

Prevention and recovery of compacted soils

Recommendations for EU policymakers¹

Guido Bakema and Derk van Balen, Wageningen University and Research

Key messages for policymakers

- Soil compaction is an increasing threat to agricultural production and thus to food security.
- Prevention of soil compaction is a complex problem that requires collaboration across the entire supply chain. It is suggested to set up a non-statutory initiative with the entire sector to address soil compaction.
- More regulation is needed to reverse the trend towards increasingly heavy machinery. We recommended to set a maximum axle load (10 tons) and make the use of low-pressure tires (maximum tire pressure 1 bar) mandatory for agricultural vehicles.
- Recovery of compacted soils should be included as a goal when drawing up the cultivation plan. We advise to train soil advisors to better inform farmers about soil compaction.
- Prevention of soil compaction fosters climate adaptation in agriculture. We suggest to engage with water boards to maintain soil infiltration capacity through targeted regulations.
- More research on crop growth in compacted soils is needed, e.g., on deep-rooted crops and their role in improving subsurface soil structure.
- It is advisable to launch a joint program with the agricultural sector, research institutions, educational organizations, and governmental bodies to find innovative solutions for the prevention and recovery of compacted soils.
- It is recommended to provide subsidies for the further development of existing machine innovations on lighter machinery to mechanization companies and contractors.

¹ The pdf file is free of charge and can be downloaded at <https://doi.org/10.18174/684899> ©CC BY 4.0

SOIL COMPACTION IS A COMPLEX PROBLEM

Soil compaction caused by agricultural vehicles is one of the biggest threats to soil functioning [1]. It negatively affects agricultural production, water infiltration (figure 1) and storage, aeration and nutrient cycling in the soil [2]. Furthermore, soil compaction accelerates the runoff of pesticides and fertilizers, degrading water quality. Soil compaction is expected to increase further due to the use of larger and heavier agricultural machinery [3]. In addition, extreme weather conditions such as droughts and floods will exacerbate the negative effects of soil compaction.

Soil compaction is seen by FAO as a major threat to soil productivity, its ecological and hydrological functions [8] and it is also mentioned in the Sustainable Development Goal (SDG) 2 about food security.



figure 2 Heavily rewetted cropland as a result of soil compaction (Bakema, 2021)

The problem of soil compaction is not new and has been increasing over the past 30 years (figure 2). The technical solutions, which have been developed over the years, only reach the market to a limited extent.



figure 1 Weight of tractors has more than doubled in the last 30 years (Bakema, 2024)

Even if the farmer wants to prevent soil compaction, he is trapped in the system when:

- the farmer has to get his crops out of the ground, sometimes under unfavourable harvesting conditions;
- the contractor invests in large machines due to a limited harvest period and a lack of personnel;
- the food processing factory can no longer wait for the crops, because the production schedule is very tight.

How can the government support and possibly regulate the market to prevent and recover compacted soils? This policy brief offers several recommendations and management options.

PREVENTION OF SOIL COMPACTION REQUIRES A COMPREHENSIVE APPROACH

Soil compaction is a problem with many causes, and there is no single solution. Technical solutions, such as tracks tires or wider tires, are designed to limit damage, but in practice they often worsen soil compaction because they make it possible to harvest under poor field conditions [4]. The European Soil monitoring and resilience directive include management options that can prevent soil compaction, often with a strong focus on knowledge transfer and promoting action by farmers. This is necessary, but still insufficient to reverse the trend towards ever-compacted soils. Furthermore, once compacted, soils are very difficult to recover [5].

But what should policymakers focus on? Based on recent research, including within EJP SOIL (<https://ejpsoil.eu/soil-research/soilcompac>), the following main suggested solutions have been formulated [2, 3, 4, 5].

MORE SUPPLY CHAIN RESPONSIBILITY

The responsibility for preventing soil compaction now lies very much with those who use the land. This responsibility should instead be shared with those who work the land, supply machinery, lease the land and process agricultural products. This means that education, subsidies and policy measures for the prevention of soil compaction should be designed for a much broader target group than just farmers.

REDUCTION OF AXLE LOAD

Low-pressure tyres help to spread pressure better over the ground level but are not sufficiently effective in limiting the deeper (>30 cm) soil compaction. The deeper compaction can only be prevented by limiting the axle load. This means that lighter machinery must be used. If such transition in the current mechanization can be combined with more autonomous vehicles and robotisation (figure 3), then this can also overcome the problem of staff shortages and expensive machines. Regulation on maximum axel load can help reverse the trend towards increasingly heavy machinery.



figure 3 Robotisation can help limiting axle load (www.wur.nl/nl/show/robotti.htm)

NATURAL RECOVERY THROUGH CROPS

Once the soil is compacted, it is very difficult to recover it. In practice, compacted layers are often recovered by deep ploughing or deep mixing. These methods are very harmful to the soil structure and re-compaction occurs within a few years [5]. It is better to restore the soil structure through natural processes such as the cultivation of crops that are able to grow through compacted layers [9] (biosubsoilers, figure 4).



figure 4 Sorghum as a method to partially crack compacted layers (Bakema, 2022)

LINK BETWEEN CLIMATE ADAPTATION AND PREVENTION OF SOIL COMPACTION

Soil compaction means that water is less able to infiltrate into the soil during wet periods and therefore drains faster [2]. In dry periods, compaction creates extra water requirements because deeper soil layers cannot supply water. Because of climate change, those problems will increase. It is important that water authorities are more involved in the prevention and recovery of compacted soils.

CROPS IN A MORE COMPACTED SOIL

The extent to which soil compaction is perceived as a problem is highly dependent on the crop and soil type. At present, most European soils are compacted to a greater or lesser extent [6]. Many farmers still experience the effects of compaction to a limited extent because they are able to irrigate and fertilize. Stricter environmental regulations and climate change will make the problem more

visible. This means that it is important to develop knowledge on crops that can root deeper and that can be harvested at an earlier moment, under often better field conditions.

MEASURES TO ACHIEVE POLICY INTENTIONS

To give more shape to policy recommendations, some suggestions are presented below:

Innovation in new machinery:

Launch a programme on the transition to lighter vehicles and robotisation, together with the agricultural sector, research institutions, educational organizations, and governmental bodies. In addition to sustainability, the focus should lie on lighter machines and robotisation (figure 4). In the short term, subsidies should be provided for the further development of existing innovations from mechanisation companies and contractors.

Reduction of soil pressure by existing machinery:

Set a maximum axle load (10 tons) and make the use of low-pressure tyres (maximum tyre pressure 1 bar) mandatory for agricultural vehicles when working in the field [7]. This could be included in the Vehicles Regulations as a separate conditionality in Good Agriculture and Environmental Conditions (GAEC) of the CAP.

Responsibility in and with the supply chain:

Facilitating a non-statutory initiative in the field of prevention of soil compaction by forming a clear government vision on this subject and supporting the dialogue between representatives of agriculture, contractors, mechanisation companies, and food processors.



Training Water management bodies' soil teams:

Soil consultants are an important link in the provision of information to the farmers. Additional training on soil compaction to the consultants is needed to improve the literacy of farmers. Training should be set in place with water management entities in EU countries.

Linking climate adaptation to soil compaction:

Many water authorities understand and perceive the importance of proper soil management. It can be considered to let them to exert more influence on the protection of soil structure through their regulations.

Stimulation of deep-rooted crops through research and incentives:

Include focused research on deep-rooted crops and their role in improving subsurface structure. Additionally, increase the incentives for deep-rooted crops in the ECO schemes of the Strategic Plan for CAP implementation.





REFERENCES

1. FAO and ITPS (2015). Status of the World's Soil Resources (SWSR) - Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
2. Bakema, G., Bakker, G.; Cruijsen, J.; Egmond van, F.; Elsen van den, E.; Heinen, M.; Schneider, H., 2023. The influence of soil compaction on the water and air balance in the soil and on plant development; Literature review. Wageningen. Wageningen Environmental Research. Report 3225. <https://edepot.wur.nl/583342> (in Dutch).
3. Keller, T., Sandin, M., Colombi, T., Horn, R. & Or, D. (2019). The historical increase in the weight of agricultural machinery increased the stress levels of the soil and had a negative impact on the functioning of the soil. *Soil and Tillage Survey*, 194, 104293.
4. Herbert, Zwanet, Jan-Paul van der Kolk and Chris Koopmans, 2023. Incentives for the prevention of soil compaction. LBI 2023-018 LbP (in Dutch).
5. Bakema, G, Arthur, E. and Balen van, D., 2023. Techniques for the recovery of compacted soils Wageningen Environmental Research, 3296. <https://edepot.wur.nl/629799>
6. Schjonning, P., van den Akker, J. J. H., Keller, T., Greve, M., Lamandé, M., Simojoki, A., Stettler, M., Arvidsson, J., & Breuning-Madsen, H. (2015). Soil Compaction. In *Soil in Europe - threats, functions and ecosystem services: A review report, deliverable 2.1 of the RECARE project* (pp. 80-93). Bioforsk.
7. Schjønning P., M. Lamandé, T. Keller, J. Pedersen and M. Stettler, 2012. Rules of thumb for minimizing soil compaction. *Land Use and Management*, September 2012, 28, 378-393.
8. FAO and ITPS (2015). Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
9. Bakema, G., van Boxtel, Q., & van Schaik, L. (2024). The effects of bio-subsoiling species on recovery of compacted subsoils: a literature review. (Rapport / Wageningen Environmental Research; No. 3375). Wageningen Environmental Research. <https://doi.org/10.18174/673624>

