practices of GHG emission-free mobility.

Recommendations

Take into account the specific wishes of the populations of large rural areas, according to the specific aspects of geography and climate. Thanks to public procurement the best solutions to meet these wishes should be tested. There is every reason to believe that car manufacturers will respond to this initial demand and then follow the buyers.

Interactions with other SDGs

Mobility and housing are mainly part of SDG 11, but for France they also interact with SDG 1, 3 and 9.

Agriculture and food: various cultivation systems

Bernard Le Buanec (French Academy of Agriculture, National Academy of Technologies of France)

Abstract. *This note compares conventional agriculture to other farming systems such as organic ("AB" in French) and high environmental value ("HVE" in French) systems, in terms of food, air quality, environmental costs, agricultural stability and food sovereignty. This comparison illustrates the complexity of choosing a cultivation system compatible with all sustainable development goals, and the absence of ready-made solutions. Further research and consultation involving all stakeholders are needed to design a productive and farm input-efficient system that ensures a healthy, sustainable and affordable food production, combats global warming and preserves biodiversity.*

In France, as far as agriculture is concerned, the term "restart" is probably not justified because during the period of containment due to the pandemic, while there was a cessation of many activities, there was no cessation of agriculture. We can clearly say that our agriculture has played its role and that there has been no food crisis in France because of agricultural production. It should also be noted that the various assertions we have seen in the press and on social networks saying that the epidemic was due to global warming, deforestation, loss of biodiversity or "intensive" agriculture are debatable[39].

Having said that, thinking about agriculture and sustainable development is not new, it is necessary and must be continued.

Agriculture is an extremely vast whole which, by its very nature, has an impact on a very large number of sustainable development objectives. Without wishing to be exhaustive, these include sufficient, safe and sustainable food and air quality (SDG2 and SDG3), reduction of environmental costs and supply chains (SDG12), climate change (SDG13), terrestrial life, soil maintenance and biodiversity (SDG15). In fact, agriculture and food have an impact on 10 of the 17 SDGs. In an analysis of the impact of agriculture on the SDGs, it is necessary to have an overall view but also to remain close to the population. On the latter point in particular, one should be wary of generalising to other countries solutions developed in certain economic and agronomic environments. The aim of this note is to show the complexity of the problem and the absence of ready-made solutions. Reflection on agro-ecology is in full development. The term has been used since the beginning of the 20th century and today many agricultural systems are related to it. In the document "*Improving the economic and environmental performance of agriculture: the costs and*

[39] Jean-François Gueguan et al. « Forests and emerging infectious diseases : unleashing the beast within » in *Environmental Research Letters*, 2020.

benefits of agro-ecology"[40] the authors refer to twelve different systems, including, among others, organic farming and so-called High Environmental Value (HVE) systems. However, if one wants to compare these systems with so-called conventional agriculture, there are few data, except for those comparing it with organic farming. While being aware of this limitation, this note will therefore be based mainly on these data. Moreover, only organic agriculture is the subject of fixed targets, 15% of the cultivated area in 2022 and 25% in 2030.

Food and drink

The sanitary quality of agricultural production in France is satisfactory, whether it is that of organic or so-called conventional agriculture, with no significant differences in terms of consumer health.

On the other hand, there is a strong difference in the quantities produced per hectare between organic and conventional. Numerous meta-analyses[41, 42, 43] have been carried out on the subject and show that, on average, the loss of yield in organic farming, all species and crops taken together, is in the order of 20 to 30%, with wide variations. In general, these meta-analyses take into account a wide variety of agricultural systems, some of which have low productivity, such as in developing countries. The differences are much greater in countries with productive agriculture. For example, for cereals in France, the decrease in organic yield is on average 50%[44]. This decrease in yield has a very strong impact on the final consumer price with an increase of 50% to 75%. This raises the question of access to food for the least well-off, given that in France 7 million people live below the poverty line and 4 million benefit from food aid. According to the latest study by the Observatory E. Leclerc des Nouvelles Consommations Observatory (6 May 2020) on Covid-19 and consumption[45], 95% of French people declare that they will continue to pay more attention to price, the first criterion of choice, after the health crisis. It is therefore essential to take this factor into account in thinking on the evolution of agriculture. One solution to the problem of loss of yield and price increases would be, on the one hand, to reduce food losses and wastage and, on the other

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[40] Grémillet A. et Fosse J.(2020), Document de travail, n° 2020-13, France Stratégie, août.

[41] de Ponti T, Rijk B, van Ittersum MK (2012) « The crop yield gap between organic and conventional agriculture », *Agric Syst* 108: 1-9.

[42] Seufert V, Ramankutti N, Foley JA (2012) « Comparing the yields of organic and conventional agriculture », *Nature* 485:229-232.

[43] Lesur-Dumoulin C, Malézieux E, Ben-Ari T, Langlais C (2017) « Lower average yields but similar yield variability in organic versus conventional horticulture. A meta-analysis », *Agron. Sustain. Dev* 37:45 DOI 10.1007

[44] Guyomard H. (dir.) (2013), *Vers des agricultures à hautes performances, Volume 1 : Analyse des performances de l'agriculture biologique,* pp 21-40.

[45] https://nouvellesconso.leclerc/consommation-le-covid-19-change-la-donne/

hand, to change the food behaviour of consumers. However, these are factors that are difficult to control because, essentially for food behaviour, they are individual decisions that take a long time to implement.

Air quality

Pesticides[46] including plant protection products are suspected of polluting the air and having a negative impact on health. Their use must therefore be limited as much as possible and follow strict rules. ANSES has studied the results of analyses carried out during national and regional campaigns on 70 substances[47]. With all the precautions taken, this report concludes: "Thus, on the basis of the available data, there is no evidence of a level of background contamination of the ambient air that would lead to existing toxicity benchmarks being exceeded".

Environmental costs

There are three main aspects to consider: climate change, soil conservation and biodiversity.

Climate change. In France, agriculture accounts for around 20% of greenhouse gas emissions due to the production of methane, mainly from ruminants, nitrous oxide and carbon dioxide. Another source of greenhouse gases comes from supply chains. Numerous research programmes are underway to reduce these emissions. The current situation shows that the production of greenhouse gases per tonne of dry matter produced in field crops is lower in organic farming than in conventional agriculture, mainly due to the non-use of soluble nitrogen fertilisers. In dairy cattle farming there is little difference between the types of production, with sometimes a slight advantage for conventional farming. Finally, in pig production, the advantage is clearly in favour of conventional.

If we go back to field crops, the analysis needs to be refined, as Arthur Riedacker[48], who contributed to the IPCC reports that won the Nobel Peace Prize in 2007, points out: in France, in the case of wheat, because of a 50% drop in organic yields, to maintain production it would be necessary to clear one hectare of forest or meadow for each hectare of organic crops at a cost of 200 t of CO2 per hectare, i.e., over a period of 50 years, 114 kg of CO2 eq/t, smoothed out over a

[46] In "pesticides" the ANSES report includes plant protection products, biocidal products and veterinary and human anti-parasitics.

[47] Rapport ANSES juin 2020. *Campagne exploratoire des pesticides dans l'air ambiant. Premières interprétations sanitaires.*

[48] Riedaeker A. (2008). « Reconsidering approaches for land use to mitigate climate change and to promote sustainable development ». In *Global warming and climate change*, Chap. 18, 38 pages, Grover ed.

period of 50 years. A similar approach made in 2019 by Laurence Smith et al.[49] indicates that the transition of England and Wales to organic farming would increase global greenhouse gas emissions due to the need to import to meet food demand. There is another element to be taken into account. In addition to being a source of greenhouse gases, crops are also carbon pumps. This function is all the more effective the higher the yields. A study by ARVALIS shows in the case of wheat that the net balance of tonnes of CO2 equivalent captured/ha/year is 7 for organic and 18 for conventional[50].

It is also important to take supply channels into consideration. Two aspects need to be taken into account: supply logistics on the one hand and production and on-farm storage on the other. The short circuits are under development and have experienced a strong development during the confinement period. However, they only represent around 10% of food purchases.

With regard to supply, there is on the one hand the supply of sales outlets and, on the other hand, the movement of consumers. For the supply of the points of sale, although the products travel a shorter distance in the context of local circuits, energy consumption and greenhouse gas emissions are not, however, systematically lower. Indeed, emissions per kilometre travelled and per tonne transported are about ten times lower for a 32-tonne heavy goods vehicle and one hundred times lower for a transoceanic freighter than for a 3.5-tonne van. For consumer travel the differences are not as clear-cut, but direct sales do not systematically imply less travel for the consumer, who may even have to travel more if the distribution points are dispersed. On-farm production in one country may also be more energy-intensive than in another country. On-farm processing and preservation processes for small quantities are generally less optimised than in the agro-food industries.

Soil conservation. There are two aspects to consider: fertility and erosion. In general, the organic matter content of soils in AB is higher than in AC[51]. This superiority is essentially linked to the application of organic fertilisers to avoid nutrient deficiencies. It should be noted, however, that the quantity of farmyard manure available is becoming more and more limiting and that this organic fertilisation actually corresponds to a transfer of fertility from the plots where the straw is harvested to the one where this manure is spread[52]. Here again, we find the situation noted concerning carbon sinks: as production in AB is lower than in AC, the quantity of organic matter

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[49] Laurence G. Smith, Guy J.D. Kirk, Philip J. Jones, Adrian G. Williams (2019). « The greenhouse gas impacts of converting food production in England and Wales to organic methods », *Nature communications* https://doi.org/10.1038/s41467-019-12622-7

[50] Presentation Arvalis at the "Symposium des commissions nationales", 15-16 January 2020, Paris.

[51] H.L. Tuomisto, I.D.Hodge, P.Riordan, D.W. Macdonald (2012). « Does organic farming reduce environmental impacts? A meta-analysis of European research », *Journal of Environmental Management* 112: 309-320

[52] see also Nesme T. et al. (2016) « L'agriculture biologique peut-elle se développer sans abandonner son principe d'écologie ? Le cas de la gestion des éléments fertilisants », *Innovations Agronomiques* 51: 57-66.

to be buried is lower. This is consistent with the remarks of Gosling and Shepperd[53] who also note that the levels of extractable phosphorus and potassium are significantly lower in AB leading to soil impoverishment. This depletion is also observed on the Arvalis experimental farm in Boigneville.

Concerning erosion control, the two most effective means are inter agricultural plots management and no tillage. Inter-plot management does not depend on the type of farming implemented. They are essentially the respect of grassed borders of the plots and the planting of hedges. No-till is one of the main features of conservation agriculture developed in the United States from the 1950s onwards. One of its limiting factors is weed control and its development was facilitated by the use of total weed killers. Conservation agriculture is therefore more difficult in AB due to the ban on synthetic herbicides. A significant increase in acreage has taken place in North and South America due to the development of genetically modified varieties tolerant to total herbicides[54]. The ban on glyphosate makes conservation agriculture more difficult, but an additional derogation will be granted in France until 2023, when it is hoped that alternatives will be found[55].

Biodiversity. The development of human activities generally has a significant impact on biodiversity. Deforestation and the use of pesticides that also have an impact on useful fauna are examples of this. What type of agriculture should be favoured to avoid this negative impact? There is no simple answer. As is often the case, the effects of organic farming are compared to those of conventional agriculture. Generally speaking, the diversity of species is much higher, of the order of 10.5% to 45% at the level of the organic plot. On the other hand, at the farm level it is only 4.6% and at the regional level 3.1%[56]. A landscaping, plot edges, hedges, ... is very effective in maintaining biodiversity in conventional agriculture. It is possible to refer here, for example, to the "high environmental value" or HVE certification created from 2011, following the Grenelle Environment Forum. This certification implies an obligation of results and not only an obligation of means as for organic farming.

Another debate is that of land sharing versus land sparing. There are two opposing strategies: on the one hand, land sparing, i.e. agriculture aimed at limiting the amount of land cultivated in intensive production in order to safeguard areas rich in biodiversity, and on the other hand, land

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[53] Gosling P. ,Shepherd M. (2005). « Long-term changes in soil fertility in organic arable farming system in England, with particular reference to phosphorus and potassium », *Agriculture, Ecosystems & Environment* 105, 425-432.

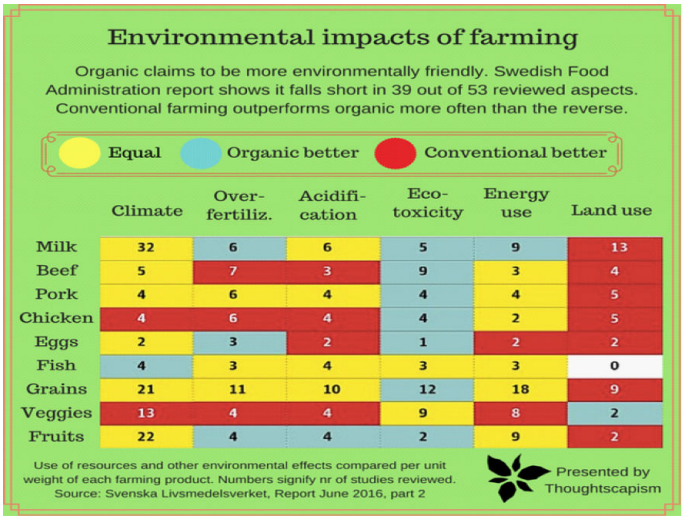
[54] https://geneticliteracyproject.org/2017/06/23/gmos-help-farmers-achieve-sustainable-conservation-agriculture/

[55] https://agriculture-de-conservation.com/LE-GLYPHOSATE-EST-IL-LE-4E-PILIER.html

[56] Schneider , Manuel K.and Lüscher, Gisela and Jeanneret, Philippe et al. (2014). « Gains to species diversity in organically farmed fields are not propagated at farm level », *Nature communications*, 5(4151). 1-9.ISSN 2041-1723

sharing aimed at combining agricultural production and biodiversity conservation in the same areas, generally by adopting farming practices that are accompanied by a loss of productivity and therefore requiring an increase in cultivated areas. This debate, known as the Borlaug Hypothesis, has been the subject of numerous publications, the vast majority of which are in favour of land sparing, particularly in developing countries and in regions with a long agricultural history. The debate is not over[57].

A report by the Swedish Food Administration summarises the situation well in the following diagram[58]:



	Climate	Over-fertiliz.	Acidifi-cation	Eco-toxicity	Energy use	Land use
Milk	32	6	6	5	9	13
Beef	5	7	3	9	3	4
Pork	4	6	4	4	4	5
Chicken	4	6	4	4	2	5
Eggs	2	3	2	1	2	2
Fish	4	3	4	3	3	0
Grains	21	11	10	12	18	9
Veggies	13	4	4	9	8	2
Fruits	22	4	4	2	9	2

The number in the different boxes represents the number of studies considered. Except for ecotoxicity, in 21 cases the impacts of the two types of agriculture are equivalent, in 16 cases conventional agriculture is better and AB is better in only 7 of the 42 cases studied. The case of ecotoxicity must be considered separately because the analysis takes into account pesticides that have been used for a long time, most of which are now banned. Today's products are increasingly safe and used at lower doses. This does not mean that this aspect should be taken lightly.

The paper by Grémillet and Fosse cited at the beginning of this note, comparing different agricultural systems on the aspects of input reduction and intensification of ecological functionality, ranks organic farming first in input reduction but ninth out of twelve on intensification of ecological functionality, well behind the most demanding HVE certification.

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[57] Law E.A., Wilson K.A. (2015). « Providing context for the land-sharing and land-sparing debate », *Conservations Letters*, 8(6), 404-413.

[58] Use of ressources and other environmental effects compared per unit weight of each farming product. Svenska Livsmedelsverket. Report June 2016, part 2. Rapport en suédois analysé en anglais sur https://thoughtscapism.com/2016/07/21environnemtal-impacts-of-farming/

Agricultural stability and food sovereignty

Although, as we have seen, the pandemic has not highlighted problems of stability in our agriculture or food sovereignty, it has provided an opportunity to take up these issues again.

The stability of agriculture. The development of agriculture in France over the last sixty years has led to an extreme simplification of crop rotation and a separation of agriculture and animal husbandry. This has led to undeniable difficulties in controlling diseases, insects and weeds and in fertilisation and soil quality. It is therefore important to revisit these practices.

As regards the diversity of crop rotation, there are two approaches: either to have a mixture of different varieties and species on the same plot, or to have highly differentiated rotations on the farm. The first approach has advantages in terms of crop protection but also significant disadvantages, particularly in terms of establishment and, above all, harvesting. It requires highly specialised agricultural equipment and often specific markets that are still not well developed. It is also more labour-intensive, resulting in higher costs. The second approach is easier to implement but, to be really effective, it requires a fairly large number of crops, which in turn requires a farm of sufficient area, 100 hectares being probably the lower limit. Depending on the agro-pedological conditions, thanks to the development of digital technology, there are nowadays decision support tools that make it possible to choose the most suitable rotations[59].

Bringing agriculture and livestock farming together poses many more difficulties, particularly of three kinds: farmers specialising in crop production are not breeders, they are different professions and the relocation of livestock to farms will therefore require specific training and the learning of a new profession. The concentration of livestock farming in certain regions has led to very heavy investments which need to be amortised. On the other hand, livestock farming implies heavy downstream structures if they are to be profitable; it is a matter of a sector like that of pork in Brittany[60]. Finally, as many farmers have pointed out, the new inhabitants of so-called neorural farming communities are very reticent about the development of livestock farming in their neighbourhood, as recent legal actions have shown us.

Food sovereignty. France is a food importer but also an exporter. It has a slight surplus but this surplus is decreasing. There is currently no problem of risk of shortfall and the pandemic has clearly shown this. The only real problem has been that of foreign agricultural labour and it has been quickly overcome. However, there is more and more talk of establishing France's food sovereignty. To put the subject into perspective, on 18 July 2020 the French Minister of Agriculture announced the holding of a conference on food sovereignty not at national but at European level. Beyond the European and national levels, the question also arises at the level of the regions for

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[59] Le Buanec B. (Dir), 2019. *L'agriculture face à ses défis techniques, l'apport des technologies*, Académies des technologies et d'agriculture de France, Presses des mines.

[60] Philippe Gate et al., 2020. « La diversification comme réponse à la multi-performance des territoires » in *Covid-19 et agriculture, Une opportunité pour la transition agricole et alimentaire ?* pp. 161-188, Académie d'agriculture de France, Presses des Mines.

territorial autonomy. This autonomy will be very difficult or even impossible to achieve due to socio-economic, biophysical and ecophysiological constraints. Economically, there are problems of national and international competitiveness and, in France, the appellations of controlled origin are a commercial asset, particularly for our exports (wines, champagne, cheeses...) but a handicap for the diversification of cultures. It is unlikely to see the Champagne vineyards transformed to produce cereals and vegetables. It should also be noted that not all crops grow everywhere. However, if we want to reinforce territorial autonomy, we will have to enhance and develop access to water, in particular by increasing the reservoirs. It will also be necessary to innovate in small storage and processing units.

Conclusions and recommendation

It is necessary to make our agriculture more input-efficient while maintaining a good level of productivity, to ensure healthy and sustainable food production, to fight against global warming and to preserve biodiversity. Changes will be necessary but there are currently no ready-made solutions and there should be no mistake on the way to implement them. Research and consultation with all stakeholders will be necessary. All this will take time. In a June 2020 article in La Recherche, Pierre-Marie Aubert believes that a decade should be enough. This is undoubtedly ambitious. During the "Covid 19: Territorialisation, Agriculture and Food" webinar organised by the Academy of Agriculture and Agreenium on 17 June 2020, the prevailing opinion was that it would probably take a generation.

Sustainable food production

Isabelle Chuine (French Academy of Agriculture, French Academy of Sciences) and Denis Couvet (French Academy of Agriculture)

The authors thank Nathalie de Noblet and Sandra Lavorel for their contribution. This note is an expanded version of a text published in the book entitled Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?[61].

Abstract. *The Covid-19 health crisis has revealed a lack of resilience of our societies when facing large-scale crises in several areas, including food supply. The purpose of this note is to show how the transition to sustainable food production makes our societies more resilient to such crises. It contains an analysis of the problems related to food and agricultural production methods, including public health, preservation of biodiversity and of services provided by nature, control of greenhouse gas emissions, and general principles for responding to them, as well as proposals for policies that generate employment. Some elements of this analysis are valid only for France and the countries of the European Union.*

I - Objectives and general principles

At least three main, complementary objectives can be considered:

- Reducing production variations, especially the ones due to climate change, by making production systems more resilient to climatic and natural hazards;
- develop sustainable agricultural systems to reduce consumption of natural resources and their environmental and health impacts, and contribute to achieving the MDGs;
- meet societal expectations for healthier food that respects the natural environment from production to processing, packaging and sale, as these expectations are embedded in several SDGs.

In order to achieve these objectives in a coherent way, at least two types of general principles can be proposed, the first concerning the first two objectives, the second concerning the third objective.

1 - Ensuring a better resilience of farms to crises (linked in particular to natural and climatic disasters...)

[61] Chuine I., Couvet D. Résilience de nos sociétés et de l'agriculture face à des crises : place de la biodiversité. Michel Dron et Philippe Kim-Bonbled (Dir.), *Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?*, Paris : Presses des Mines, collection Académie d'agriculture de France, 2020, p : 39-56.

One way to increase farms resilience - and therefore of agriculture and our food - is to promote the diversification of production, as well as of associated practices for the same production, and furthermore to increase per se their autonomy, their capacity to absorb shocks.

The benefits of diversifying production in space and time are many and varied.

Crop rotations have long been the basis of agricultural practices, in particular to preserve soil fertility and limit phytosanitary risks. The appearance of agricultural inputs in the second half of the 20th century led to a reduction in the diversity of species and varieties cultivated and to the specialisation of agricultural production systems. However, the diversification of crop rotations, in space and time, at farm and commodity chain level, has many advantages in resisting the hazards that are summarised below. This diversification should be encouraged.

a) Reduction in the use of chemical inputs (pesticides and fertilisers)

- regular changes of crops on a plot break the development cycles of weeds, making it possible to reduce or even avoid the use of herbicides;
- Since pathogens (insects, fungi, bacteria, viruses) are adapted to certain species of plants known as hosts, the alternation of host and non-host plants reduces the relative risk of disease outbreaks and therefore makes it possible to reduce the use of insecticides and fungicides;
- the introduction of leguminous plants (alfalfa, peas, lentils) in crop rotations fixes nitrogen from the air and transforms it into natural nitrogen fertilizer that can be used by the following crop, thus reducing the use of synthetic nitrogen fertilizers and thus GHG emissions.

b) Limiting soil degradation

Cultivated species differ in their root depth and density, and thus exploit different layers of soil, which limits soil compaction.

c) Improved resistance to climatic and natural hazards

Combining on the same plot, or on mosaics of small plots, different crops and different varieties makes it possible to combine different water, light and nutrient use strategies, which can limit competition between varieties and crops for these resources. These different crops and varieties also have different water and heat stress resistance capacities and different pest and pathogen resistance capacities, which slows the spread of pests and pathogens and limits yield losses during extreme weather events. The complementarity and redundancy of these different strategies and resistance capacities lead to greater crop resilience to natural hazards.

d) Landscape and plot diversification

The increase in the diversity of crops and varieties in the field makes it possible to create a mosaic of habitats, which is conducive to maintaining biodiversity, because species have affinities that vary

according to the type of habitat. Greater biodiversity can in turn provide further services to agriculture, notably for pollination, pest and disease regulation, soil quality, regulation of local climatic conditions and water resources, and mitigation of the effects of extreme weather events (storms, floods).

e) Reduction of financial risks on the farm

These can be obtained by :
- reducing operating expenses related to purchases of fertilisers and pesticides, by making them less sensitive to price variations;
- spreading the workload more evenly over the year, due to the diversity of biological rhythms of cultivated species;
- reducing the risk of yield losses;
- varying sources of income, which reduces the risk of climatic and economic hazards, exposure to price volatility risks.

2 - Supporting production patterns that contribute to sustainable diets

A sustainable diet is one that has a lower impact on the environment, contributes to food and nutrition security and a healthy life for present and future generations.

In OECD countries, the challenge is to move towards more vegetarian diets, lower in sugars, fat and empty calories' content. In addition to improving human health, such diets reduce the environmental impacts of agriculture: meat, sugars and empty calories are costly to produce in environmental terms, as they require land (for the production of animal feed in particular), fertilizer and pesticides' inputs, soil tillage... Indirectly, the reduction of these productions favors an increase in 'natural' areas, which provide multiple services to humans, like water supply, food, medicines, renewable energy, raw materials, regulation of the climate and of the water and nutrient cycles, physical and mental well-being of human populations[62,63]... Moreover, according to many scientific scenarios, reduction in food demand provides the benefit that 'natural' areas' growth does not lead to food prices growth[64].

II - Some tools

These tools have to be considered in a systemic framework of agro-ecology. Agroecology aims to simultaneously advance the economic performance, environmental performance and social quality of production systems for both farmers and society. Agroecology revisits agricultural practices in the

[62] Guerbois, C. et Firtz, H. (2017). « Patterns and perceived sustainability of provisioning ecosystem services on the edge of a protected area in times of crisis », *Ecosystems Services* (28) 196-206

[63] Voir la note « Stopper le déclin du vivant », I. Chuine et D. Couvet, p. 83.

[64] Obersteiner, M. et al. (2016). « Assessing the land resource–food price nexus of the Sustainable Development Goals », *Science Advances*, 2(9), e1501499.

light of our knowledge of ecological processes in order to make crops and livestock more resilient to hazards while maintaining similar or even higher yields. Its principles and logics are explained in the box below.

Logics and benefits of agro-ecology in achieving SDGs

The fundamental principles of agroecology are:

- **Decreasing the use of phytosanitary products**. This is not only a major public health issue, but also an environmental and economic one. Crop protection products kill pests and pathogens, but also species that are necessary to the proper functioning of ecosystems, to humans, such as bees. One of the ways of reducing the use of these products is to use biocontrol, i.e. plant protection methods using natural mechanisms (e.g. use of predatory species of crop pests).
- **Reducing the use of antibiotics and medicines on livestock farms** in order to reduce the risk of antibiotic resistance.
- **Use varieties and breeds that are** better adapted to local pedoclimatic conditions, more resistant to pests and pathogens and, above all, more diversified.
- **Maintain and enrich the soil**. Soil health is a very important condition for crop productivity. However, modern agricultural practices have tended to deplete it in terms of organic matter (an increasing use natural fertilizers is a response) and biodiversity (favorizing engineering soil species such as earthworms is a response). One of the principles of agroecology is to maintain a permanent plant cover and to limit tillage, which has many positive effects. This limits erosion (and thus soil loss) and the formation of surface crust (which limits water infiltration and promotes surface runoff). It also limits water pollution (leakage of nitrates, plant protection products and pathogenic microorganisms) and greenhouse gas emissions (winter denitrification of soils under anaerobic conditions). Finally, it also maintains and protects soil biodiversity (from macrofauna to microorganisms), which ensures that soils function properly, and increases the amount of carbon that will remain in the soil (see Initiative 4 per thousand: https://www.4p1000.org/fr).

The agro-ecological transition requires diagnostic and decision-support tools for farmers. In addition to meteorological forecasting tools, forecasting tools for health and agroclimatic risks will have to be improved. It will require training for future farmers as well as for active farmers, the development of production tools that consume less energy and raw materials, and varieties that are better adapted to future climatic conditions.

As a result, agroecology contributes to sustainable development objectives in many ways:
- Food security (SDG 2)
- Improving the health of farmers and consumers (SDG 3)

- Improvement of water quality (SDG 6)
- Responsible production (SDG 12)
- Improving the status of terrestrial and marine biodiversity, ecosystem services and soil quality (SDG 14 & 15)
- Climate change mitigation (SDG 13)
- Technological innovations (SDG 9)

While the contributions of agro-ecology to the various SDGs have not yet been fully quantified, its contributions to DO 13 climate change have been the subject of several reports, including IDDRI's report *'An agroecological Europe in 2050: multifunctional agriculture for healthy eating'*[65], which indicates a 36% reduction in greenhouse gas emissions between 2010 and 2050 thanks to a Europe-wide agro-ecological transition scenario. This reduction in GHGs is primarily attributable to "the nitrogen sobriety of the scenario: fewer N2O emissions linked to the application of fertilisers in direct emissions, and almost total elimination of emissions associated with the manufacture of inputs". It is also attributable to significant reductions in energy consumption and improved effluent management. Other studies indicate comparable effects.

Within the framework of agro-ecology (see above), at least five categories of tools can be distinguished. Listed below, from the least to the most inclusive. They correspond to previous public policies, some have been proposed by stakeholders[66], or by IPCC, in particular the *Special Report on Climate Change and Land*[67].

1- Incentives to diversify production

Beyond diversifying crop rotation (the different crops on a given farm at a given time), the objectives are to diversify the farm's herds, to lengthen rotations (increase the number of different crops following one another on a given plot of land). That leads to increased diversity of production in space and time, a desirable condition, for environmental and economic reasons (see box).

Incentives, positive or negative, contributing to this diversification

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[65] Poux, X. et Aubert, P.-M. (2018). *An agroecological Europe in 2050: multifunctional agriculture for healthy eating Findings from the Ten Years For Agroecology (TYFA) modelling exercise,* IDDRI- AScA *Study* N°09/18.

[66] France Stratégie, *Faire de la politique agricole commune un levier de transition écologique,* https://www.strategie.gouv.fr/publications/faire-de-politique-agricole-commune-un-levier-de-transition-agroecologique

[67] IPCC (2019). *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems,* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)], in press

Incentives for permanent grassland ;

Incentives for areas of ecological interest, wetlands, Natura 2000, areas of high natural value of the Green and Blue Frame, etc., according to the contribution of the actors to the achievement of the environmental objectives ;

Taxes on pesticides and antibiotics, greenhouse gas emissions ;

Measures in favour of organic farming, agroecology, production with high environmental value (taxes, aids, creation of labels, remuneration for positive externalities).

Contract for Agroecological Innovation (CIAE)

This type of contract, signed between groups of farmers and the public authorities, should be a commitment to practices enabling the provision of local public goods (improving water quality by reducing the use of fertilisers and pesticides, for example). The main orientations of this contract would be collectively developed at the level of the relevant territories or sectors. They could be broken down into collective contracts, with or without territorial continuity.

Operational groups' would be made up of various stakeholders wishing to work together on the same innovative project (farmers, SMEs, advisors, researchers, NGOs) in a given territory. These contracts would thus support innovation and training dedicated to the local agro-ecological transition, in favor of local public goods.

It seems important to mention here that while the principles of agroecology (see box) have so far been implemented mainly on small farms, it is important to have tools so that large farms can also carry out this conversion (which some have done).

Indicators to be put in place

Among them, the diversity of crops in space can be measured by the Shannon index, which increases with the number of crops and the equi- distribution of their surface area. This index can be calculated from the area declarations currently recorded in the graphical plot register. Knowledge of the species and varieties used - weighted by their genetic differences - provides other valuable indicators. Biodiversity indicators (farmland bird index… should also be used.

2- Aid to the agricultural sector according to the number of annual work units*.

(*corresponds modo to the number of working hours per year)

The objective of this aid is to ensure that all farmers receive a minimum payment, disconnected from the level of agricultural production, in order to increase resistance to crises and prices volatility.

Another important reason for the introduction of such a tool is that agro-ecological practices (diversification of production, organic farming, etc.) can lead to a higher workload than conventional practices (mechanical weeding as a substitute for pesticide use, for example) and

therefore require more labour. This aid would also support sectors rich in employment (e.g. market gardening, livestock farming).

3- Supporting sustainable diets

It is important to encourage a lower consumption of animal proteins and a greater consumption of plant-based products, but also a consumption of products that are more respectful of the environment and health (reduction in the use of pesticides and antibiotics)[68]. Consumer information is not enough. There is a need to change the socio-economic environment (food prices and taxes, subsidies, signage, advertising, etc.). The recommendations of the Citizen's Convention for the Climate are an example of several possible concrete actions in this direction, such as the commitment of collective catering to more virtuous practices, the continuation of efforts to reduce food waste and others.

4- Promoting the deconcentration and relocation of agricultural production

Globalisation and the concentration of food production has had many negative consequences, including reduced diversity of crops and crop varieties, loss of cultural identity and local knowledge, and lack of resilience to shocks. These shocks can be related to crises (of any kind) that disrupt the movement of goods and people between and within countries[69] and to crises caused by natural disasters that disrupt the production of agricultural goods. In response, many studies suggest the relevance of movements to deconcentrate and relocalise production, both in France[70] and in the countries of the European Union[71] but also in the countries of the South[72]. Deconcentration means increasing geographic distribution of producers, relocation meaning production closer to consumers, i.e. relocation in France of products that are mainly imported but which could be produced in France. That means also relocation in several different regions for production that is mainly concentrated in restricted production areas, and relocation within territories to be closer to consumers (measures to support producers through local food network : set the maximum distance between producer and point of sale at 70 kilometres, for example). This movement aims to increase territorial autonomy and calls for an increase in the number of farms that would be better spread throughout the territory. Territorial food projects proposed by law in France in 2014, which aim in

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[68] See "Territorialised food systems", J.-L. Rastoin.

[69] See in particular Méjean et al. (2018). « The Micro Origins of International Business Cycle Comovement », *American Economic Review*, 108(1):82-108.

[70] Académie d'Agriculture (2019). *Transition alimentaire : pour une politique nationale et européenne de l'alimentation durable orientée vers les consommateurs, les filières et les territoires,* https://www.academie-agriculture.fr/publications/publications-academie/avis/rapport-transition-alimentaire-pour-une-politique-nationale

[71] Commission Européenne (2020). *Towards a sustainable food system,* rapport du Group of Chief Scientific Advisors Scientific Opinion Nº 8, https://ec.europa.eu/info/research-and-innovation/strategy/support-policy-making/scientific-support-eu-policies/group-chief-scientific-advisors/towards-sustainable-food-system_en

[72] http://www.fao.org/cfs/home/activities/smallholders/en/

particular to accompany the transition of agricultural and food systems towards more sustainable models, to consolidate territorialised sectors, to develop local food network, are part of this movement.

The entire population will certainly not be able to be supplied solely by small producers, but a clear increase in the number of small producers would make it possible to increase the resilience of our societies in the event of a crisis and to respond to several SDGs (see box above). This resilience is based on the diversification of production and supply locations.

For several years now, this movement of deconcentration and relocation has been favoured by a section of the population that wants to eat better and protect the environment, preferring to buy from small producers at farmers' markets and in local food networks. As a market already exists, the measures that can be recommended are essentially aimed at helping the installation of corresponding agricultural, craft and industrial companies. The Food Transition report of the Academy of Agriculture of France makes proposals in this direction: aid for tangible (equipment, bringing up to standard) and intangible investment (R&D, training, communication), incentive taxation (reduced rate VAT), taxation of food with negative externalities in terms of public health, employment and the environment. To this should be added the regulation of land markets by local authorities and SAFERs to help these companies gain access to the land they need. It should be noted that these production and marketing systems affect a small fringe of the population. One reason often given, but on which specialists do not agree, is the question of the consumer' cost - it may also be a question of accessibility. Solutions to improve accessibility - more favorable public policies - and to give the lowest incomes access to healthy and sustainable food must be studied (see Points of vigilance).

Contribution of relocation and deconcentration of food production to SDGs

The relocation (in France and within the territories) and the deconcentration of food production allows :

-better remuneration for smallholders who can sell their production directly to consumers thanks to local food networks (SDG 8), which can tend to reduce income inequalities between small and large farmers (SDG 10). However, this requires that these smallholders have a good control of production and marketing costs;

-facilitation of the conversion of farms to agro-ecology, whose practices ensure sustainable production (SDG 12),

-climate mitigation (SDG 13),

- improvement of the health of populations that are less exposed to harmful chemicals in the air, water and food (SDG 3),

-contribution to increasing terrestrial biodiversity (SDG 15) by increasing the surface area of habitats favourable to it, and marine biodiversity (SDG 14), by reducing the quantity of chemical inputs, medicines and antibiotics which, by following the water cycle, end up in the oceans.

5- Transformative governance of the 'agriculture-food-' sector

The IPBES special report sets out the main features, in terms of logic and values, in social, economic, technological and scientific terms, of this transformative governance, that is changing the logics of the 'agriculture-food-' sector, leading to sustainability . Above all, it is important to articulate the previous different strands. This mode of articulation, its logic, as well as the importance of changing the logic of the agriculture-food system, are detailed in the note "Halting biodiversity decline " (and see the special 2019 IPBES report). Its application to the agriculture-food sector is detailed in the report *Towards a sustainable food system*[73]. The objective is to combine governance, participation and regulation, integrating all stakeholders, including citizens and consumers. One should avoid silo policies, agricultural policies that are independent of other public policies. Training (initial training in BTA, agronomy schools, and ongoing training for the retraining of farmers) must accompany these objectives.

6- Matters of concern

The transition to agro-ecology requires particular vigilance on three points: agrosystem complexity, cost control and productivity.

The greater diversity of crop rotations, rotations and techniques can lead to greater complexity in production, processing and consumption systems. It is important to know how to manage this complexity so that it is a source of resilience and not of vulnerability.

Conversions to agro-ecology, to production with high environmental and biological value and to selling through local food networks can generate additional costs and an increase in selling prices that could deprive part of the population of access to healthy and sustainable food, and harm SDGs 3 (health) and 12 (responsible consumption). Targeted aid for populations with low purchasing power must avoid this access problem. Conversely, when the economic cost is invoked, it is important not to neglect the hidden costs of present forms of conventional agriculture, particularly the negative externalities (greenhouse gas production, health effects that affect the most vulnerable populations first and foremost, effects on biodiversity, etc.) which may be stronger than those of more agro-ecological forms[74]. These externalities primarily affect the most vulnerable populations[75]. Such differences contextualise the effects of better biodiversity conservation on prices[76].

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[73] European Commission (2020). *Towards a sustainable food system,* report of the Group of Chief Scientific Advisors Scientific Opinion Nº 8, https://ec.europa.eu/info/research-and-innovation/strategy/support-policy-making/scientific-support-eu-policies/group-chief-scientific-advisors/towards-sustainable-food-system_en

[74] Reganold, J. et Watcher, J. (2016). « Organic agriculture in the twenty-first century », *Nature Plants,* 3(2):15221.

[75] *Millenium Ecosystem Assessment*, 2005

[76] Obersteiner M. et al. (2016). « Assessing the land resource–food price nexus of the Sustainable Development Goals », *Science Advances*, e1501499.

The transition to agro-ecology can generate productivity declines. Current full-scale experiments involving farmers (e.g. the DEPHY network of farms in the ecophyto plan of the Ministry of Agriculture and Food[77]) show that on average there is some decline (14% on field crops). However, the increased experience of farmers, combined with progress in agro-ecological research could, in the short term (<10 years), make it possible to envisage higher production levels, even higher than conventional production.

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[77] https://agriculture.gouv.fr/dephy-expe

Territorialised food systems

Jean-Louis Rastoin (French Academy of Agriculture)

Abstract. *This note describes the links between the food system, understood as "the way people organise themselves, in space and time, to produce and consume their food" and three sustainable development goals: zero hunger (SDG n°2), good health and well-being (SDG n°3) and responsible consumption and production (SDG n°12). It deals in particular with the effects of the pandemic on the goal of ending hunger by 2030, the links between nutrition and disease, the consequences of losses and waste, the low resilience of current global value chains and the effects of production patterns on zoonoses. The concept of territorialised food system and its compatibility with the sustainable development goals are presented in conclusion.*

The SDG 2030 adopted by the United Nations General Assembly in 2015, after a difficult start, now constitute a reference framework that is known and present in many countries, including France.

If we adopt a holistic approach based on the major functions essential to life and to individual and collective well-being (feeding, caring, protecting, educating, etc.), we will be able to achieve a better quality of life for all. Indeed, by definition, the food system (FS) covers the entire population[78] (2020: 7.9 billion worldwide; 2030: 8.5 billion). In addition, the FS currently has just over a million companies and nearly 3 million jobs in France in several economic sectors: agri-supply, agriculture, food processing, packaging, commerce, catering, logistics, business services and public services. In most countries of the world, the FS is the leading economic sector in terms of turnover and employment.

The Note "Sustainable food production" deals more specifically with agricultural activity in relation to ecosystems. In this paper, we will further explore the link between FS and 3 SDG: 2 (zero hunger), 3 (health and well-being), 12 (responsible consumption and production). From the point of view of food, SDGs 2 and 3 belong to the same category. SDG 12 refers to the products consumed and how they are produced within the global value chains.

SDG 1 "Zero Hunger

The number of undernourished people in the world in 2018 was 820 million[79]. The state of famine is mainly due to armed conflict and political instability, secondarily to climatic and land-based

[78] Malassis, L. (1994). *Nourrir les Hommes*, Flammarion, coll. Dominos, Paris, 126p.

[79] FAO (2019). *La situation mondiale de l'alimentation et de l'agriculture 2019. Aller plus loin dans la réduction des pertes et gaspillages de denrées alimentaires*, Rome.

disasters. The Covid-19 pandemic could increase this figure to 900 million[80], mainly due to poverty generated by unemployment. The "Zero Hunger" objective, already hypothetical before the coronavirus, will therefore not be achieved by 2030, as the economic crisis is expected to increase the poverty rate. This situation of undernourishment, still described as 'food insecurity', also exists in rich countries: 13.6% of the population in France and 17.3% in the European Union[81]. The funds allocated by the European Union to food aid within the framework of the EAFD (European Fund for Aid to the Most Deprived) represent less than €14 per year and per person in a situation of food insecurity. The organisation of food aid also has a number of weaknesses in terms of subsidised products (chosen without taking nutritional considerations into account) and the logistics of delivery and storage. In poor countries, the delivery of relief is made difficult by problems of governance and infrastructure, while globally the good harvests of the previous three years and the level of stocks do not give rise to fears of shortages, subject to possible speculative movements in the markets. To sum up, two levers are essential to reduce food insecurity: the achievement of MDG 1 "No Poverty" and an in-depth reform of food aid, with more substantial funding.

SDG 3 "Health and Well-being

Food and nutritional security presupposes 4 attributes: access to food (physical and monetary), quantity, quality and diversity of food (nutritional aspects), social and cultural adequacy (food heritage), education and fair information of consumers (knowledge)[82].

The health aspect is mainly covered by the 2nd attribute (nutrition). In addition to the energy deficit mentioned (insufficient calories), there is a deficit of nutrients (mainly proteins), vitamins and trace elements (mainly iron, zinc and iodine) for about 2 billion people in the world. These deficiencies cause pathologies in vulnerable groups (children, pregnant women, the elderly).

More recently, there has been a sharp increase in chronic foodborne diseases (FCD) caused by an excess of nutrients (mainly fats, sugar, salt, animal proteins, highly processed foods): obesity, cardiovascular diseases, type 2 diabetes, certain cancers. According to estimates by the Global Burden of Disease (GBD) network, which brings together doctors and nutritionists from 195

[80] GNAFC & FSIN (2020). *Global report on food crisis*, UN, New York: 240 p.

[81] Blasco J., Gleizes F. (2019). *Dossier — Qui est pauvre en Europe ?*, Insee Références, Paris, Insee: 20 p.

82 CSA (2012). *S'entendre sur la terminologie, Sécurité alimentaire, Sécurité nutritionnelle, Sécurité alimentaire et nutrition, Sécurité alimentaire et nutritionnelle*, 39th session, Point V. a, Rome, 15-20 2012: 17 p.

countries[83], the number of people affected by obesity[84] worldwide were 711 million in 2015 (including 108 million children), i.e., a prevalence rate of 10% of the total population[85]. In 2015, it reached 38% of adults in the United States, 32% in Mexico, 24% in Germany, 15% in France and 4% in Japan. The global obesity rate doubled between 1980 and 2015 and could reach, according to WHO projections, 25% by 2045. If the criterion of overweight (BMI > 25), which is also a risk factor to a lesser degree than obesity, is taken into account, the population concerned would be around 2 billion individuals (including obese people). Overweight is therefore a major public health problem.

Due to the possible simultaneous occurrence of several foodborne pathologies (double or triple burden), it can be assumed that at least 3 billion people in the world today are malnourished (nearly 40% of the total population), leading to an economic loss of around 4 to 5% of GDP[86]. The food and health couple is thus at the centre of both social and economic issues. As food has an impact on public health, a preventive approach to the MCOA would not only bring us closer to the objective of "well-being", but would also enable us to make substantial savings in health expenditure (in France in 2018, nearly 14% of final household consumption will be related to food in 2018, compared with around 15%).

A diet in line with the concept of food and nutritional security would thus make a major contribution to MDG 3 "Health and well-being" in the context of widespread malnutrition worldwide. Collective catering, which affects a large number of consumers, particularly school children, can play an important role in improving diets.

SDG 12 "Responsible Consumption and Production".

Responsible" food consumption can only be "sustainable". The global average of food availability per day and per capita in 2018 was 2800 kCal, while nutritionists estimate the need at 2200 kCal. There is therefore a significant over-consumption on average, with, of course, significant differences between countries and social categories within countries. This over-consumption is accompanied by extremely high losses and wastage at all stages of the food chain. Specialists estimate that 30% of

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[83] Public statistics on health and food are incomplete, published with long delays and on sites with poor ergonomics in France, in most countries and at the WHO, hence the organisation of researchers in networks to compensate for these deficiencies. The FAO, on the other hand, has an efficient database on nutrition.

[84] Body mass index (BMI) above 30.

[85] GBD 2017 Risk Factor Collaborators (2018). *Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017.* Lancet (London, England), 392 (10,159), 1923–1994.

[86] Hawkes C., Fanzo J., Udomkesmalee E. (ed.) (2017). *Global Nutrition Report 2017: Nourishing the SDGs*, Bristol, Development Initiatives, 115 p.

food production is not consumed, with significant variations according to the region: 42% in North America, 19% in North Africa. In rich countries, it is at the consumption stage that losses (and therefore wastage) are highest (61% in North America, 33% in Europe). In southern countries, 39% is lost in the fields and 37% during harvesting and transport[87]. In France, in 2016, 10 million tonnes of food will have been lost or wasted (33% of which at home), a value of €16 billion, representing 15 million tonnes of carbon (3 times the emissions of air transport on domestic routes)[88]. Reducing food loss and waste would therefore have a significant impact in terms of social, economic and environmental sustainability.

A change in the food consumption model (partial substitution of animal proteins by vegetable, seasonal and organic products) would have an impact on production and would make food systems more sustainable[89].

With the expansion of the intensive, specialised, concentrated, globalised and financialised agro-industrial techno-economic model, the mode of governance of commodity chains or "global value chains" (GVCs) most frequently observed in high-income and emerging countries is based on a goal of revenue growth and short-term profit maximisation as the main if not the only "value". These GVCs are geographically long and segmented, just-in-time, subject to speculation on physical and financial markets, not very resilient in health terms and characterised by an unbalanced sharing of the value created between players. For example, according to FranceAgriMer, in 2015, a French farmer received 6.5% of the price of a product paid by the consumer, agri-food companies 11.2%, traders 15.2%[90].

The way food is produced also induces pathologies due to contaminants such as nitrogen dioxide and pesticide residues emitted in abundance by chemically intensive agriculture and due to the ultra-transformation of certain food products which modify the intestinal microbiota and thus promote viral immune disturbances as in the case of covid-19[91].

Against the backdrop of the covid-19 pandemic, it should be remembered that animals harbour viruses and 70% of infectious diseases in humans originate from them (zoonoses). The Spanish flu of 1918-19 is estimated to have caused between 20 and 50 million deaths, the Hong Kong flu (1969) more than a million, including 40 000 in France, SARS (2002-2003) a thousand, EBOLA (2013-14)

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[87] FAO (2019). *La situation mondiale de l'alimentation et de l'agriculture 2019. Aller plus loin dans la réduction des pertes et gaspillages de denrées alimentaires*, Rome.

[88] ADEME (2016). *État des lieux des masses de gaspillages alimentaires et de sa gestion aux différentes étapes de la chaîne alimentaire*, Paris : 168 p.

[89] Couturier C., Charru M., Doublet S., Pointereau Ph. (2016). *Afterres 2050*, Toulouse, Solagro, 96 p.

[90] Boyer Ph. (2019). « L'euro alimentaire : le contenu de la dépense alimentaire en production agricole, en emplois et en valeurs ajoutées, importations et taxes », *La Lettre de l'Observatoire de la formation des prix et des marges des prix alimentaire*s, 16, Montreuil, FranceAgriMer : 5-8

[91] Duru M., Fardet A., Rock E. (2020). « Mieux s'alimenter pour prévenir les maladies chroniques et infectieuses », *The Conversation*, 17 mai, Paris, CEST.

more than 12 000, and covid-19 nearly 310 000 by 16 May 2020. Crossing the species barrier remains relatively infrequent, but human activity is an important factor in the emergence and then spread of zoonoses: progressive decline in immunity due to lifestyle, armed conflict, climate change, dense and frequent travel, international trade in goods, intensive agricultural and livestock production systems[92].

Concentration and specialisation on a limited number of plant species and varieties and animal strains make the agro-industrial production mode highly exposed to health and economic risks. The epizootics of 1995 and 2000 (bovine encephalopathy), 2004 (avian influenza H5N1), 2014-2020 (African swine fever) have a viral origin. In 2020, the Office International des Epizooties (OIE) counted 117 animal diseases, infections and infestations that have a greater impact on livestock farms as they become increasingly intensive, industrialised and concentrated or, on the contrary, too small to have access to veterinary care.

It is unlikely that a simple 'adaptation' of agro-industrial 'global value chains' will be able to achieve MDG 12 'responsible consumption and production' and meet the serious challenges of sustainable food security[93].

SDG and territorialised food systems

An alternative scenario to the global value chain model is proposed by the forecast based on the triptych of sustainability: equity, environment, economy. This model, known as the "territorialised food system (TFS)"[94], implies changes in consumer behaviour. The aim is to move towards a natural, varied and balanced diet. The production model is evolving towards less intensification, diversification through agro-ecology and the circular bioeconomy, with a generalisation of eco-design at the industrial and logistical levels.

The TFS scenario is based on 4 interdependent pillars: extended product quality, territorial autonomy, ecosystem proximity and solidarity between actors. Territorial food autonomy will necessarily be accompanied by inter-regional and international exchanges in order to have locally a diversified basket of goods and to respond to the principle of solidarity. Governance is based on the principle of subsidiarity at regional level, with networking between regions and national and European coordination. It allows a rebalancing between urban and rural areas. The construction of

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[92] Apollin F., Dufour B., Miller M., Petit H. (2020). « Agir au sud pour lutter contre les zoonoses est une nécessité impérieuse », *AVSF — Agronomes et Vétérinaires sans frontières* — www.avsf.org — 30 march.

[93] IPES-Food (2017). *Too big to feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector*, Paris: 106 p.

[94] Rastoin J.-L. (2015). « Les systèmes alimentaires territorialisés : considérations théoriques et justifications empiriques », *Économies et Sociétés*, Tome XLIX, (11/2015), Série Systèmes agroalimentaires, AG, N°37, Paris, Isméa Les Presses: 1155 – 1164.

TFSs implies proactive public policies that consider food as a 'common good'[95] (Rastoin, 2020). In this respect, the "Farm to Fork" strategy recently proposed by the European Commission as part of the New Green Deal is an encouraging prospect if it is confirmed by a transformation of the CAP into the CAP (Common Food and Agricultural Policy)[96].

[95] Rastoin J.-L. (2020). Éditorial, *Crises sanitaires, résilience et refondation des systèmes alimentaires, Systèmes alimentaires -Food Systems*, 5, Éditions Garnier, Paris: 17-31

[96] For a detailed analysis of the sustainable transition of food systems, see Rastoin J.-L. et Candau M., 2020, « Systèmes alimentaires en temps de crise : Vers une transition socio-écologique territorialisée ? », in Dron M. et Kim Bonbled Ph. (dir.), Préface de Constant Lecoeur et Nadine Vivier, 2020, *Covid-19 et agriculture, Une opportunité pour la transition agricole et alimentaire ?*, Presses des Mines, Collection Académie d'Agriculture de France, Paris : 209-222

Agriculture, food and SDGs — Some findings drawn from working with the inter-academic group « Restarting with the SDGs »

Gérard Payen (National Academy of Technologies of France)

Abstract. *Profound changes in food and agricultural production methods are necessary conditions for the success of the majority of the SDGs. Therefore:*
- *the world of food industry professionals has a major role to play in the success of the SDGs as a whole;*
- *however, these professionals should not decide alone on agriculture and food issues because the corresponding stakes concern society as a whole.*

In order for the "solutions" implemented to meet all the challenges, the debates relating to one or another evolution of the agricultural or food sectors must not be confined to their specific field. They should systematically consider the impacts on the areas of the many SDG targets that are concerned.

The various notes produced by the members of our inter-academic group made me aware of the importance of Sustainable Development Goals (SDGs) as a reference framework for agricultural and food systems.

Agriculture is, of course, directly concerned by Sustainable Development Goal 2 "Eradicate hunger, ensure food security, improve nutrition and promote sustainable agriculture". However, agriculture has many more impacts on society than just feeding it. Many SDG targets have no chance of being achieved if food production and consumption patterns are not rapidly transformed in a way that is adapted to the current challenges of our societies. The stakes are high.

These changes have no reason to be driven by one SDG rather than another. They must allow all the needs identified by the SDGs to be met simultaneously, which requires an overall vision of the issues at stake.

I am not at all a specialist in agriculture or food, so my findings from discussions with my colleagues may be inaccurate in certain details.

1. Necessary adaptations and changes by many stakeholders

Due to the strong technical, physical and economic constraints of agricultural production and distribution chains (yields per hectare[97], arable land[98], rainfall quantities, rainfall variability,

[97] See note by B. Le Buanec

[98] See note by B. Le Buanec

droughts, market prices[99], differences according to latitude, water consumption, energy consumption, etc.), the requirements of the SDGs and their associated objectives (Paris climate agreement, Sendaï resilience objectives, Aichi objectives for biodiversity) mean that :

- the agri-food sectors will have to adapt to
  - reduce their total GHG emissions[100] (not just emissions per kg of product sold), which may need shorter supply systems, different productions, etc.
  - reduce their water consumption (per kg and total) in areas experiencing increasing water stress
  - overcome longer droughts
  - reduce their release of unwanted chemicals into the soil and water systems
  - improve the living conditions of seasonal workers[101]
  - ensure a diversification of food production in any territory[102]
- the population will have to
  - adapt its diets by agreeing to eat less meat, more local and more seasonal products[103]
  - agree (and being able to agree) to consume more expensive products
- the public authorities will have to
  - organise an economic sharing that allows farmers to do what society needs
  - ensure that agricultural prices do not exacerbate poverty
- the population, manufacturers, suppliers and restaurant owners have to
  - reduce waste of edible food[104].

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[99] See note by B. Le Buanec

[100] See note by B. Le Buanec

[101] See note by B. Tardieu and J.P. Chevalier

[102] See note by D. Couvet and I. Chuine

[103] Excerpt from J.L. Rastoin's note: "*A change in the food consumption model (partial substitution of animal proteins by vegetable, seasonal and organic products) would have an impact on production and would make food systems more sustainable* ".

[104] See note by J.L. Rastoin

Figure 6.1. Extract from Box 1.2 of the Global Sustainable Development Report 2019 (GSDR2019) showing the influences of SDG 2 themes on other SDGs. The risks of negative impacts ('trade-offs') are assessed in orange. Their aggregated weight above 50 in the right-hand column is the highest of all the themes of the 17

If these adaptations do not occur, the target of hunger eradication (SDG 2.1) and SDG targets 8.1 and 8.2 on economic growth and productivity may be achieved[105], but many of the other SDG targets will not be met.

The 2019 UN Global Sustainable Development Report[106] analysed the interactions of the themes of the different SDGs. The extract below from Box 1.2 shows that action on SDG 2 themes - 'End hunger, food security, improved nutrition and sustainable agriculture' - has strong positive influences but also creates significant risks for the achievement of many SDGs.

The annex lists ten SDGs that can only be achieved if agriculture and food systems are modified[107]. Thus the majority of the SDGs are concerned. There are only ten years left until 2030. These adaptations are therefore urgent.

2. The whole society is concerned

As ten out of seventeen SDGs are impacted by agriculture and food practices, the world of agri-food professionals obviously has a major role to play in the success of the whole SDG programme.

Because of their impact on the majority of the SDGs, the urgent changes described above do, however, concern society as a whole. Society must therefore take ownership of the corresponding issues and not leave it up to the agri-food professionals to decide alone on the adaptations of the

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105 However, Jean-Louis Rastoin's note indicates that the "Zero Hunger" target is out of reach by 2030.

106 "*The Future is Now: Science for Sustainable Development, World Report on Sustainable Development 2019*" (United Nations, New York, 2020), a report byan Independent Panel of Scientists appointed by the UN Secretary-General. The interactions between SDGs published in this report are based on the detailed analyses presented on the blog https://datablog.cde.unibe.ch/index.php/2019/08/29/sdg-interactions/

107 According to the note from B. Le Buanec: "*Changes will be necessary but there are currently no ready-made solutions and there should be no mistake on the way to implement them".*

agricultural and food sectors. In addition, actions by public authorities and the population are needed.

This clearly illustrates the overall objective of Agenda 2030 to stop working in sectoral or sub-sectoral "silos". This decompartmentalisation is the only way to ensure the necessary interaction between the population, public authorities and professionals in the different specialties.

3. Questions

Organising interactions between sectors is necessary but not sufficient. An overall vision of the stakes is desirable in order to avoid committing to partial solutions that would ultimately prove unsatisfactory in relation to several SDGs. This is the role and great value of the systemic approach of Agenda 2030 and its 17 SDGs. From this perspective, two types of questions arise:

- Do the current debates on food production, supply and consumption really cover all the SDG issues described above? Do they not each time focus on a particular topic or group of topics without taking into consideration the many related issues[108]?

- Do agriculture and food specialists manage to break out of their respective “silos”? Public opinion hears above all the voices of the proponents of this or that "solution" presented in competition with each other. Yet most of the time, these so-called "solutions" are only partial contributions that are unable to respond to all the issues alone. They only seem to be satisfactory if they are combined with others. Does a central government manage to deal with all the issues by systematically making the Ministry of Agriculture interact with the many other ministries concerned?

Our working group is a good example of decompartmentalisation of silos. Exchanges between academics from several academies have provided the kind of interaction that is eminently necessary and has enabled each person to revisit their field of expertise by gaining from different perspectives.

Thus, in order for the "solutions" implemented to meet all the issues at stake, the debates relating to one or another evolution of the agricultural or food sectors should not be confined to their specific thematic fields. They should systematically consider the impacts on the areas of the many SDG targets concerned.

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[108] For example, while Solagro's Afterres2050 scenario is intended to be systemic and examines many of the aspects mentioned above, it says nothing about the social aspects of the fight against poverty (SDG1). When it says on page 74 that “*The increase of agricultural prices also has an impact on household purchasing power, but here the volume effect is predominant. Households buy slightly less but mainly they buy cheaper products: more cereals and less meat, and so the household food bills decrease.*” it is reasoning on a macroeconomic average without considering the case of people who already cannot afford to buy meat more than once a week.

Annex - SDGs whose success depends on changes in agricultural and food practices

SDG 1 – Poverty alleviation

Target 1.1: Eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day.

Target 1.2: Reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.

If the cost of food rises, in the absence of social measures, poverty worsens.

If agricultural prices remain at the competitive level of intensive agriculture, which consumes high inputs and does not respect the environment (GHG, pollutants, etc.), it will be difficult for small farmers to make a living by selling healthy products that are more environmentally friendly.

SDG 2 – Hunger, food security, improved nutrition and sustainable agriculture

Target 2.1: End hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

" there is a deficit of nutrients (mainly proteins), vitamins and trace elements (mainly iron, zinc and iodine) for about 2 billion people in the world. These deficiencies cause pathologies in vulnerable groups (children, pregnant women, the elderly).[109]»

Target 2.3: Double the agricultural productivity and incomes of small-scale food producers …

Target 2.4: ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

SDG 3 - Health

Target 3.4: Reduce by one third premature mortality from non-communicable diseases through prevention and treatment …

"More recently, there has been a sharp increase in foodborne chronic diseases (FCD) caused by an excess of nutrients (mainly fats, sugar, salt, animal proteins, highly processed foods): obesity, cardiovascular diseases, type 2 diabetes, certain cancers[110].

[109] Excerpt from Jean-Louis Rastoin's note

[110] Excerpt from Jean-Louis Rastoin's note

Target 3.9: Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

Agricultural practices can lead to surpluses of plant protection products or excessive animal discharges that make water unfit for consumption. Some products can remain in the soil for a very long time. Air pollution from agricultural spraying became "visible" during the 2020 containment when other sources of fine particles dried up.

SDG 6 - Water

If agricultural practices do not better control water consumption and the release of nutrients and chemicals into water and soil,

- the target SDG 6.3 to restore the quality of freshwater resources cannot be achieved ;
- the target SDG 6.4 to improve the efficiency of water use is also compromised;
- the target SDG 6.6 to preserve water ecosystems is also compromised.

SDG 8 - Decent employment

Target SDG 8.5: achieve … decent work for all women and men, including for young people and persons with disabilities, …

The Covid-19 crisis has made indecent housing conditions for many seasonal agricultural workers visible.

SDG 10 - Inequalities

Target 10.1: progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average

This target directly concerns small farmers and complements Target 2.3.

SDG 12 - Sustainable production and consumption

Target 12.1: Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.

Target 12.3: Halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

SDG 13 - Climate

Targets SDG 13.1 and 13.2 and the Paris objective to limit warming to +2°C or even 1.5°C are impacted by food systems.

SDG 14 - Oceans

Target SDG 14.1: Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

SDG 15 - Ecosystems, Biodiversity and Deforestation

Target 15.1: … ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, …

Target 15.2: Halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity …

Thus, ten out of seventeen SDGs, i.e. the majority of SDGs, can only be achieved if agriculture and food systems evolve. There are only ten years left before 2030. These changes are therefore urgent.

Nature and agriculture in the city

Isabelle Chuine (French Academy of Agriculture, French Academy of Sciences) and Denis Couvet (French Academy of Agriculture)

The authors thank Nathalie de Noblet and Sandra Lavorel for their contribution. This note is an expanded version of a text published in the book entitled Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?[111].

Abstract. *This note first describes the beneficial effects of nature and agriculture in urban and peri-urban areas. Some recommendations for increasing the role of natural elements in these environments are then made. Finally, important points to keep in mind regarding the increase of vegetation cover and farms in urban and peri-urban environments are listed.*

1. The benefits of the natural elements in an urban environment

Natural spaces in urban areas essentially provide three types of services to the urban population: regulation of the flow of water, air and energy, well-being (physical and mental), and to a lesser extent supply of goods and services. The maintenance of green spaces, including playgrounds and outdoor recreation areas, in urban areas is very important for the mental and physical health of city dwellers (ODD 3), particularly in the event of crises that lead to the confinement or limitation of movement, as was the case during the COVID-19 health crisis. Contact with natural elements has many benefits for humans: reduced stress, increased attention and cognitive abilities, increased sense of well-being. The presence of vegetation in the city makes it possible to capture fine particles and ozone and thus to reduce, in some cases, the exposure of inhabitants to atmospheric pollution (but see Points of Vigilance). It also makes it possible to mitigate global warming through its natural air-conditioning effects (albedo, evapotranspiration), thus significantly reducing the effects of heat islands, as well as better manage the flow of dissolved pollutants and the effects of runoff during torrential episodes.

An increase in the surface area of green spaces, with or without wetlands, is therefore desirable, as well as the greening of urban areas without encroaching on buildings or roads. The quality of the services provided by nature in the city also depends on the type of spaces and the way they are managed. Maintaining permeable soils in these spaces, using ecological management methods, creating a mosaic of environments contribute to the quality of these services. These modes of nature management in the city must be carried out by mobilising all our knowledge of the ecology

[111] Chuine I., Couvet D. Résilience de nos sociétés et de l'agriculture face à des crises : place de la biodiversité. Michel Dron et Philippe Kim-Bonbled (Dir.), *Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?*, Paris : Presses des Mines, collection Académie d'agriculture de France, 2020, p :39-56.

and the biology of species in order to avoid undesired effects (see Points of vigilance). This will also require technological innovations (adequacy of buildings, sustainability of maintenance of vegetated systems) and the training of green space managers.

Measures taken in urban areas in favour of biodiversity and nature areas can also have effects beyond the urban perimeter. Indeed, pollution in urban areas is often advected outside the urban area, causing pollution that compromises agricultural production. Conversely, depending on the atmospheric context, agricultural production sites can bring atmospheric pollutants into urban areas. Finally, we could imagine developments favouring the advection of fresh air into the city from the countryside.

Moreover, one of the ways to increase the resilience of our societies to crises, especially health crises, is a deconcentration accompanied by a relocation of the production of food products, especially agricultural products[112]. Indeed, a number of relocations seem relevant when the often-implicit social and environmental costs of long circuits (or global value chains) are taken into account. Deconcentration accompanied by a relocation of agricultural production implies a fragmentation of production among more numerous producers scattered throughout the territory. Of course, this does not mean seeking to supply urban populations exclusively with the production of urban or peri-urban farms, but an increase in the number of urban or peri-urban farms would increase the resilience of these populations in the event of a crisis, since the resilience of our food system also depends on the diversification of production and supply locations[113]. If these farms use agro-ecological practices, this contributes in addition to sustainable development goals 3 (health), 8 (decent work), 10 (reduced inequalities), 12 (sustainable production), 13 (fight against climate change), 14 (marine environments) and 15 (terrestrial environments)[114].

2. How to bring natural elements back to the city

The organisation of cities and their periphery must therefore be rethought so that they can accommodate natural elements, which will make urban areas more resilient to crises, and provide a better quality of life in general.

Many actors have already started to rethink nature in cities and the number of initiatives is increasing. Among the actions that can be put in place to bring nature to the city and to increase their self-sufficiency in fresh food we can mention the following:

Vegetation on façades, roofs and sidewalks

- Creation of shared gardens for market gardening

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[112] See "Sustainable food production", I. Chuine et D. Couvet.

[113] *Ibid.*

[114] *Ibid.*

- Increasing the surface area of public recreational gardens with or without wetlands
- Setting up small market gardening farms on the urban periphery or even in urban areas
- Establishment of small livestock farms on the urban periphery

However, real estate pressure linked to economic development and demographic growth makes it difficult to increase the area under cultivation in peri-urban or urban areas. Nevertheless, solutions do exist, particularly those recommended to move towards net zero artificialisation. France Stratégie[115] and IDDRI[116] have made a certain number of recommendations which are summarised below with a few other proposals:

- Requisition of empty properties to renovate them into housing (if possible social housing) and take measures against real estate speculation in order to limit the construction of new buildings that would draw on natural spaces.
- Exclude from eligibility to the Pinel regulatory law and to interest-free loan building projects on artificialized lands, and totally exempt from development tax projects that do not change the footprint of the building (raising, renovation, reconstruction).
- Impose an obligation to increase density by introducing a density floor and a minimum urban renewal rate in each municipality for new construction.
- Compensate partly what consumes the most agricultural and natural land. This implies finding artificial land and rehabilitating it into natural habitats.
- Create an institute in charge of monitoring the evolution of land use and reconversion of artificialized areas into natural areas.
- Ensure that all stakeholders have access to the knowledge needed to build territorial projects and to the solutions available to control artificialisation, and raise the awareness of all stakeholders: administrations, local authorities, households.
- Include in training courses for professions related to urban planning and earthworks, lessons on climate, biodiversity, ecosystem services and the means of improving them in urban areas.
- Change the urban planning design of French housing estates to encourage semi-collective housing, collective green and recreational spaces.
- Create a space for dialogue and negotiation between actors involved in environmental protection and actors involved in real state development and land use planning.

3. Points of vigilance

[115] France Stratégie (2019). *Objectif « Zéro artificialisation nette » : quels leviers pour protéger les sols ?*

[116] IDDRI (2018). « Zéro artificialisation nette, à quelles conditions ? », blog.

Introducing more vegetation in urban areas can generate undesired effects that must be anticipated in order to avoid them. These undesired effects include the allergenic effects of certain plants or their pollen (e.g. cypress, grasses, birch), which should therefore be avoided in urban areas, but also the production of volatile organic compounds by plants leading to the formation of ozone and particles[117,118].

The presence of trees in the city (e.g. plane tree, chestnut tree), especially along roads bordering high buildings, can in some cases prevent air circulation and the evacuation of air pollution generated by traffic and volatile organic compounds produced by plants. Impact studies on air circulation in order to optimise it are therefore necessary before any tree planting in such a context.

The development of urban and peri-urban agriculture could pose health problems if farmers use herbicides, pesticides and chemical fertilisers to which the population would be exposed. In this context, a type of agriculture with very limited or even non-existent use of these products, such as agro-ecology, should therefore be encouraged.

The presence of livestock farms in urban and peri-urban areas can pose health problems due to the greater proximity between the human population and livestock potentially carrying diseases transmissible to humans (zoonoses). It is therefore preferable to set them up in peri-urban areas. Small farms using a diversity of breeds and species would also limit the risk of spreading zoonoses.

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[117] Churkina, G., Kuik, F., Bonn, B., Lauer, A., Grote, R., Tomiak, K., et al. (2017). « Effect of VOC emissions from vegetation on air quality in Berlin during a heatwave », *Environmental Science & Technology*, 51(11), 6120–6130.

[118] Eisenman T.S., Churkina G., Jariwala S. P., Kumar. P, Lovasi G. S., Pataki D. E., Weinbergerg K. R., Whitlow T. H. (2019) « Urban trees, air quality, and asthma: An interdisciplinary review », *Landscape and Urban Planning*, 187: 47–59.

Air quality through the prism of the SDGs

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Abstract. *The topic of this note is air quality, a major public health issue and a fundamentally multidisciplinary, multi-scale and cross-cutting area, and which, as such, is adapted to the systemic framework of SDGs. The economic and health crises due to Covid-19 are related to this issue, marginally because health measures have led to a decrease in the concentration of certain pollutants, but mainly because economic stimulus measures may affect air quality in a long-lasting way. This note provides an analysis of the links between air quality and all the SDGs, detailed in its appendix. Recommendations on how to take this issue into account in stimulus packages are derived from this analysis.*

Air pollution is a major environmental issue. Despite significant efforts to limit this pollution, particularly in Europe and North America, the levels of pollutants in the atmosphere are still a major health concern, especially in Asia and Africa but also in Europe, as evidenced by the recent EC warning to France and Germany on this subject[119]. For example, it is estimated that fine particles (identified as the pollutants most harmful to health) are responsible, in France, for several tens of thousands of premature deaths and impose on society a cost of about 100 billion euros per year[120]. This air quality problem also includes indoor environments in which people actually spend a significant fraction of their time, but which are subject to very little regulation and assessment.

The anthropogenic sources of this pollution are multiple and are mainly associated with transport, energy production, industrial production, waste treatments and agriculture, and a variety of domestic activities (household fires, cooking, construction and landscaping materials, etc.). Urban environments are the nexus of these phenomena because their high population density favors the clustering and densification of emitting activities, and also provides the conditions for intense, chronic and massive exposure to air pollution, leading to the expression of a wide range of health impacts affecting a very large part of the population. The health effects of air pollution are determined by exposure levels but also by the increased vulnerability of certain categories of the

[119] « Pollution de l'air : la France de nouveau dans le collimateur de la Commission européenne », Le Monde, 28 Mai 2020.

[120] *Pollution de l'air : le coût de l'inaction*, Rapport de la commission d'enquête du Sénat sur le coût économique et financier de la pollution de l'air, L. Aïchi, J-P Husson, rapport n°610.

population[121] (pregnant women, elderly people, children). However, exposure levels and vulnerability may also be determined by social, geographical and cultural factors[122] (access to healthcare, smoking, housing conditions and location, working conditions, etc.) which raises the question of cumulative environmental pollution, multi-exposure areas[123] and exposure contrasts[124]. These issues are complex to grasp because they involve a multitude of levers and require a fundamentally cross-cutting approach, both in terms of research disciplines and public policies, as well as operational tools for air quality management. They are still subject to large uncertainties and require more studies. Finally, it should be kept in mind that although this issue is generally more local than that of greenhouse gases because of the shorter life span of the species concerned, it remains intrinsically a multi-scale issue (individual, local, regional, continental).

As has been observed for atmospheric CO_2[125], the concentrations of some pollutants co-emitted with CO_2 have dropped very significantly during the lockdown associated with the current pandemic (effect of the decrease in industrial activity and road transport). Thus, for NO_2 and the fine fraction of atmospheric particles - having transport as a predominant source - decreases in concentration between 30% and 60% have been observed in China[126]. In Europe[127], a 40 to 50% decrease in nitrogen dioxide (NO_2) concentrations has been observed near roadways. For a city like Paris[128], this corresponds to the relative decrease observed between 2000 and 2020 for the measurement sites located close to traffic. The trends were not the same for all pollutants. Thus, $PM_{2.5}$ (particles smaller than 2.5 microns in diameter) decreased less than expected, partly due to increased emissions from domestic heating[129] at the beginning of the lockdown period, and partly due to pollution events following agricultural spreading around Paris. Similarly, urban ozone concentrations have automatically increased as a result of lower nitrogen oxide levels in cities.

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[121] Kihal-Talantikite, W., Perez Marchetta, G., and S. Deguen, « Infant Mortality Related to NO2 and PM Exposure: Systematic Review and Meta-Analysis », *International Journal of Environmental Research and Public Health*, 2020.

[122] Deguen S, et al., « Neighbourhood Characteristics and Long-Term Air Pollution Levels Modify the Association between the Short-Term Nitrogen Dioxide Concentrations and All-Cause Mortality in Paris », *PLOS ONE* 11(3), 2016.

[123] Sandrine Gueymard and Nicolas Laruelle, «Identifier des zones d'exposition aux problems environnementaux», in *Les Cahiers de l'ORS*, n°170-171, IAU îdF, septembre 2014, pp. 85-87

[124] Host S. and Chatignoux E., *Pollution atmosphérique de proximité liée au trafic : expositions et effets sanitaires*, ORS Île-de-France, 2009. 12p. http://www.ors-idf.org/index.php/environnement-et-sante

[125] https://www.icos-cp.eu/gcp-covid19

[126] Shi X. and G.P. Brasseur, « The Response in Air Quality to the Reduction of Chinese Economic Activities During the COVID−19 Outbreak », *Geophys. Res. Lett.*, 47, 2020.

[127] Menut L., B. Bessagnet, G. Siour, S. Mailler, R. Pennel and A. Cholakian, « Impact of lockdown measures to combat Covid-19 on air quality over Western Europe », *EST*, 741, 2020.

[128] http://www.airparif.fr/actualite/detail/id/282

[129] https://insu.cnrs.fr/fr/cnrsinfo/la-pollution-parisienne-diminue-t-elle-pendant-le-confinement

Finally, it should be noted that there is a strong presumption that exposure to air pollution may be a risk factor in COVID-19[130]. While this may be a trigger for health problems, it is probably too limited in time to have a significant impact.

In this crisis, it is above all the prospects for economic recovery and the associated measures that must be addressed, as they can have a lasting impact on air quality and its consequences on our societies, and particularly health impacts. Indeed, as mentioned above, this problem is multi-sectoral and the solutions to be provided (i.e. emission control, exposure reduction in relation to land use planning etc.) also depend on the culture and socio-economic levels of the countries and citizens concerned (e.g. heating and mobility equipment). In order to ensure a greater effectiveness of these solutions, it seems appropriate to have a systemic approach and the SDO context seems to be a suitable framework to do so[131],[132]. Below, we will therefore describe the air quality issues and challenges in relation to the SDO objectives, identifying potential synergies and co-benefits per objective where appropriate.

Synthesis of the links between air quality and SDG

Two main SDGs are associated with air quality issues: SDG 3, because air quality has a very significant impact on health - so any action to reduce air pollution contributes to the achievement of this goal; and SDG 11, because urban environments both contain the most intense sources of emissions and are the places where the greatest health impacts are observed (since they house the majority of the world's population).

The main levers for reducing air pollution depend on controlling the main sources of emissions and are therefore linked to SDGs 2, 7, 9 and 12, which aim to achieve more sustainable and responsible production and consumption patterns for energy, transport, consumer goods and food.

Exposure to air pollution and the resulting impacts fall unevenly and more heavily on the most vulnerable populations, particularly social groups and countries with low economic incomes (SDG 1

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[130] Wu X., R.C. Nethery, M. B.Sabath, D. Braun, F. Dominici, « Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study », medRxiv preprint, doi: https://doi.org/10.1101/2020.04.05.20054502, 2020.

[131] Rafaj, P., et al., « Outlook for clean air in the context of sustainable development goals », *Global Environmental Change*, 53, 1–11, 2018.

[132] WHO (a), *Burden of disease of household air pollution for 2016*, Geneva, 2018 (http://www.who.int/airpollution/data/HAP_BoD_results_May2018_final.pdf?ua=1, accessed 17 July 2018).

and SDG 8). This is observed in Europe[133] and in France[134]. There are also inequalities (SDG 10) that are related to gender (SDG 5) and age (children - SDG 4 - and the elderly)[135].

Some recommendations and preliminary findings to support economic recovery with the SDGs

The issue of air quality is linked to many of the SDGs and this insert provides a summary of the recommendations presented in more detail below.

- Reducing GHG emissions generally has positive effects on improving air quality, but there may be conflicting situations to consider.
- The structuring and organisation of urban spaces must be thought out in a way that systematically integrates the issue of air quality.
- The investment in a decompartmentalized research is necessary to improve our knowledge and ultimately the effectiveness of the implemented measures.
- It is possible/necessary to include this issue more widely in the SDG approach.

One last element, which is more of a reminder than a recommendation, is that improving air quality means improving the health of everyone, even the most vulnerable and the poorest.

In terms of solution, it should be stressed that - due to the excessive consumption of fossil energy, leading to the co-emission of CO_2 and pollutants with a high health impact (NO_2, soot, ...) - air quality should strongly benefit from the various climate actions, including the reduction of greenhouse gas emissions. Examples include some agricultural activities that co-emit ammonia (leading to the formation of particulate matter) and nitrous oxide, or the fact that an increase in methane concentrations could be accompanied by increased ozone concentrations[136]. However, many conflicts may arise in the joint management of these environmental problems. Particulate matter emissions from wood energy, as well as and the excess of energy required for the treatment of pollutant releases are simple and emblematic examples. It is also known - even with large

[133] Temam S, et al, « Socioeconomic position and outdoor nitrogen dioxide (NO_2) exposure in Western Europe: A multi-city analysis », *Environ. Int.*, 101, 117-124, 2017.

[134] Deguen S, et al., « Neighbourhood Characteristics and Long-Term Air Pollution Levels Modify the Association between the Short-Term Nitrogen Dioxide Concentrations and All-Cause Mortality in Paris », *PLOS ONE* 11(3), 2016.

[135] WHO (c), *Beyond the mortality advantage. Investigating women's health in Europe*, Copenhagen: Regional Office for Europe; 2015 (http://www.euro.who.int/___data/assets/pdf_file/0008/287765/Beyond-the-mortality-advantage.pdf ?)

[136] Fortems-Cheiney A., et al., « A 3 °C global RCP8.5 emission trajectory cancels benefits of European emission reductions on air quality », *Nat. Comm.*, 8, 89, 2017.

uncertainties - that a significant part of the potential warming due to GHGs is masked by the negative radiative forcing of aerosols and their impact on cloud behaviour[137]. Actions to reduce these pollutants to protect human health and the environment could therefore contribute to accelerated warming. It is therefore necessary to think about regulatory approaches that find the right path (including in terms of temporality) between climate benefits and the reduction of exposure to pollutants.

Moreover, the fight against environmental pollution cannot be limited to the question of energy choice or combustion efficiency. Within urbanized areas, which are among the largest contributors to the greenhouse effect and to pollution at the local scale, it is necessary to integrate the difficulty of finding urban configurations and lifestyles that reduce individual transport demand, to consider the cultural, financial, fiscal and political levers for a change in consumption patterns, and also to address the issue of social and environmental inequalities (both outdoor and indoor). This is a complex issue in which the duality between air quality and climate is also strongly expressed. Thus, the paradox of an energy-efficient urban compactness that favors local exposure to pollutants has been at the centre of many debates for several decades[138]. Finally, because of the high dependence of climate and air quality issues on mobility and energy consumption at the individual level, it seems essential to recall that stress and unfavourable socio-economic contexts can be a brake on the transition to greater energy sobriety.

The air quality issue is protean, multidisciplinary and decompartmentalized, and systemic approaches such as those developed in the SDGs are therefore essential to ensure its effective management. However, the state of knowledge must be greatly improved, in particular to be able to 1/ reduce the uncertainties that hinder the implementation of really effective actions and 2/ develop a more quantitative and shared systemic approach. For this, transdisciplinary research must be implemented in a much more systematic way.

Finally, the positive feedback of air quality improvement on health (notably SDG 3) reinforces the positive impact of actions to reduce greenhouse gas emissions. This argues for a more systematic inclusion of air pollution issues in the various SDGs for which indicators do not necessarily exist.

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[137] Stocker, T.F. et al., 2013: *Technical Summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

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Annex - Detailed analysis of the links between air quality and SDGs

SDG 1 - Poverty Reduction

The literature identifies two major links between poverty and risks associated with air pollution, both expressed as a form of vulnerability of populations and territories.

1/ First, the highest rate of accumulation of environmental problems is found in territories with socio-economically vulnerable populations. Thus, the location of dwellings near major roads and industrial zones[139], as well as the poor quality of furnishing materials and the potential insalubrity of housing, are factors favoring the exposure of inhabitants to degraded indoor air quality and even to biological pollution (mold, fungus development). Indoor pollution is also closely linked to lifestyles, and in particular to the use of wood for cooking (a common practice in developing countries, but also in so-called "low-income" countries) or for heating (this time a practice less specific to low-income populations, even if it remains most often a financial choice for households). Finally, the occupations most exposed to the different forms of air pollution (specific or not) generally correspond to low socio-professional categories, in which the poorest fraction of the population is found.

2/ In turn, the multi-exposure of these socially disadvantaged populations, often combined with limited access to health services, makes them more vulnerable to air pollution-related pathologies.

Reducing exposure to air pollution therefore requires a reflection on multi-exposed territories, aiming at improving the living conditions as well as the health and well-being of the poorest part of the population. This approach should trigger a more virtuous circle around the issues of education (see SDG 4), employment, productivity (see SDG 8), health benefits and reduction of health expenditures.

SDG 2 - Hunger

Ozone resulting from the degradation of primary air pollutants plays a major role in agricultural productivity, drastically reducing the yields of several types of crops (by 3 to 20% depending on the crop species : wheat, rice, maize, etc.[140],[141]). Our ability to control average - and peak - levels of atmospheric ozone at the regional scale is therefore a major determinant in achieving the objectives of SDG 2. Moreover, since ozone impacts vegetation in general, there is a co-benefit here with the goals of SDG 14, which focuses on terrestrial ecosystems.

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[139] Menut L., B. Bessagnet, G. Siour, S. Mailler, R. Pennel and A. Cholakian, « Impact of lockdown measures to combat Covid-19 on air quality over Western Europe », *EST*, 741, 2020.

[140] Cellier, P. et al, *Agriculture et pollution de l'air, impacts, contributions, perspectives : Etat de l'art des connaissances*, mai 2015 - 7 p. - Réf. 8374, ADEME.

[141] Mills, G., et al., « Tropospheric Ozone Assessment Report: Present-day tropospheric ozone distribution and trends relevant to vegetation », *Elem Sci Anth*, 6(1), p.47. DOI:http://doi.org/10.1525/elementa, 2018.

On the other hand, the issue of agricultural production (related to SDG 12) is for most associated with the massive use of fertilizers, for example nitrogen fertilizers that generate ammonia emissions which in turn will lead to a significant formation of fine particles (ammonium nitrate). Finally, we can mention the use of pesticides, some of which will volatilize and end up in the atmosphere, thus exposing agricultural workers but also potentially more widely the inhabitants of rural areas[142].

SDG 3 - Good health and well-being

This is the number one objective of air quality control policies, as air pollution has become one of the main causes of premature mortality in the world[143], with a significant burden of morbidity, resulting in significant economic costs for States[144].

The most direct lever here is to be able to reduce emissions from the main polluting activities, transport and mobility in general, which are strongly linked to urban planning and therefore to SDG 11, energy production (SDG 7), industrial production (SDG 9) and agriculture (SDG 2 and 12).

It should be mentioned that air pollution and in particular its health effects can also be associated with other events/situations. Cases of crises such as the heat wave (ozone and very high temperatures are strongly correlated[145]) or the COVID-19 pandemic (suspected co-morbidities related to exposure to air pollution[146]) are striking illustrations of this type of situation in which the level of vulnerability to pollution can be critical.

It should also be noted that this SDG is associated with an indicator that explicitly refers to air quality (3.9.1), and represents the mortality rate attributed to air pollution in domestic and ambient environments. The calculation of this indicator is based on the knowledge of dose-response relationships, in particular between particulate matter concentrations and mortality risk. In France, the number of premature deaths is high (48,000 deaths/year associated with particulate matter) but the steady decrease in aerosol concentrations automatically induces a decrease in this number. However, major efforts must be made to improve the estimation of these dose-response relationships in order to include all pollutants and their combined effects ("cocktail effect") for a greater number of pathologies.

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[142] Gros, V., S. Génermont, P. Buysse, C. Bedos, R. Ciuraru, B. Loubet, J.-F. Castell, P. Cellier, G. Uzu, Colloque « Agriculture et qualité de l'air », mars 2019, *La Météorologie* - n° 106 - août 2019.

[143] WHO (b), *Air quality and Health*, Copenhagen: WHO Regional Office for Europe; 2018 (http://www.euro.who.int/__data/assets/pdf_file/0004/381919/fs-sdg-air-quality-health-eng.pdf).

[144] *Pollution de l'air : le coût de l'inaction*, Rapport de la commission d'enquête du Sénat sur le coût économique et financier de la pollution de l'air, L. Aïchi, J-P Husson, rapport n°610.

[145] https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.8328

[146] Menut L., B. Bessagnet, G. Siour, S. Mailler, R. Pennel and A. Cholakian, « Impact of lockdown measures to combat Covid-19 on air quality over Western Europe », *EST*, 741, 2020.

SDG 4 - Quality education

This goal can be a long-term lever for action through awareness of environmental issues in general. The perception by citizens of certain topics related to air quality, such as the problem of indoor air, remains low[147]. We can think of two aspects that can contribute to the achievement of the SDGs and that concern the training of decision-makers and that of the medical profession. The reflection should focus both on initial training (at several levels, from college to higher education) and on continuing education and the possibility of training professionals in administration or health. Finally, citizens must be made aware of these issues through the communication of the agencies in charge of these subjects (e.g. ADEME, ANSES, Santé Publique France in France) but also through other actions such as participatory science[148].

More directly, chronic diseases caused or exacerbated by air pollution may also have an impact on schooling. Cognitive abilities could also be impacted by exposure to high levels of pollution, whether in ambient or indoor air.

SDG 5 - Gender equality

Globally, indoor air pollution from cooking and heating on open fires or traditional stoves has a greater impact on women (and children)[149]. Exposure related to certain occupations that may be more female or more male may also arise. For example, in Côte d'Ivoire, fish smoking is a female task that generates a very significant amount of fine particle pollution. As mentioned earlier, several studies tend to show the vulnerability of pregnant women to air pollution[150,151].

SDG 6 - Clean water and sanitation

SDG 7 - Clean and Affordable Energy

The use of fossil fuels leads to massive emission of a multitude of pollutants into the atmosphere (primary and secondary particles, nitrogen oxides, volatile organic compounds, sulphur dioxide, etc.). Whether in the industrial sector, in domestic combustion activities or in the road transport

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147 https://barometre.irsn.fr/qualite-de-lair-interieur-relever-le-defi-de-la-pollution-de-lair/

148 https://caspa.fr/

149 Wu X., R.C. Nethery, M. B.Sabath, D. Braun, F. Dominici, « Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study », medRxiv preprint, doi: https://doi.org/10.1101/2020.04.05.20054502, 2020.

150 Kihal-Talantikite, W., Perez Marchetta, G., and S. Deguen, « Infant Mortality Related to NO2 and PM Exposure: Systematic Review and Meta-Analysis », *International Journal of Environmental Research and Public Health*, 2020.

151 WHO (a), *Burden of disease of household air pollution for 2016*, Geneva, 2018 (http://www.who.int/airpollution/data/HAP_BoD_results_May2018_final.pdf?ua=1, accessed 17 July 2018).

sector, decarbonation is obviously an essential means of reducing air pollution. Like electric vehicles, whose penetration into the vehicle fleet is highly dependent on the national context, a real implementation of these new energies in our daily practices can only be done with support for the change of practices, which necessarily includes financial incentives but also the establishment of conditions for change (logistics of access to energy, education and awareness of environmental issues...) and a strong political support, in a context that is in line with concerns for social and environmental justice (see SDG 16). Thus, the gradual elimination of the use of wood for domestic heating (which induces very high emissions of particulate matter and gaseous pollutants) has been successfully carried out in several mountain areas where this practice was in the majority, thanks to the support of ADEME in the deployment of new technologies. The solution that has been found comes from the use of alternative fuels that are less polluting, such as the recovery of waste from the wood industry, and/or technologies that allow for a more complete combustion of the fuel. The implementation in the field has long been ensured by the financial aids for the change of the oldest equipment. This approach is of course possible in so-called "high-income" countries, but it is technically limited in emerging countries where access to renewable energies and to the latest generations of combustion equipment is impossible for the vast majority of the population.

In terms of housing, the issue of new energies imposes strong requirements on the equipment of new housing and the renovation of old housing of poor energy quality. However, the construction and renovation of buildings that aim at saving energy can be counterproductive in terms of air quality because buildings that are too confined can lead to the appearance of mold and fungi that are harmful to health. Here again, technical solutions exist to propose efficient ventilation systems in terms of energy savings and air quality. However, the issue of containment must be systematically included in the specifications.

SDG 8 - Decent work and economic growth

There is also an entry point in this goal (also in connection with SDG 1 and SDG 10) since offering decent work also means offering work for which exposure to pollution is controlled. And this has consequences on the health and well-being of workers and therefore on their productivity. The loss of productivity due to poor air quality is indeed a striking example, as lost workdays for businesses and institutions is one of the most direct economic impacts of high levels of particulate matter[152]. This includes both outdoor air pollution and that associated with housing, but also specific pollution caused by occupational exposures.

SDG 9 - Industry, Innovation and Infrastructure

Industry is a major source of pollutants; regulations and the development of associated polluting ctonrol technologies are relatively effective in controlling emissions of harmful species. This situation is more prevalent in high-income countries, while it is deteriorating rapidly in poorer countries. On the issue of air quality, which local in nature, issues of relocation (or even relocation) of industries have consequences. These considerations resonate, of course, with SDGs 1 and 10.

[152] United Nations Environment Programme, « Urban Air Quality Management Toolbox », 2015

The fields of technological innovation to reduce pollution are major levers for boosting the economy. For example, the desire to reduce industrial emissions can lead to the design of more efficient production processes: the expected improvements in energy efficiency can increase productivity and reduce dependence on energy supply. Similarly, innovation in biofuels, energy efficiency in buildings or smart cities is supported by booming research and development sectors, and growing markets. However, a clear signal from long-term public policies and an international agreement on decarbonation that offers guarantees on the future price of carbon are essential to begin the transformation of our industry and face the environmental challenges[153].

SDG 10 - Reduced Inequalities

As mentioned earlier, low-income households and low-income countries may be more exposed to poor air quality (and its health consequences) when exposure to air pollution is not explicitly addressed in national labour codes and regulations. For the reduction of inequalities, see also the issues of poverty, multi-exposure and vulnerability mentioned in SDG 1.

It should also be noted that certain populations, whatever their socio-economic level, are also more affected, such as children, the elderly and people already suffering from certain pathologies such as respiratory or cardiovascular diseases.

SDG 11 - Sustainable Cities and Communities

The urban environment is associated with most of air pollution occurrence, a dominant proportion of which in Europe is linked to transport. The importance of the risks associated with air pollution in the urban environment is linked to two parameters: the very nature of the city - as a densely populated space - and the expression of the health impacts of pollution which are maximised in the case of continuous, long-term exposure. Thus, the European Environment Agency recognizes that the chronic fringe of effects is expressed very strongly in large metropolises where it affects a very large population on a daily basis[154]. In this context, the focus on transport is justified by the estimate of the very high percentage of people who are closely exposed to exhaust fumes and fine / ultrafine particles from road traffic every day. In large cities, this constitutes an increased risk of death.

It is clear that cities are the laboratory for the transformations to be carried out because first, they contribute to the greenhouse effect and local pollution, second they have the technical skills and strategic and human resources and third, they can implement financial, fiscal and political levers to act effectively. In France, regional planning policies seek to reconcile sustainability and development, based on issues of urban planning, housing, energy and climate as well as transportation and mobility in the territories. Technological solutions include the use of cleaner vehicles and alternative forms of mobility. At the same time, changes in urban planning, in the

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[153] Patricia Crifo, Manuel Flam, Matthieu Glachant, *L'industrie française face à l'économie verte : l'exemple de sept filières*, Rapport pour le Cercle de l'Industrie, Juin 2011

[154] European Commission, *Quality of Life in European Cities, 2015*, Publications Office of the European Union, 2016.

structure and organization of the city, and in access to business areas can help to control transport demand and opening up confined spaces. The reflection on the changes to be made must include the individual, in the sense that urban functioning is based on the structuring of individual practices of mobility, energy consumption and the spatio-temporal organization of professional and private activities.

In this urban space other sources of pollution must be considered, such as energy production, sometimes industry, agriculture and waste treatment. It should also be emphasized that there may be great disparities between countries in terms of sources and means of action, which conditions the nature of the solutions to be provided. In high-income countries, for example, emission reduction policies are based on monitoring networks. These networks still need to be improved to better identify and quantify the sources of pollutants, allowing for more targeted and therefore more effective action. Many large megacities do not yet have such tools and those that do should be able to sustain them[155].

In the case of this SDG, there is also an indicator directly related to air quality (11.6.2), which consists of as a function of population density. In the case of France, and in particular in the large agglomerations, the levels observed are rather decreasing but concentrations remain too high for PM_{10} (and NO_2, a pollutant not included in the SDG indicator)[156]. It should also be noted that the thresholds recommended by the WHO (more stringent) are still far from being reached. This is particularly the case in the vicinity of major roads, whereas the measurement sites located in the urban background have 30-50% lower concentrations. The permanence of concentration gradients in urban areas raises the question of the representativeness of average levels of pollution in cities and the spatial scale on which to assess individual exposure.

SDG 12 - Responsible consumption and production

Moving towards responsible production and consumption (including waste management) is an important lever for action reducing emissions of air pollutants that are harmful to health, as mentioned in SDGs 2 for agricultural production and SDG 9 for industrial production.

Target 12.4 explicitly mentions the objective of reducing emissions, including air emissions, of chemicals and pollutants associated with waste management by 2020. However, there are no indicators associated with this target for air quality and air pollutants in general. It is possible to consider integrating the footprint of pollutant emissions on these aspects in a targeted manner. Indeed, the indicator of SDG 11, which deals with the monitoring of particulate matter concentrations in the atmosphere, is quite integrative (it is already a fairly relevant indicator for estimating health impacts) and does not directly allow the identification and monitoring of the different sources of pollution and their impacts.

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[155] http://www.journaldelenvironnement.net/article/air-les-aasqa-de-nouveau-inquietes-pour-leurs-finances,106804

[156] « Pollution de l'air : la France de nouveau dans le collimateur de la Commission européenne », *Le Monde*, 28 Mai 2020.

SDG 13 - Climate Change Actions

Measures taken to combat climate change, in particular the reduction of greenhouse gas emissions, have very significant co-benefits for air quality since a significant proportion of air pollutants are co-emitted with CO_2 or other greenhouse gases. The link between methane and air quality should be emphasized, with a strong link to ozone production, which suggests an increase in ozone long-term concentrations associated with that of methane. Furthermore, the use of nitrogen fertilizers is accompanied by joint emissions of ammonia (which leads to the formation of fine particles) and nitrous oxide (N_2O, the third most important species for the greenhouse effect). Finally, some pollutants (SLCFs, short-lived species exerting climate forcing) are species with an impact on both health and climate change (ozone, soot). Controlling their concentrations is of course a health/ climate co-benefit.

However, as already mentioned for SDG 7, there are two potentially negative effects related to the use of wood as fuel, which leads to the emission of fine particles or other harmful gases, and to the thermal renovation of buildings, which can lead to increased concentrations of air pollutants in indoor environments.

SDG 14 - Aquatic Life

There is an impact related to the deposition of harmful airborne species (metals, endocrine disruptors).

SDG 15 - Terrestrial life

As already mentioned in SDG 2, some pollutants (ozone but also others) have an impact on vegetation and can also be responsible for acidification and eutrophication of natural ecosystems. It is also known that ozone damage to ecosystems also reduces their ability to store CO_2[157], again a climate co-benefit is identified by controlling ozone concentrations (itself a greenhouse gas).

SDG 16 - Peace, Justice and Effective Institutions

The issue of air quality in urban areas, but also more recently the acceptability of environmental policies based on the taxation of polluting vehicles, highlight the emergence of a strong public concern for social and environmental justice. These concerns are prompting governments to rethink air quality management policies, particularly in urban and peri-urban areas, which by their very nature are home to highly heterogeneous social populations and environmentally contrasting territories.

These movements for social and environmental justice in different parts of the world are based on the perception of the environment as a living environment, subject or not to the occurrence of localized pollution episodes, or as the ability to access various environmental resources, which they describe through a multiplicity of indicators such as the health status of populations, exclusion

[157] Unger, N., Zheng, Y., Yue, X. et al. (2020). « Mitigation of ozone damage to the world's land ecosystems by source sector », *Nat. Clim. Chang.* 10, 134–137, https://doi.org/10.1038/s41558-019-0678-3.

from protected areas or poverty. These movements aim to oppose different forms of environmental oppression (including the inability to participate in the environmental debate or exposure to ecological and environmental risks) and seek to combat different forms of environmental segregation. Initiatives to include social equity in policies to protect the atmosphere and people from environmental health risks could therefore move towards greater social peace and justice. However, this requires that environmental inequalities and injustices are first thought through, identified and mapped, forcing governments to probe the multi-scale and multi-actor social, economic and political dimensions of the environment. It will also be necessary to reflect on how to build a policy based on environmental equity, notably through redistributive or compensatory measures[158].

SDG 17 - Partnerships for project implementation

In the case of air quality, there is no body similar to the IPCC, i.e., one that has the support of a broad scientific community (i.e., multidisciplinary and international) and is able to make recommendations to reduce the impacts of air pollution.

On the other hand, there is a multitude of organizations, often more local, that try to develop multi-sectoral synergies around air quality issues. Nevertheless, we can mention the existence of international groupings dealing in part with this issue and relying on the SDGs (even if the approaches are not really systemic): the Climate and Clean Air Coalition[159], which is developing projects around the issue of SLCFs (Short Lived Climate Forcer) and the GAHP[160] (Global Alliance for Health and Pollution), which supports and implements actions around the health impact of toxic agents in the environment (air, water, soil). Because of their international dimension, these organizations respond well to the need for connections and exchanges between high-income and low-income countries.

In the field of air quality, it can be stressed, whether at national or European level, that the link between scientific knowledge (academic world), monitoring (operational world) and actions (political world) is fairly well structured around agencies (ANSES, ADEME), federations of associations (ATMO) and EPIC (INERIS, CSTBN, LNE, ...). The WHO, for its part, now acts as a reference organization on the state of knowledge and especially brings a vision and a more global approach to air quality issues, highlighting the need for differentiated approaches according to regions and countries of the world.

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[158] Blanchon, D., Moreau, S. & Veyret, Y. (2009). « Comprendre et construire la justice environnementale », *Annales de géographie*, 665-666(1), 35-60. https://doi.org/10.3917/ag.665.0035

[159] https://www.ccacoalition.org/en

[160] https://gahp.net/about-gahp/

From a research point of view, it is clear, through the SDGs, that the approaches developed must be multisectoral and multidisciplinary; it is this type of partnership that can and must be developed[161].

[161] Foret, G. et al., « État et perspectives de la recherche dans le domaine de la qualité de l'air », *Responsabilité & Environnement, Les annales des Mines*, ,N° 96 - Octobre 2019 - La pollution de l'air

Stopping the decline of wildlife, on land and at sea

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The authors thank Nathalie de Noblet and Sandra Lavorel for their contribution. This note is an expanded version of a text published in the book entitled Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?[162].

Abstract. *This note explains why biodiversity plays a key role in building resilience to large-scale crises, health related or otherwise. It summarises recommendations to reduce anthropogenic pressures on biodiversity and proposals to facilitate the adoption of such recommended measures. It then highlights some key messages.*

1. Importance of life and its condition (diversity, ecological functions) for the resilience of human societies

All kind of living organisms are necessary to humans and their activities, through the ecosystem services they participate to (Fig. 9.1): biological control of pests and pathogens, climate regulation - local through water and energy cycles and emission of short-lived pollutants, global through the carbon cycle -, regulation of hydrographic flows, water and air quality, provision of goods (food, materials) and drugs, source of artistic and scientific inspiration, and cultural identity[163]. Therefore, beyond SDGs 14 (preservation of aquatic life) and 15 (preservation of terrestrial life), life in all its biodiversity plays an equally important role in SDGs 3 (health), 6 (water), 7 (renewable energy), 12 (sustainable food production), and 13 (climate).

For example, agriculture depends on living organisms through soil fertility, pollination, biological control of pests and pathogens, control of soil erosion. For an assessment of the considerable socio-

[162] Chuine I., Couvet D. Résilience de nos sociétés et de l'agriculture face à des crises : place de la biodiversité. Michel Dron et Philippe Kim-Bonbled (Dir.), *Covid-19 et agriculture. Une opportunité pour la transition agricole et alimentaire ?*, Paris : Presses des Mines, collection Académie d'agriculture de France, 2020, p :39-56.

[163] Díaz, S. et al. (2018). « Assessing Nature's Contributions to People », *Science*, 359(6373), 270–272.

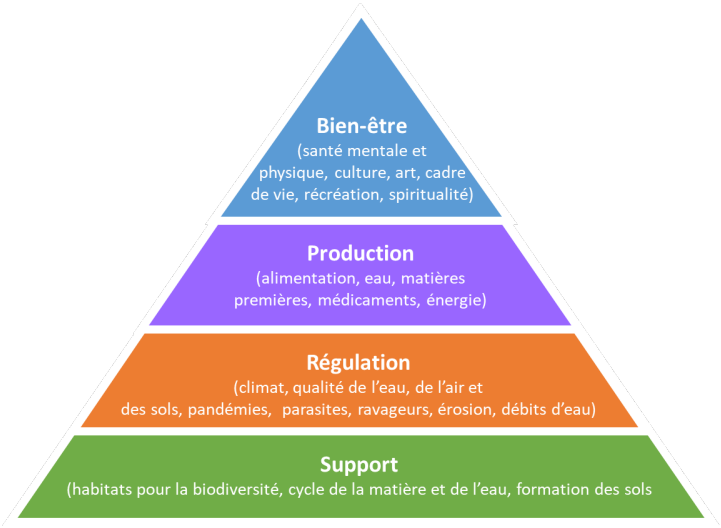

Figure II.9.1. Pyramid of ecosystem services to humans. Each level of the pyramid supports the level above it.

economic stakes, see Costanza et al. 1997[164], Chichilnisky and Heal 1998[165], Diaz et al. 2019[166]. Soil fertility depends on vegetation cover and many soil organisms (worms, arthropods, fungi, bacteria) that break down the organic matter produced by plants and release the nutrients that plants need to grow in return. Many crops are also dependent on the activity of pollinating insects, which ensure the fertilisation of flowers necessary for the development of fruits and seeds.

The quality of life, the maintenance of its diversity and the ecological functions it provides are therefore a major and necessary factor to the resilience of human societies. However, according to a report by PwC UK[167], SDGs 14 and 15 have received the least attention from companies.

The decline in biodiversity, ecosystem services and the associated contributions of nature to humans is significant and widespread[168]. The measures needed to halt this decline are considered at three successive, complementary levels in the IPBES special report[169].

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[164] Costanza, R. et al. (1997). « The value of the world's ecosystem services and natural capital », *Nature*, 387(6630), 253-260.

[165] Chichilnisky, G., Heal, G. (1998). « Economic returns from the biosphere », *Nature*, 391(6668), 629-630.

[166] Diaz S. et al. (2019). « Pervasive human-driven decline of life on Earth points to the need for transformative change », *Science*, 366(6471).

[167] PwC UK (2019). *Creating a strategy for a better world — SDG challenge.*

[168] Diaz, S. et al. (2019), *ibid.*

[169] IPBES (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, S. Díaz et al. (eds.), IPBES secretariat, Bonn, Germany, 56 pages.

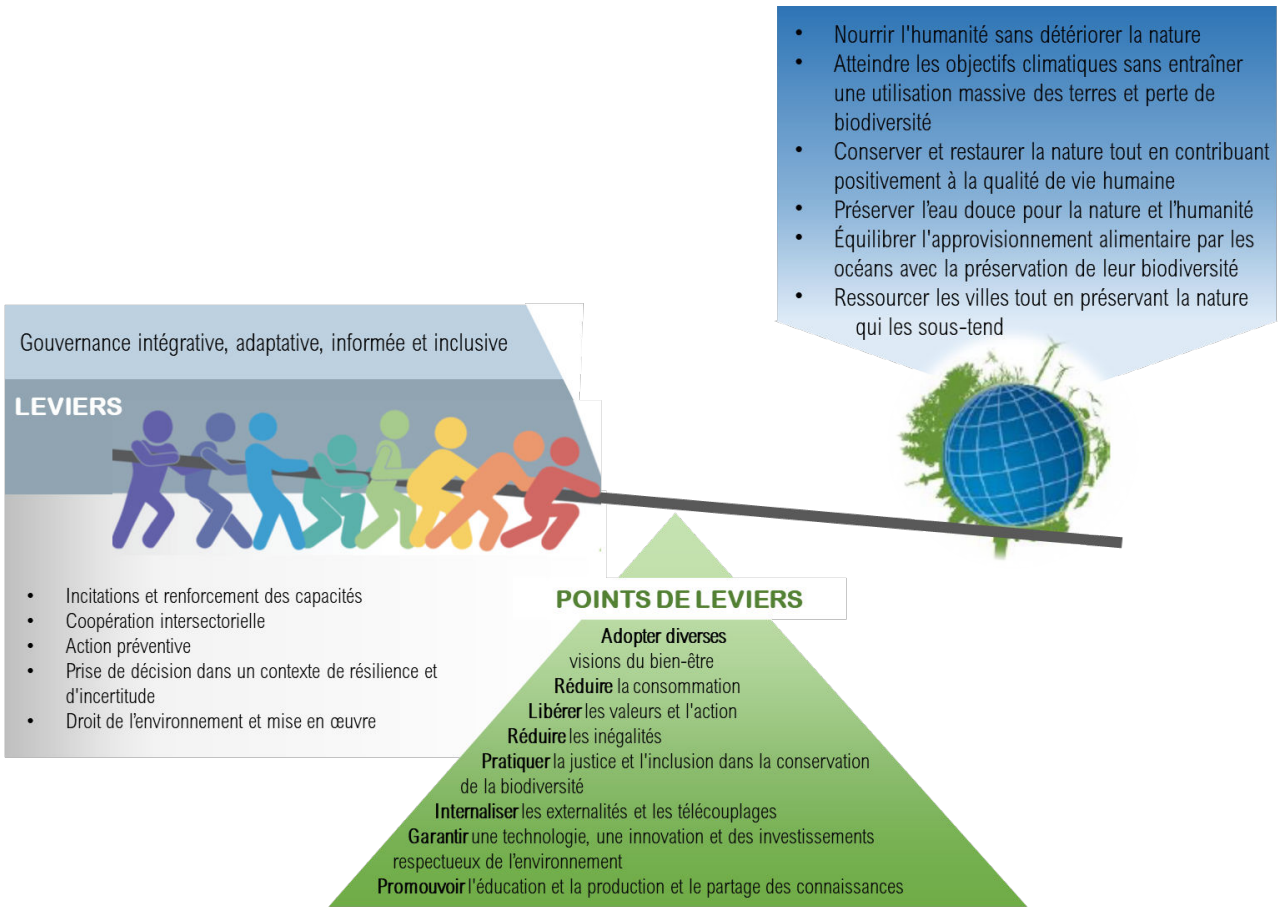

Figure II.9.2. For transformational change. Collaborative implementation of priority interventions (levers) targeting key intervention points (leverage points representing the main indirect drivers) could enable transformational change from current trends to more sustainable trends. Effectively addressing these levers and leverage points requires innovative governance approaches and organising the process around nexuses, representing closely interdependent and complementary objectives. From Fig. 7, Diaz et al. 2019, ibid.

2. Measures to reduce anthropogenic pressures on biodiversity

There are major pressures on biodiversity: habitat transformation and degradation, climate change, ecotoxicity, overexploitation, etc. Driving forces are at the origin of these pressures on biodiversity and ecosystems. These forces are demographic, economic, political, societal and institutional, and determined by social values. They also interact with each other. Reducing them presupposes understanding their dynamics and interactions. This is what the nexus approach, or combination of driving forces associated with the functioning of human production and consumption systems, proposes[170].

The analysis of these nexuses, associated with past development patterns, shows the major role of those associated with food, energy, water, habitat and the interaction between socio-economic sectors. The IPBES report thus lists six main nexuses (Fig. 9.2), including an essential nexus that links climate change, life and food. Meeting the needs to mitigate climate change, halt the decline

[170] Liu et al. (2018). « Nexus approaches to global sustainable development », *Nature Sustainability*.

of life and ensure adequate food for all human beings is a very complex task. Indeed, most of the scenarios envisaged to limit warming to 1.5°C or 2°C by the end of the 21st century are based on large-scale production of bioenergy crops, reforestation and/or afforestation, which can negatively affect biodiversity, food production and water demand[171]. Similarly, increasing the amount of agricultural land to eradicate world hunger would also have a negative impact on biodiversity and further exacerbate climate change. The challenge is to transform these nexuses and reduce their environmental impacts, taking into account their tensions and synergies. The aim is thus to reduce pressures and driving forces, while avoiding their displacement, for example from one area or country to another. For example, Europe protects its spaces, its forests, deintensifies its agriculture, but as a result imports more from less developed countries, which thus find new markets, but often to the detriment of the quality of their environment. To achieve climate change mitigation one could for example focus on restoring ecosystems capable of storing carbon sustainably, on reducing food waste and over-consumption and food choices before investing massively in bioenergy monoculture plantations which may cause other environmental problems[172].

A number of public policies have been proposed[173]. Measures to reduce the direct pressures on biodiversity include protected areas, endangered species protection, ecological corridors, and a plan to suppress the use of herbicides in agriculture. These measures are currently very insufficient, particularly because they are not adapted to the socio-ecological context (see box "Limits and failures of protected areas") or because the pressures, resulting from driving forces, are shifting[174]. For example, in Languedoc, the measures taken to counter coastal erosion due to sea level rise (offshore sand input) transfer the current vulnerability of the region, faced with a decrease in income from seaside tourism, to the future vulnerability of the ecosystems of the seabed. This example illustrates a long-term maladjustment: the addition of sand to the beach reduces the perception of beach erosion, and therefore the long-term adaptive capacity of the users, and is based on a finite resource whose extraction threatens another ecosystem, namely from the sand dune ecosystem to the seabed ecosystem.

The policy proposals that accompany these measures (taxes and subsidies, quotas, taxation, etc.) have had little effect to date. The reasons for this failure are mainly due to the fact that the proposed policies:

1) are little accepted by local actors because they can be sources of social injustice,

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[171] Diaz, S. et al. (2019), *ibid.*

[172] Voir la note « Production alimentaire durable », I. Chuine et D. Couvet, p. 35.

[173] Voir la note « Systèmes alimentaires, territoires et ODD », J.-L. Rastoin, p. 47.

[174] Barreteau, O. et al. (2020). « Transfers of vulnerability through adaptation plan implementation: an analysis based on networks of feedback control loops », *Ecology and Society*, 25(2).

2) are little implemented[175] (in particular ecological taxation, according to a report published in 2019 by the *Conseil des prélèvements obligatoires*[176], tax expenditure unfavourable to the environment is twice as costly for the State budget as that favourable to the environment - €7.5 billion compared with €3.1 billion in 2017) ;

3) can have rebound effects (new technologies...), significantly reducing the expected environmental benefits.

Boundaries and failures of protected areas

The creation of protected areas is one of the measures that reduce pressure on biodiversity. However, the regulatory texts in force are insufficient, and the protected areas are poorly distributed among regions. For example, in the Mediterranean, 72% of marine protected areas do not have any regulations to protect marine fauna and flora, and only 0.23% of the Mediterranean is concerned by real protection measures (see Claudet J., Loiseau C., Sostres M., Zupan M. (2020). « Underprotected marine protected areas in a global biodiversity hotspot », *One Earth*, Volume 2, Issue 424:380-384.). It is therefore necessary to avoid the displacement of anthropic pressures towards unprotected areas, to increase the level of protection of protected areas, and in particular, to thoroughly review the texts regulating protected areas. This revision of regulations must be carried out by understanding how humans interact with the biodiversity of protected areas in order to find regulations that will be effective because they are better accepted by all. This requires implementing socio-ecological and participatory action research approaches to identify interventions that will maximise co-benefits (for biodiversity and for resource users) and only conserve those that are viable in the long term for both social and ecological components. For example, in Moorea, the Polynesian people have a very close relationship with the sea, both nourishing and existential. Creating a marine protected area in Moorea without taking into account this very close relationship between man and nature would be doomed to failure. A study of fishing practices and the state of the ecosystems and their biodiversity makes it possible to target the protection measures that have the least impact on the fishing activity of the Polynesian people and that are the most effective for the preservation of lagoon ecosystems and their biodiversity. In order for the measures to be effective, it is also necessary to involve stakeholders from the territories concerned in the reflections and discussions from the outset.

More generally, while a large number of measures have been proposed over the last three decades to reduce the pressures and driving forces weighing on living organisms (see CBD Aichi objectives), measures targeting driving forces are the least adopted (Fig. 6 in Diaz et al. 2019, ibid.).

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[175] Jolivet, S., Centre d'analyse stratégique (2012). *Les aides publiques dommageables à la biodiversité, Rapport de la mission présidée par Guillaume Sainteny. Revue juridique de l'Environnement*, 37(1), 209-210.

[176] Conseil des prélèvements obligatoires (2019). *La fiscalité environnementale au défi de l'urgence climatique.*

3. Systemic proposals to facilitate the adoption of the measures to reduce pressures and driving forces proposed over the last three decades

Systemic measures (see box) seem necessary to facilitate the adoption of previous policies (see Fig. 7 of Diaz et al. 2019, ibid.), and to avoid their perverse effects.

The proposals made by IPBES in this sense can be summarised as follows:

to allow, or even encourage, a "good" conception of life, which is desirable but is dissociated from the increase in material consumption; such an increase makes it more difficult to halt the decline of biodiversity and to mitigate climate change;

reduce inequalities, because they reduce the acceptability of nature conservation policies and alter the effects of economic and technical tools;

to put in place economic incentives, taxes, quotas, labels, subsidies (payments for environmental services), but within an adequate social and ethical framework, in order to avoid perverse effects (increase in inequalities...);

promote technical innovations within an adequate ethical, social and economic framework, the idea being that the deployment of renewable energies, new agricultural production systems, will only have perverse social and/or environmental effects if the incentive framework is relevant;

promote education and access to information for everyone, but within an appropriate ethical and social framework, respecting the constraints of sustainable development.

Systemic (excerpt from Wikipedia)

It is a way of defining, studying, or explaining any type of phenomenon, which consists above all in considering this phenomenon as a system: a complex set of interactions, often between subsystems, all within a larger system. It differs from traditional approaches, which attempt to divide a system into parts without considering the functioning and activity of the whole, i.e. the overall system itself. The systemic thus favours a global, macroscopic, holistic or synthetic approach; it observes and studies a system from various perspectives and at different levels of organisation; and above all it takes into account the various interactions existing between the parts of the system (including possible sub-systems).

Indicators exist for at least three of these leverage points. For the reduction of material consumption, this is the ecological footprint; inequalities can be assessed using the "Environmental justice index"[177]. Education is taken into account in the HDI "Human development index".

The construction of indicators relating to economic and technological levers seems more difficult. Life-cycle analyses, with their many variations, provide leads for developing such indicators.

4. European context

Two reports analyse the situation of biodiversity and ecosystem services at the European level and propose strategies to protect and restore them: the report by the European Commission's DG Environment (2020)[178], and the IPBES Europe & Central Asia report (2018)[179]. These reports notably present a plan to restore nature and its contributions to humans, a better assessment of the economic stakes associated with biodiversity, and an improvement of agricultural policies and the CAP. The IPBES report highlights several important points summarised here :

- Europe's biodiversity is undergoing a strong and constant decline.
- Some measures have contributed to reversing negative trends in biodiversity (more sustainable management of fisheries and reduction of eutrophication) but progress remains insufficient.
- Changes in land use are the main driver behind the loss of biodiversity and ecosystem services in Europe.
- The impact of climate change on biodiversity and ecosystem services is growing rapidly and is likely to be one of the most important drivers in the future.
- Economic growth is generally not decoupled from environmental degradation. Decoupling them would require tax reforms as well as policy transformation.
- Long-term social transformation based on lifelong learning, knowledge sharing and participatory decision-making is a common feature of the most effective trajectories for moving towards a more sustainable future.

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[177] Pour une revue générale de l'existant dans le domaine, voir Kuruppuarachchi et al. (2017). « A comparison of major environmental justice screening and mapping tools », *Environ. Manag. Sustain. Dev*, *6*, 59-71

[178] Communication from the Commission to the European parliament, the Council, the European economic and social committee and the committee of the regions (2020). *EU Biodiversity Strategy for 2030 — Bringing nature back into our lives.*

[179] IPBES (2018). *The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia.* Rounsevell, M., Fischer, M., Torre-Marin Rando, A. and Mader, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 892 pages.

- Better integration and coordination between sectors in order to coordinate the governance of biodiversity and ecosystem services would avoid negative impacts on nature and people. This would in particular be possible for the agriculture, forestry and fisheries sectors and urban development.

5. Points of vigilance

The acceptability to local stakeholders of the measures taken locally by the public authorities to halt the decline of biodiversity and restore ecosystems is undoubtedly the most important point of vigilance, as it very strongly conditions the success of these measures.

Among the other points of vigilance, controlling the negative externalities of agriculture (water, air, etc.) is a major challenge for biodiversity and ecosystem restoration.

The possible overexploitation of forests, particularly in Europe, due to the increase in demand for wood energy and wood as a substitute for other materials, is another point of vigilance because it could run counter to other desired uses such as carbon long term storage and the provision of habitats for biodiversity.

Access to nature and its equity is an important social and cultural issue. In this area, protected areas play a major role[180].

180 Buckley, R. et al. (2019). « Economic value of protected areas via visitor mental health », *Nature Communications*, 10 (1).

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