



Transforming **U**nsustainable
management of soils in key
agricultural systems in EU and China

Developing an **i**ntegrated platform of
alternatives to reverse soil degradation

Soil protection and ecosystem services by hedgerows



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Short Description of soil degradation problem and Protection/Restoration strategy

Due to intensified production and industrial farming practices, modern agricultural landscapes face multiple challenges. Ongoing changes towards large-scale homogenization and loss of structure pose an increasing threat to the functional capacity of soils, nutrient cycles, and the water balance on landscape-level. Habitat degradation in intensively managed landscapes acts as key driver for the loss of biodiversity and climate change increases difficulties for conventional agriculture. However, well-structured cultural landscapes show a higher resilience to various of the abovementioned effects. The creation and revitalization of effective hedgerow networks represents a multifunctional nature-based strategy to oppose current and future challenges.

Target area

Hedges are among the oldest and most widespread elements of cultural landscapes worldwide. With the industrialization of agriculture, the hedgerow inventory declined sharply. However, focusing on solutions for present and future problems of modern agricultural systems, the implementation of hedgerows is beneficial in all types of crop land. Woody field margins planted in right angles to slope direction reduce surface soil transport, stormwater run-off and nutrient loss. Planting hedgerows crossways to the main wind direction leads to a reduction of wind speed, therefore decreasing wind erosion and (soil) surface water loss. Increasing percolation and



air humidity, hedges support local water cycles, leading to a cooling effect and close-range VPD reduction. Hedgerows facilitate the connection of habitats and the creation of wildlife corridors, supporting biodiversity and natural pest control in adjacent fields.

Problem identification

Hedges can counteract a lack of biodiversity, pests, erosion processes, and soil structure degradation. These problems leading to severe yield losses

are usually quickly identified by farmers. Erosion and soil structure assessment can be supported by the TUDI soil erosion app "[Link will be provided](#)".

Detailed description of protection

Generally, hedgerows can be created alongside any field margin of choice. However, depending on the desired effects, slope, main wind direction as well as existing hedges or habitat patches nearby should be considered. Hedges have a three-dimensional structure that consist of the vertical zoning in cross section, the horizontal zoning from bottom to top and the longitudinal structure. The ideal cross section is composed of a herbaceous buffer strip followed by a shrub-dominated mantle zone, a tree containing core zone, a second mantle zone and a second buffer strip on the other side of the hedge. Depending on planting strategy and

management practices, hedges can miss one or more zones. For full ecological functioning, the woody part of the hedge should have a minimum width of 2.5m, the recommended width for the buffer strip is $>2\text{m}$. The fringe acts as relevant habitat for a variety of insects and reduces potential shading effects on adjacent cropland. Depending on age, canopy density and light conditions, the horizontal zoning of a hedge is composed of understory herbs and herbaceous plants of the fringe, shrubs and small trees as well as overgrowing trees. The longitudinal structure is important in terms of ecological connectivity, diversity of habitats and the natural

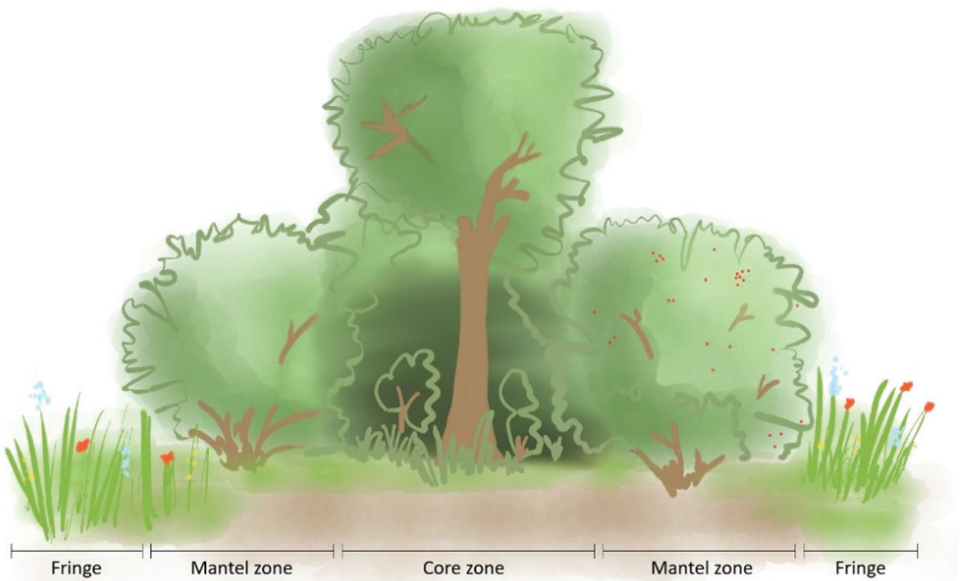


Fig. 1: Typical hedge structure with core zone, two mantel zones and two fringe zones; Source/Author: Heck. in/Alexandra Dürr 2023.



Fig. 2: Hedge with fringe to the left of the hedge;
Source/Author: Heck.in/Alexandra Dürr 2023.

barrier effect. Hedges can be created on a relief of dykes and ditches to maximize the desired effects regarding erosion, soil and nutrient transport as well as rainwater retention. Preferably, hedges should be closed throughout their entire length, however a maximum amount of 5-10% gaps in total (individual gap <5m) is feasible. Well-structured hedgerows have an important role as wildlife corridors and for biotope cross-linking. For the ecological value of woody field margins, the species selection plays an important role. Most regions have a native/traditional set of woody pioneer/hedgerow species. It is recommended to take these plants into consideration. They support the functioning of local ecosystems as well as potential symbioses and therefore promote crop health through increased pollination and natural pest control. This can contribute to a significant decrease in the use of pesticides. Choosing edible plants, such as fruit bearing trees, supports wildlife, but it also opens the option for an additional

harvest. To maintain its character, a hedgerow needs management. It is recommended to cut the grassy buffer strips once or twice a year. For the woody structure, it is advisable to stick to traditional management practices, such as coppicing, hedge laying or single stem sampling. Dead and cut wood can be left in the hedge to support structural breeders and saproxylic species, however it could also be used as firewood or in biomass heating plants. Hedgerows boost carbon sequestration in agricultural landscape through biomass accumulation and increase the soil carbon stock. Furthermore, they constitute climate change adaptation measurements as they have a stabilizing effect on the local microclimate. Hedgerows mitigate stormwater run-off in case of heavy rain events and contribute to slope protection. Thus, they have a positive influence on the soil water movement on slopy sites and can therefore reduce the needed amount of fertilizers.



Fig. 3: Source http://www.rexinger-themenwege.de/natur-und-kultur/13_lebensraum_hecke.

Effects/results/case studies

All hedges and hedgerow networks can deliver a broad range of ecosystem services. However, depending on location, structure, length, age, species composition and management practices, the extent of different effects can vary greatly. Special assessment manuals, such as Heck.in (Dürr et al. 2023), enable the detailed analysis of a hedgerow's benefits and possible trade-offs. These, most commonly indicator-based, appraisal systems can be applied to evaluate the ecosystem service delivery of any existing hedgerow. Additionally, they can be used as guidelines for the creation of new hedges. The manuals provide an insight into the complex interrelationships between hedge features, landscape, and ecosystem



Fig. 4: Developed hedge with path and dead wood; Source/Author: Heck.in/Alexandra Dürr (2023).

services delivery. Using an assessment system as orientation guide makes it easy to create a customized hedgerow that delivers the desired effects.

Pros/Cons of technique, Obstacles to implementation

Hedges provide multiple complex benefits for ecosystem, biodiversity, soil and crop health. They act as diverse habitats and wildlife corridors. Well-structured woody networks can increase the water retention on landscape-level, mitigating soil erosion and the risk flood events. They act as windbreaks and have a stabilizing effect on the microclimate. Hedgerows are highly effective long-term measurements. However, it is important to note that they need time to develop. Newly planted ones have only low immediate effects. Also, hedges

have a higher land consumption than regular field margins and have higher management requirements. Grown hedgerows with narrow buffer strips can have negative effects on adjacent crop rows through shading. Various positive effects can decline with increasing distance to the hedge.



More literature

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Drexler, S.; Gensior, A. u. Don, A. (2021): Carbon sequestration in hedgerow biomass and soil in the temperate climate zone. *Regional Environmental Change* 21 (3). <https://doi.org/10.1007/s10113-021-01798-8>

Summary text

The continuously reduced complexity of agricultural ecosystems leads to a variety of far-reaching problems on the one hand, climate change increases the challenges for crop production and food security on the other hand. Therefore, multifunctional approaches to tackle a wide range of challenges are urgently needed. Hedgerows combine a multitude of long-term positive features. Thus, their transforming effects have high potential for modern agricultural landscapes and crop production. Hedgerows have a long cultural tradition; however, they represent a



Fig. 5: Newly planted hedge; Source/Author: Heck.in/ Alexandra Dürr (2023).

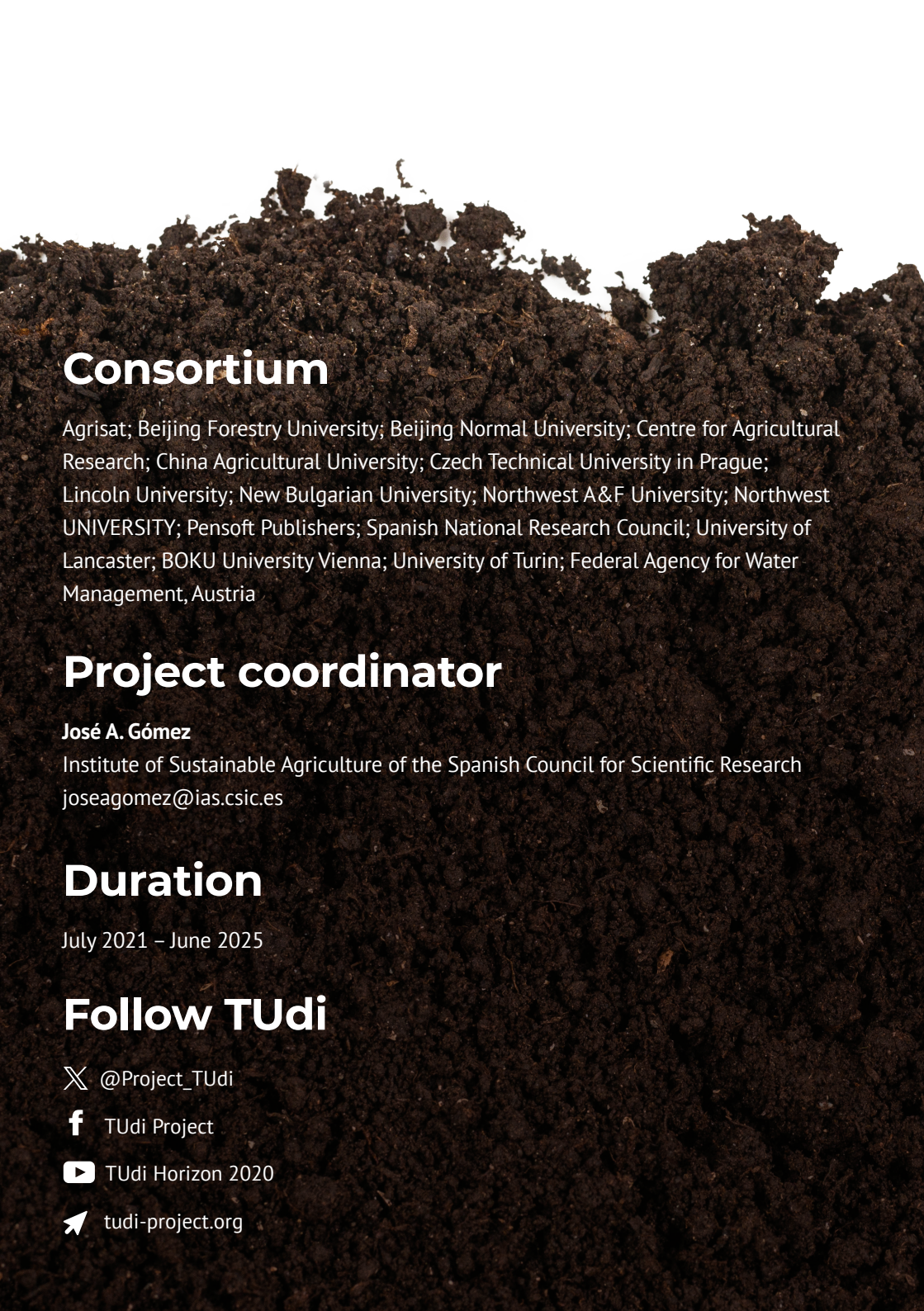
contemporary strategy to counter pressing problems. Hedges can be designed to provide required functions, they can be adapted to local needs and ecosystems, plus they can be easily implemented.



Summary table

	Rating	Comments
Soil health overall	**	
Water budget	**	Reduced VPD; cooling effect
Soil structure	*	No influence on soil structure in adjacent fields
Erosivity	**	Barrier effect, water retention; reduced surface runoff & soil loss; reduction of windspeed and wind erosion
Nutrient balance	**	
Soil life	***	Healthy soil life under hedges; permanent habitat structures for reproduction and wintering support healthy populations and increase abundance in adjacent fields
Practicability	**	Hedges can be easily implemented in modern agroforestry systems, however they reduce total crop land area
Economy	*	Land use, additional costs for planting and management; funding available in Austria (?)





Consortium

Agrisat; Beijing Forestry University; Beijing Normal University; Centre for Agricultural Research; China Agricultural University; Czech Technical University in Prague; Lincoln University; New Bulgarian University; Northwest A&F University; Northwest UNIVERSITY; Pensoft Publishers; Spanish National Research Council; University of Lancaster; BOKU University Vienna; University of Turin; Federal Agency for Water Management, Austria

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