The Sustainable Intensification of European Agriculture

Preliminary ideas from a review sponsored by the RISE Foundation
Motivation, definitions and interpretation

This document lays out the initial findings of the RISE Review of the Sustainable Intensification of European agriculture. **The final report will be released in June 2014**. If you wish to receive a final version of the report, please email rise@risefoundation.eu.

Why Sustainable Intensification?

The concept arises as a response to the challenges to ***global*** food security posed by continuing population and economic growth in the face of scarcities of agricultural land and water and the dangers posed by climate change, agricultural pollution and biodiversity loss.
Whilst strenuous efforts must be devoted to reducing food waste and the harmful effects of overconsumption, a significant growth in food production will be required by mid-century.
There is general consensus that it would be unacceptably damaging to climate and biodiversity if this were based on further conversion of forest, grasslands and wetlands.

Thus the next increment in output must come from continued intensification of existing agricultural land – but this must be accompanied by a step reduction in the negative environmental impacts of agriculture. Hence the concept of sustainable intensification.

What is Sustainable Intensification?

Sustainable Intensification means simultaneously improving the productivity & environmental management of agricultural land.
The prime goals are a resource efficient agriculture with significantly higher environmental performance. Ecosystem degradation is itself reducing agricultural productivity.
Intensification is ***not*** the goal, but will be a consequence of achieving those goals.

The principal agricultural input which will have to increase is **knowledge per hectare**.
This means improving productivity of crops and animals whilst reducing: the leakages of nutrients, crop protection chemicals and greenhouse gases; soil erosion and biodiversity loss; and expanding conservation outputs of agriculture.
Because intensity and sustainability of agricultural systems vary enormously the sustainable intensification development path will differ widely between locations, increasing agricultural output in some and conservation outputs in others.

What Does this Mean for EU agriculture?

Most of the increased food demand will arise outside Europe. EU agriculture is already amongst the most intensive in the world. The EU has a large environmental footprint through its agricultural imports, and much EU farming fails to meet environmental standards.
Together these imply that sustainable intensification of EU agriculture must place more emphasis on the first word of the couplet.

This will require: significant changes in the mind set of land managers; innovation in the way we do and communicate research and development; more benchmarking of environmental as well as economic performance of farms; greater cooperation horizontally and vertically in the food chain and with other rural stakeholders. Research, trade, environmental and agricultural policies will also have to adapt.

Deconstructing sustainable intensification.

Intensity is well defined (as a ratio of inputs or output per hectare) and it is measurable but it is generally denigrated! This is because of concern about the harmful polluting effects of *some* inputs in *some* circumstances.
High intensity does not automatically mean unsustainable agriculture / unacceptable environmental performance. Where it does, there may have to be a reduction in intensity. Our case studies on soil resilience and nutrient surplus in some livestock areas illustrate this.

If we are prepared to use the language of ecosystem services, recognizing that agricultural land can provide both provisioning services of food and energy, and non-provisioning regulating supporting and cultural services, then intensification can refer to more food output per hectare *or* more environmental services per hectare (e.g. lapwings fledged/ha).

Sustainability is not well defined or measured but is universally loved! The Brundtland definition "*meeting the needs of the present generation without compromising the ability of future generations to meet their own needs*" does not define the time horizon, and implies that an unsustainable system has exceeded a limit, tipping point, threshold or irreversibility.

Unfortunately the literature on the sustainability of agricultural systems is non-convergent. Each study invents its own indicators and whether and how to aggregate them, and does not seem to have accepted official indicator sets such as defined by the EEA. In 49 studies reviewed we counted 500 different indicators covering the three dimensions, economic, social and environmental.

There have been few attempts to discover sustainability thresholds, and the only limits identified were set by legislation. Improving sustainability is therefore a matter of raising environmental performance where it does not meet EU standards

Sustainability metrics at the farm level

A sustainable intensification path, can only be defined with respect to specific farm systems in specific locations to address specific concerns.
There are considerable efforts to collect, benchmark and publicize farm economic performance, and there are reasons to believe farmers will respond positively to such information. In contrast, there are few efforts to collect farm environmental performance, no benchmarks, and less reason to expect farmers to respond spontaneously.

There is scope for more public action to collect and disseminate information to help farmers improve environmental performance – but few resources. However, there may be considerable scope to extend and deepen the role of commercial sustainability schemes to bring about noticeable improvement in productivity and environmental performance.

Policy levers

Europe already has a highly developed framework of agricultural support and environmental regulation. Patently it has not yet guided the sector to the optimal mix of productivity gain with acceptable environmental standards. The report, to be released in June 2014, will suggest directions for future policy reform.

The report will include three case studies: soil resilience and performance, nutrient recovery and recycling and biodiversity management.

European Land Quality as a Foundation for the Sustainable Intensification of Agriculture

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The quality of land and soil is one of the most important parameters for agricultural production. However, agricultural land use causes physical, chemical and biological impacts, resulting from mechanical soil management like tillage and harvesting to the application of organic and inorganic fertilizers and pesticides.

The European agricultural sector has steadily intensified for centuries and is now among the most productive in the world. Agricultural activities take place on sites and soils with different depths, textures, mineralogical and chemical composition, organic matter content, and topographic features. This means that they react very differently to agricultural soil management.

The questions we now face are: can we further increase agricultural production, and should biomass production be considered the only target of agriculture? If not, how do we maximize the output of goods and services provided by soils and land, such as rainwater filtration, production of clean and drinkable groundwater, or the maintenance of biodiversity? These are especially important given that industrialised agriculture produces mainly monocultures, which are ecologically unstable and can only be maintained by protective human interference.

Under intensive agricultural systems, the additional functions of soil and land mentioned above can be attained only if the soil is resilient to environmentally negative impacts such as erosion, compaction, and contamination. At the same time, soils and sites must perform in a way that guarantees an optimal agricultural biomass production.

In view of all these aspects of sustainable land use, we developed a soil and land evaluation scheme for Europe. It was based on the assumption that the best soils would display both the highest resilience and the best productive performance.

Our first step was to analyse 61% of all arable land in 23 EU countries, based on available data on physical and chemical soil characteristics and the geographical distribution of the plots. By scoring 6 main soil parameters, including soil organic carbon, clay content, clay and silt content, depth, pH and cation-exchange capacity, and topography, we found that 39% of the soil is not suitable for sustainable intensification at all. 17.6% of the soil may be further intensified on a limited basis. Moreover, 6,2% of the productive surface should be extensified for environmental reasons, and sustainable intensification can be recommended for just 37,2% of the arable land surface.

More details will be presented in our final report in June 2014, along with concrete proposals for the improvement of agricultural nutrient management and synergies for the protection of biodiversity.

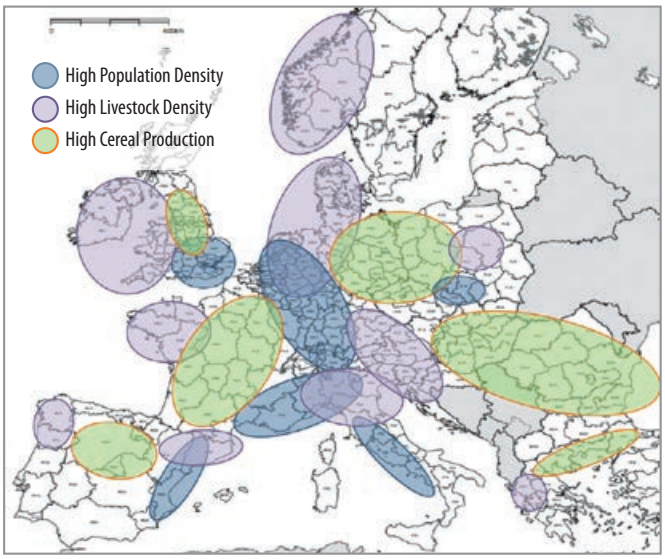
Sustainable Intensification – Nutrient Management

Nutrient Flow in Europe

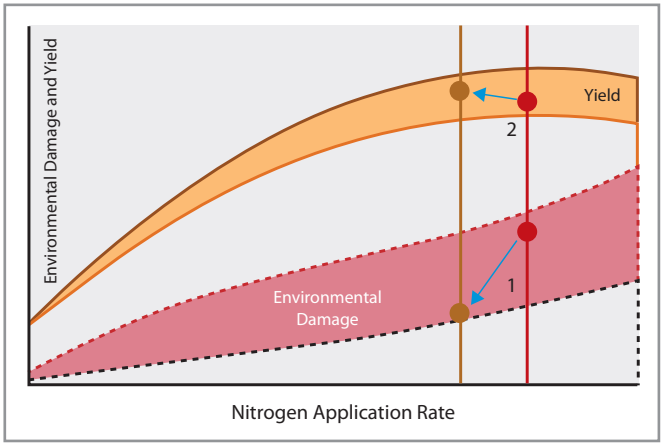
Three areas can be identified in Europe:

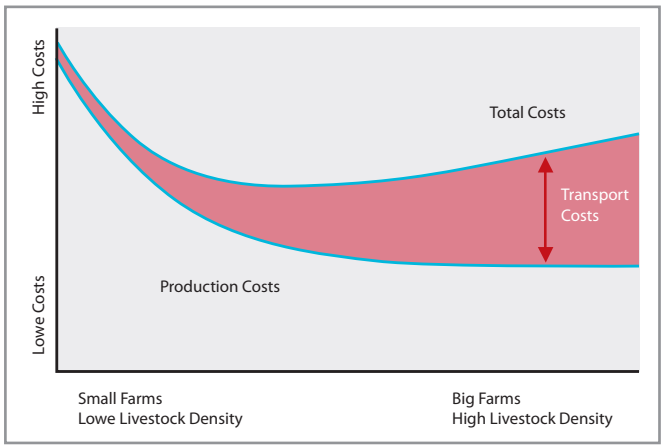
- Arable areas
- Livestock regions
- Urban regions

Arable regions export food and feed including nutrients. High amounts of mineral fertilizer have to be applied in these regions. In livestock regions the feed import leads to an excess of nutrients. In urban regions excess nutrients occur in wastewater and sewage sludge. Closing the nutrient loop means transporting nutrient surpluses back to arable regions.



Applying the concept of SI to nutrient management requires a reduction in environmental damage (1), whilst maintaining or increasing yields (2) through more efficient nutrient use.
The pattern of nutrient use in Europe offers the possibility of finding better ways to use nutrients in manure or sewage sludge in order to reduce pollution and the need to apply artificial fertilizers and make better use of these scarce resources.



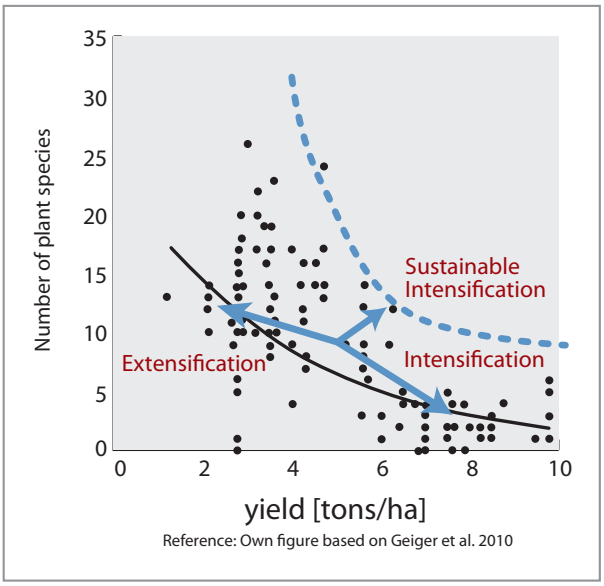


Economies of Scale and Transport Costs

The concentration of nutrients is reduced when animal feed is fed to livestock. There is high water content in manure and sewage sludge and therefore waste transportation is expensive. A better husbandry option is to couple the numbers of livestock in a region to the area of cultivated land requiring fertilizer, thus preventing a regional imbalance of nutrients. This may require a reduction in scale of animal production, with higher production costs, but lower total costs when waste transport costs are included. The challenge is to find the economically and environmentally optimum concentration of livestock per area.

Manure properties such as sanitary features and odor impact can be improved by thermophilic digestion. This new waste processing option also produces green energy. Future agricultural policy needs to focus more on nutrient management. Different political options lead to a more efficient nutrient use. The key question is how to enforce or encourage the rescaling and relocation of livestock production. This implies regional thresholds: measure oriented policy like thresholds for livestock units per hectare or goal oriented policy like maximum nutrient leaching per hectare.

Biodiversity and Agricultural Production: Supporting Synergies



Reference: Own figure based on Geiger et al. 2010

Agriculture is one of the most important causes of biodiversity loss due to intensification and land use changes. In this section, we focus on agro-biodiversity i.e. biodiversity (above and below ground), which is connected with agricultural production.

The general assumption is that biodiversity declines with increasing yield/intensity (black line in graph), but there is also evidence, that biodiversity varies considerably between sites of the same intensity.

Currently, an increase in biodiversity usually induces a decrease in yield (extensification), and an increase of yield induces a loss of biodiversity (intensification). Sustainable intensification can mean an increase of both factors at the same time and/or same place.

One main reason for variations in biodiversity at the same level of yield is the difference in landscape structure. This refers to the quantity and quality of landscape elements. In complex landscapes the intensity can be higher without decreasing biodiversity.

There are further approaches to increase biodiversity and intensity simultaneously: through the design of spatio-temporal variety of land use, agro-forestry, eco-agriculture (McNeely, J.A. & Scherr, S.J. 2001), differentiated land use (DLN) (Haber 1971), and increase of efficiency. These approaches either affect the landscape or the field as a site of conservation and take place either within the field or between the fields (landscape elements).

The task is to evaluate which combinations of approaches/measures are able to increase biodiversity without decreasing (or with increasing) yield within a given landscape. A site-specific approach is needed. Therefore we have to (a) improve the knowledge about positive trade-offs between biodiversity and intensity, (b) define "new" measures and instruments like cooperation measures, regional budgets and planning instruments, and (c) evaluate effects of implementing the defined measures/instruments on economic, social, (and other ecological) factors.

Landscape		Field	
between field	within field	within field	
Allocation of land	Management of spatiotemporal variety of land use	Extensification	Increase of efficiency
Allocation of ecol. set-aside (biodiversity friendy land use corresponding to the possible spatial and temporal factors e.g. agro-forestry, late cutting, etc.)	Variety in crop rotation (spatial, temporal) Late, differentiated cutting time Reduction of field size Prevention of abandonment of land use	Reduced use of fertilizer Reduced use of pesticides Minimum tillage Ecol. farming	Precision farming
Eco-Agriculture DNL Agro-Forestry			

Some tentative conclusions

- Sustainable Intensification is a useful, globally based, concept to steer farmers to land management which has a better balance between food production & environment.
- The EU must maintain its drive for agricultural productivity improvement, and at the same time all agricultural research and development must show it has integrated environmental considerations to enable a step-up in environmental performance.
- No single (or pair of) simple development paths emerge from the concept of Sustainable Intensification. Each farm system/location has its own combination of economic, environmental challenges and contributions. Each will have its own optimum combination of provisioning and non-provisioning services.
- Greater effort should be made to measure and benchmark farm-level environmental performance as a spur to action, matching the success of farm management economics.
- There is scope to get greater traction towards sustainable intensification from commercially inspired sustainability schemes; these could usefully enrol existing commercial relationships between farmers and up- and down-stream sectors.
- More focussed efforts are required to help identify zones and issues where practices are approaching – or have surpassed environmental thresholds, as exemplified by our soil study.
- For some challenges, solutions will require innovative approaches which involve cooperation between farmers and other stakeholders in catchments, natural zones or intensive livestock regions.
- Policy conclusions will be produced in the full final report (to be released in June 2014).

The RISE Foundation is a public utility foundation that supports sustainable agriculture and rural communities in Europe according to a long-term vision which is not only resource efficient and increasingly productive, but also works to ensure ecosystem resilience, produces safe and healthy food, manages the countryside and improves the quality of life in rural areas. Our long-term vision is a productive, green agricultural sector supporting a vibrant rural economy in Europe.

If you are interested in supporting our work and future work on sustainable intensification, please contact us at:

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