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Implementing an OECD Farmland Habitat Biodiversity Indicator: Lessons and guidelines from eight pilot studies

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Note by the Secretariat

This document presents a summary of the pilot studies to implement the indicator in seven OECD countries (Costa Rica, Finland, Germany, Japan, Latvia, Norway, Switzerland) plus Brazil and identifies challenges and lessons learned. This work is in line with the Expected Output Result 3.2.3.2.1 of the 2023-24 Programme of Work and Budget (PWB) of the Committee for Agriculture and is one of two deliverables under "Improving agri-environmental performance".

This work is outlined by the scoping paper [COM/TAD/CA/ENV/EPOC(2023)5], and incorporates comments received on the first draft [COM/TAD/CA/ENV/EPOC(2025)1] and revised draft [COM/TAD/CA/ENV/EPOC(2025)1/REV1]. It builds on the previous work "Guidelines for the development of an OECD Farmland Habitat Biodiversity Indicator" (Bayr et al., 2023[1]) which was declassified at the 54th Session of the JWPAE.

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This document was declassified at the 58th Session of the Joint Working Party on Agriculture and the Environment.

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Abstract

This paper outlines the rationale for, and the current state of, mapping habitat diversity. It provides an overview of progress in assessing and monitoring farmland habitat biodiversity at the national level, in line with the proposed OECD Farmland Habitat Biodiversity Indicator (FHBI). The paper describes pilot studies by eight countries, summarising the approaches to mapping habitats, assessing habitat quality, and implementing the FHBI at the national level. Drawing from the experience of the FHBI pilot countries, this paper offers general guidelines for defining habitats and assigning biodiversity values of habitats for calculation of the FHBI. It provides guidance on selecting the appropriate tier level for data acquisition, processing, and reporting, and summarises strengths, weaknesses and opportunities of the current FHBI structure used in the pilot studies.

1. Monitoring farmland habitat biodiversity: Importance, approaches, and indicators

1. Agricultural landscapes are central to global food security, but they are also critical habitats for a diverse range of flora and fauna (German National Academy of Sciences Leopoldina, 2020[2]). This biodiversity (of farmland) refers to the variety of life found in these landscapes, including genetic diversity, species diversity, and habitat diversity (King et al., 2021[3]). Farmland biodiversity is also essential for ecosystem functioning and agricultural productivity, providing vital services such as pollination, pest control, nutrient cycling, and soil fertility (Seppelt et al., 2020[4]). Moreover, farmland biodiversity increases resilience to environmental changes, including climate variability, and supports the viability of food production systems (Altieri et al., 2015[5]).

2. Intensified agricultural practices have led to significant changes in farmland ecosystems (Tribot, Deter and Mouquet, 2018[6]), often resulting in biodiversity loss and the environmental degradation (Newbold et al., 2015[7]). The shift towards monocultures, the extensive use of chemical fertilisers and pesticides, habitat fragmentation, and the conversion of natural ecosystems to agricultural land have all contributed to the decline in species richness and ecosystem complexity (Emmerson et al., 2016[8]). These changes not only threaten biodiversity, but also undermine the ecosystem services that are critical for long-term agricultural productivity and environmental health (Emmerson et al., 2016[8]). Understanding and monitoring farmland biodiversity is therefore essential for managing biodiversity, and for environmental and agricultural sustainability.

3. Given the critical role of biodiversity in maintaining ecosystem functions and the apparent decline of biodiversity in agricultural landscapes, monitoring is becoming an essential tool for conservation and sustainable land management (OECD, 2023[9]). Continuous monitoring can support ecosystem services by informing biodiversity impact assessments of agricultural practices, farmland biodiversity policy developments, and ecosystem risk assessments (Leibniz Research Network Biodiversity, 2024[10]).[1] However,

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[1] Experts involved in the pilots underlined the differences between monitoring (as the continuous, systematic collection of data to track the progress or status of an indicator) and evaluation (as the systematic assessment of the relevance, efficiency, effectiveness, and impact of a measure or intervention). Monitoring data serves as the evidence base for answering evaluation questions about effectiveness, relevance, and impact. Yet, limitations of monitoring data for evaluation include 1) lack of depth (monitoring focuses on what is happening, often without exploring underlying

monitoring and preserving biodiversity is a complex task due to the large number of species and the complex relationships within ecosystems, which, in turn, interact with abiotic factors and human activities.

4. Current monitoring programmes focus primarily on single, often conspicuous species groups, such as birds and butterflies, often recorded by volunteers. Such programmes have important limitations, particularly in regions where comprehensive monitoring is difficult. In addition, higher numbers of farmland birds do not always indicate positive environmental conditions, as the species being counted may not represent useful ecological indicators.

5. Biodiversity broadly is categorised into habitat, species, and genetic biodiversity. Habitat diversity refers to the variety and complexity of different habitats or ecological environments within a given area (Bunce et al., 2013[11]) or on farms (Herzog et al., 2017[12]). It can also serve as a proxy for species diversity (Bunce et al., 2013[11]; Cervellini et al., 2021[13]), as correlations between habitat and species diversity have been observed, albeit imperfectly (Billeter et al., 2007[14]; Hendrickx et al., 2007[15]). As each habitat type supports different species, communities, and ecological processes, landscapes with a high diversity (i.e. more complex agricultural landscapes) are likely to support more species and have greater ecological resilience (Estrada-Carmona et al., 2022[16]).

6. However, habitat diversity is not just about supporting a variety of species within their respective habitats, but also about the functional complementarity between different habitats within a landscape. Many species depend on different habitats throughout their life cycles for food, breeding, shelter, and movement (Law and Dickman, 1998[17]). For example, pollinators may rely on flower-rich meadows for nectar while nesting in adjacent hedgerows, and amphibians require wetlands for reproduction but need nearby woodlands for refuge. The presence of interconnected, complementary habitats ensures that ecological functions such as pollination, seed dispersal, pest control, and nutrient cycling can occur efficiently across the landscape (Thompson, Rayfield and Gonzalez, 2016[18]).

7. In addition to habitat diversity, habitat quality is a critical component of farmland biodiversity and encompasses the suitability of habitats to support various species (Broquet et al., 2024[19]). High-quality habitats provide the necessary resources, such as food, water, and shelter, and maintain the ecological processes essential for species survival and reproduction. A large area of high-quality habitat is essential to maintain viable populations and ecological processes (species-area-relationship) (Lomolino, 2000[20]). Small, isolated patches of habitat are more vulnerable to degradation, fragmentation, and edge effects, which can reduce their capacity to support biodiversity in the long term. Larger and well-connected habitats provide more resources, reduce competition, allow for genetic exchange between populations, and provide refuge during environmental disturbances such as extreme weather events. High-quality habitats, characterised by minimal human disturbance, structural complexity, and rich species assemblages, and their connectivity, are particularly important for supporting specialist species that have narrow ecological requirements and are often more sensitive to habitat loss and degradation (Kneitel, 2018[21]).

8. Quantifying habitat quality poses significant challenges due to its dynamic nature and the need to consider the interaction and interplay of multiple biotic and abiotic factors.

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causes or contextual factors), 2) causality challenges (monitoring data alone cannot establish causal links between interventions and observed changes, as it this is dependent on the analytical/experimental set up), and 3) bias in metrics (monitoring often tracks predefined indicators that may not fully reflect system complexity).

Factors such as soil fertility, plant health, the presence of contaminants, and management practices can vary widely over time and space, making consistent assessments difficult. Despite these challenges, spatially detailed data on habitat quality is essential for targeted conservation and restoration planning.

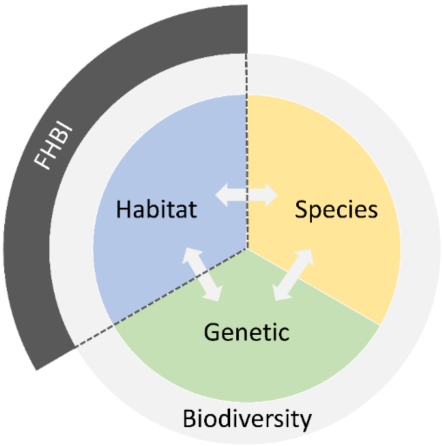
9. Mapping and monitoring farmland habitat diversity and quality can therefore be a crucial aspect of ensuring sustainable agricultural practices and preserving biodiversity. Globally, several initiatives, tools, and methodologies have been developed to monitor and assess farmland habitat diversity (for an overview, see Bayr et al. (2023[1]). However, monitoring farmland habitat diversity requires co-ordinated efforts across scales and regions (Bayr et al., 2023[1]), while the relevance of monitoring approaches can vary significantly across regions, taking into account country-specific agricultural practices, policies, and the resulting challenges and opportunities. While several OECD Members have developed sophisticated monitoring frameworks, challenges related to data availability, quality, and consistency remain significant. By actively addressing these challenges, global and OECD-specific monitoring efforts can become more robust, contributing to safeguarding biodiversity in agricultural landscapes.

10. The OECD Farmland Habitat Biodiversity Indicator (FHBI) provides an approach to monitoring and assessing habitat quality. The FHBI structure harmonises reporting from different national monitoring programmes, while recognising that different biogeographical regions and agricultural systems have different species pools and baseline levels of biodiversity (Bayr et al., 2023[1]). The focus is on providing a general guideline and a tool for the overall assessment of farmland habitat biodiversity monitoring in each country. The emphasis is therefore on monitoring relative FHBI trends within countries, rather than on absolute comparisons of FHBI values and trends across countries. The indicator enables the assessment of habitat trends and supports the development of policies aimed at maintaining and/or improving the quality of farmland habitats and thereby conserving farmland biodiversity.

11. Importantly, the FHBI addresses one dimension of the three dimensions of biodiversity: habitat diversity (Figure 1.1). Given the links between the three dimensions, habitat diversity can be interpreted as a proxy for habitat quality, which influences patterns and trends in species and genetic diversity (i.e. depicting the potential of farmland habitat to support species diversity). For example, higher farmland management intensity is generally associated with lower species diversity (Kehoe et al., 2015[22]; Newbold et al., 2015[7]). Moreover, farmland with a higher compositional and configurational heterogeneity is generally related to higher species diversity (Martin et al., 2019[23]; Priyadarshana et al., 2024[24]; Sirami et al., 2019[25]). Finally, a higher proportion of (semi-) natural habitats on and in the vicinity of farmlands promotes farm productivity, biodiversity conservation, and ecosystem services (Garibaldi et al., 2020[26]; Garibaldi et al., 2023[27]; Jeanneret et al., 2021[28]).

12. This paper summarises the OECD FHBI pilot project. It provides an overview of the indicator and a summary of the different methodologies used by the pilot countries to implement the indicator. It synthesises the lessons learned from the pilot project, identifies gaps and areas for further improvement of the indicator, and proposes further clarification of the tier-structure used to reflect data availability in member countries (Bayr et al., 2023[1]).

Figure 1.1. Three dimensions of biodiversity and the target dimension of the Farmland Habitat Biodiversity Indicator (FHBI).



2. Concept of the OECD Farmland Habitat Biodiversity Indicator

13. Although the current OECD agri-environmental indicators can be used to assess biodiversity-supporting measures and activities in agricultural landscapes, there is currently no standardised way of monitoring farmland habitats. Existing biodiversity monitoring initiatives by OECD Members generally tend to be country-specific and to vary in their underlying definitions of habitats, sampling plans, and survey methods. This contributes to an uneven distribution of available data among Members, as well as to uneven data quality and thematic inconsistency.

14. For example, while Europe has comprehensive databases such as the pan-European land cover inventory Corine Land Cover (CLC), other regions and continents may lack such data. In addition, the quality of data for assessing farmland habitats often depends on the methods used to collect data. While remote sensing is commonly used, it may not capture finer details of habitat diversity, such as species composition. Field surveys, on the other hand, while more accurate, are expensive and time-consuming and are hence rarely or infrequently updated. Integrating data from different sources, scales, and of varying quality consequently therefore poses challenges in terms of standardisation and compatibility. This issue is especially pronounced when trying to implement the indicator across countries with different monitoring systems.

15. Another challenge is the spatial and thematic consistency of global monitoring of farmland habitats (see e.g. (Bailey et al., 2007[29])). Differences in land-use classification systems, mapping scales, and monitoring protocols between countries lead to inconsistencies in data. Furthermore, although long-term monitoring is essential to detect trends in habitat diversity and quality, temporal consistency in habitat monitoring is often lacking.

16. To address these limitations, Bayr et al. (2023[1]) outlined the development of the OECD FHBI. The indicator specifically builds on national monitoring activities within OECD countries to avoid duplication, administrative burden, and additional financial costs. It may also be of interest to countries that have not yet established a system for monitoring farmland habitats and their quality. The proposed approach recognises that different agricultural systems and environmental conditions lead to different species pools and ultimately different farmland habitat baselines. It also takes into account differences in data availability in general as well as diversity of monitoring programmes. This is done by the

use of a three-tiered system, in which the tiers are defined based on the availability and quality of (monitoring) data, ranging from Tier I with high coverage, through Tier II with moderate coverage, to Tier III with limited data availability (Table 2.1).

17. Once the target tier is defined, Bayr et al. (2023[1]) suggest the following steps for the development of a national FHBI:

1. Define farmland habitats and map habitat diversity
2. Categorise farmland habitats based on their habitat quality for biodiversity: very low (1), low (2), moderate (3), high (4), very high (5)
3. Calculate the proportion of farmland habitats in each biodiversity category
4. Derive an FHBI value based on the individual habitat shares and the assigned values for a desired aggregation level (e.g., administrative units, sampling grid).

Table 2.1. Description of the different tier levels for the calculation of a national FHBI

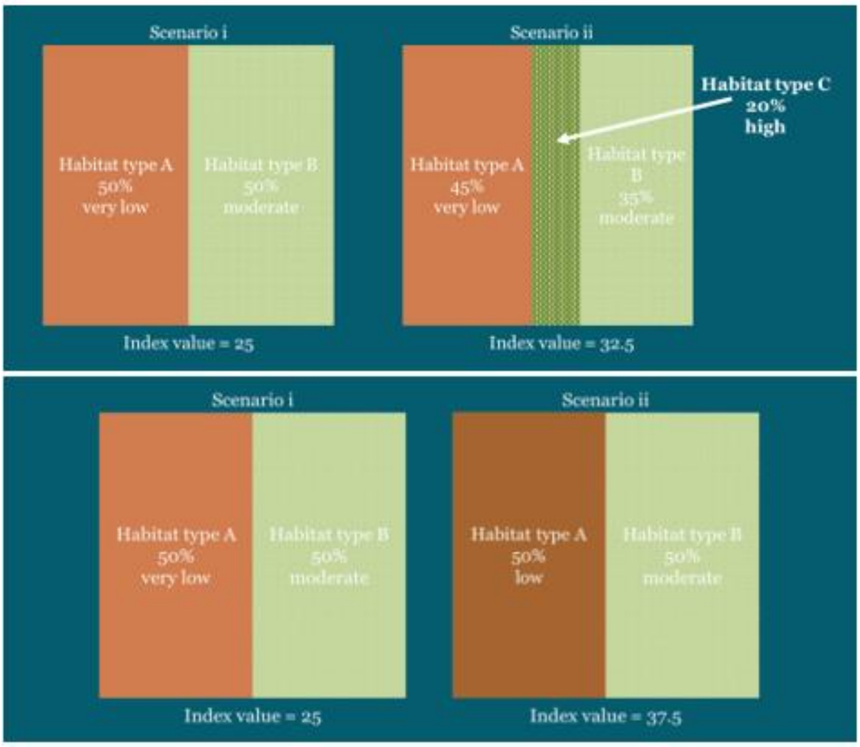
	Tier I (high)	Tier II (moderate)	Tier III (limited)
Data availability	Field data, remote sensing and aerial imagery	Very high-resolution remote sensing, aerial imagery	Census reporting, remote sensing imagery
Biodiversity value	Species monitoring data	Species distribution maps, known habitat associations	Expert opinion, "most probable value"

18. For the last step, a weighting function is proposed that limits the indicator values to a range from zero to one hundred (Equation 1). The indicator can be aggregated to different spatial units and allows, for example, the identification of regions with a high(er) proportion of high biodiversity value habitats. Regular assessment of this trend indicator over time enables the identification of trends in farmland habitat biodiversity and the interpretation of the impact of changes in habitat composition and/or quality on the indicator value and, thus, on farmland habitat biodiversity.

$$FHBI = (\%\,Very\ low\ x\ 0) + (\%\,Low\ x\ 0.25) + (\%\,Moderate\ x\ 0.5) + (\%\,High\ x\ 0.75) + (\%\,Very\ high\ x\ 1) \quad (1)$$

19. As an example, Figure 2.1 illustrates the sensitivity of the FHBI to changes in the composition of agricultural land, as well as to changes in habitat quality within a habitat type, for example as a result of the implementation of environmental measures as part of national agricultural or environmental policies. However, the interpretation of the indicator only enables the assessment of net changes in habitat quality values for a given aggregation unit, while gross changes may go unnoticed. For example, if one region of an aggregation unit experiences a decline in habitat quality while another region experiences an increase in habitat quality, this could result in a stable habitat quality value for the aggregation unit (net change) while gross changes are substantial. Whether this compensation is actually "biodiversity-neutral", as the stable habitat quality values suggest, needs to be assessed in more detail. Therefore, when reporting FHBI values, countries should ensure that changes in habitat composition are provided in addition to overall FHBI scores to track FHBI trends and disaggregate the components.

Figure 2.1. Illustration of the basic principle of the Farmland Habitat Biodiversity Indicator (FHBI)



Note: Top: Impact of changes in farmland composition on the FHBI value.
Bottom: Impact of changes in habitat quality on the FHBI value.

3. Method development in FHBI pilot countries

20. To demonstrate the applicability of the workflow proposed by Bayr et al. (2023[1]) at the national level, seven OECD Members (Costa Rica, Finland, Germany, Japan, Latvia, Norway, and Switzerland) plus Brazil agreed to participate in this pilot study. The first seven countries have completed the initial implementation of their farmland biodiversity/habitat monitoring programmes; Brazil is participating asynchronously in the pilot and at this stage, has contributed a conceptual assessment of a possible future implementation of the FHBI. All countries identified the farmland habitats to be monitored in their respective countries and determined an appropriate tier level based on data availability and quality. This pilot study enabled the identification of strengths and potential limitations of the proposed FHBI approaches. The following sections describe the individual approaches taken by the pilot countries to calculate, map, and report a first version of a national FHBI.

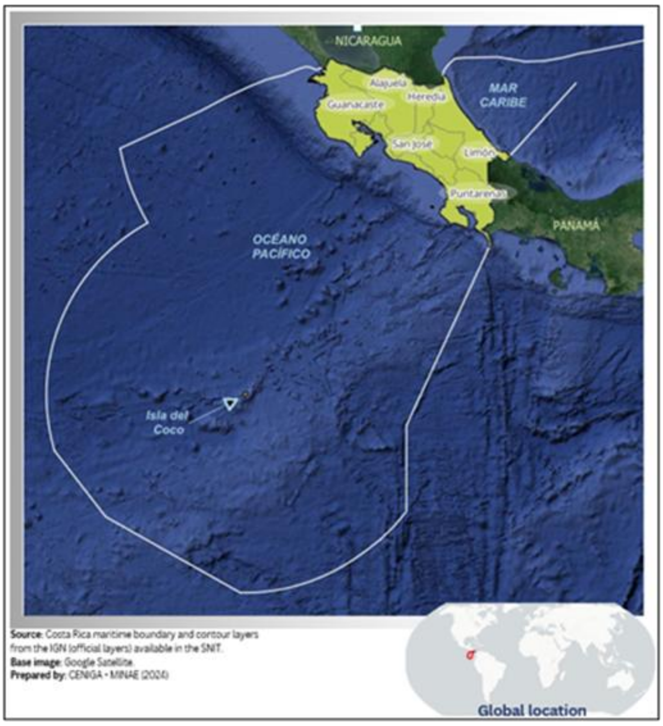
3.1. Costa Rica

3.1.1. Key characteristics of farmland habitats and land use

21. Costa Rica is a small country (54 000 km² and approximately 5 164 860 inhabitants). Approximately 26% of Costa Rican territory is designated as protected wildlife areas, and nearly 60% of the country is covered by forests, reflecting the result of the country’s long-term commitment to environmental sustainability. Costa Rica

harbors approximately 6% of the world's biodiversity, making it one of the most biologically diverse countries. However, natural habitats like forests, mangroves, wetlands, and other ecosystems face considerable pressure due to population growth, urbanisation, expansion of the agricultural frontier, and demand for food and economic income generation.

Figure 3.1. Costa Rican territory



Source: Costa Rican pilot country experts.

22. Costa Rica has developed a diverse agricultural sector. According to the Costa Rican Agency for Foreign Trade Development (PROCOMER), in 2023 the country had 649 agricultural exporting companies, 369 exported products, and 108 export destinations, coexisting with significant conservation efforts. Recent data and trends, according to the Executive Secretariat of Agricultural Sectoral Planning (*la Secretaría Ejecutiva de Planificación Sectorial Agropecuaria*) (SEPSA) shows relevant information on the Costa Rican agricultural sector during the period 2020-2023: (a) decrease in GDP contribution from 4.3% (2020) to 3.8% (2023), (b) the share of agriculture in exports (by value) fell from 42.2% (2020) to 33.3% (2023) and, (c) agricultural employment as a share of the total workforce fell from 11.6% (2020) to 9.5% (2023).

23. In terms of cropland use, Costa Rica presents a mix of annual and perennial crops, as well as extensive areas dedicated to pastures. Annual crops (Figure 3.2), such as rice, beans, corn, onions, and melons, occupy significant areas, especially in the northern plains and coastal zones. These crops are characterised by short life cycles and frequent rotation, which can have negative impacts on biodiversity due to the reliance on agrochemicals and intensive practices. On the other hand, perennial crops (Figure 3.2), such as coffee, bananas, pineapples, and sugarcane, predominate in long-term production areas, contributing to the stability of agricultural ecosystems and, in many cases, harbouring greater species diversity. Areas dedicated to perennial crops are often associated with

agroforestry practices and live fences, benefiting both biodiversity and ecological connectivity in the landscape.

24. Grasslands (Figure 3.2), primarily used for cattle ranching, for both meat and dairy production, are also common in the Costa Rican agricultural landscape. These are often associated with agroforestry systems, including shade trees and live fences, which enhance their value for biodiversity. Although grasslands can be intensively managed, their integration with natural elements such as biological corridors and protected water bodies allows these agricultural habitats to contribute to biodiversity conservation in the country.

25. According to the National Institute of Statistics and Census (2015), in Costa Rica it is estimated that around 2 406 418.4 ha are dedicated to agricultural production and 1 044 909.6 ha are used in grazing livestock; which is equivalent to 43.4% of the total land used.

26. Finally, bare land and other land use types like natural or artificial ones are primarily found in urban areas or those affected by human activities such as construction and mining. These areas have very low biodiversity value, as they lack natural vegetation and are subject to frequent human intervention. However, Costa Rica has developed policies to rehabilitate degraded areas and promote biodiversity conservation in agricultural landscapes (e.g. the National Biodiversity Strategy and Action Plan), which is an important step in maintaining the country's biological wealth.

Figure 3.2. Examples of agricultural lands in Costa Rica

Note: Left: vegetable crops. Centre: coffee plantation with shaded tree cover. Right: pastures with live fences for beef cattle ranching.
Source: Costa Rican pilot country experts.

3.1.2. Data

27. The mapping of agricultural habitats in Costa Rica relies on a comprehensive approach that integrates advanced remote sensing technologies with national databases. The country has developed a strong capacity for land use mapping through its Secretariat for Reducing Emissions from Deforestation (REDD+). For the FHBI pilot project, existing maps produced by the REDD+ Secretariat were utilised for the analysis. However, the level of detail in this context is limited, both spatially and thematically. As part of the FHBI pilot project, land cover maps were generated using Landsat imagery and classified with the Random Forest algorithm. These maps span an eight-year period (2013–2021) and offer a spatial resolution of 30 x 30 m, enabling the classification of major agricultural land use categories with high accuracy.

28. The classification process for these maps based on the physical land characteristics and productive activities carried out on them, enabling the identification of five land use categories relevant to the FHBI calculation: annual croplands, perennial croplands,

grasslands, artificial bare lands, and natural bare lands.[2] While natural and artificial bare lands were categorised as such, this designation does not necessarily imply restrictions on their potential agricultural use. At the time of mapping, these lands were not classified as agricultural but appeared as bare in the imagery used for classification. Many represent land under preparation, while some natural bare lands consist of soils that do not necessarily have legal restrictions preventing their eventual conversion to agriculture.

29. Costa Rica currently reports at the **Tier III** level, as defined in Table 2.1. While the country has made significant progress and has initiatives that could enable **Tier I or Tier II** reporting in the future, these efforts are not yet systematically organised or easily accessible to users.

30. Regarding temporal resolution, the data covers five points in time (2013, 2015, 2017, 2019, and 2021), spanning an eight-year period. These maps allow for the observation of land use changes over time, which can serve as a basis for inferring potential impacts on biodiversity if necessary. However, their primary purpose is not to directly assess biodiversity impact but rather to track trends in agricultural land use. It is important to highlight that while the country has a vast amount of biodiversity-related data, much of it remains unsystematised and not publicly accessible. This lack of availability and organisation has led Costa Rica to report under Tier III for this pilot project, indicating that although valuable information exists, it is not yet fully integrated for optimal decision-making in biodiversity conservation within agricultural habitats.

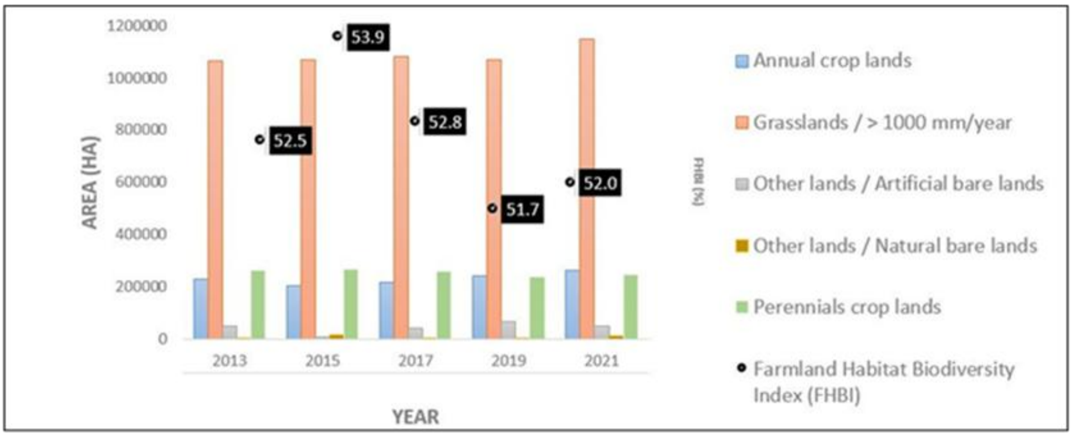
3.1.3. Calculation of the FHBI

31. The FHBI was calculated in strict adherence to the pragmatic scope proposed in the pilot's technical document. Habitat quality values were assigned to each of the five land use categories relevant to the FHBI calculation, as identified in the REDD+ Secretariat maps: annual croplands, perennial croplands, grasslands, artificial bare lands, and natural bare lands.

32. This process was carried out in several stages, starting with the classification of agricultural habitats based on their biodiversity value. This value was reviewed and agreed upon by an agronomic engineering professional with extensive knowledge in agricultural production, sustainable farming, and experience in various initiatives aimed at improving agricultural extension in the country, as well as strengthening the experimental capacity of agricultural producers. This expert also had experience in areas related to sustainable agricultural production, sustainable production and consumption in agri-food systems, climate-smart agriculture, and other relevant fields. Additionally, a forestry engineering professional specialised in natural resource management, agricultural production technologies, and geographic information systems (GIS) and remote sensing systems was involved. For this purpose, the five categories of value for biodiversity (from very low to very high), as proposed by Bayr et al. (2023[1]) were used (Section 2). In Figure 3.3, data on the area in hectares for each category of land use or with potential to be used in agricultural production in the country is presented.

[2] Artificial bare lands and natural bare lands were not interpreted as agricultural use at the time of mapping; rather, they are areas that, at the time the imagery used for mapping was captured, appeared as bare lands. Many of these are lands under preparation, while in the case of natural bare lands, many are soils that do not necessarily have a legal restriction that would prevent their eventual transition to agricultural use.

Figure 3.3. Area in hectares for each category of land use or with potential to be used in agricultural production in Costa Rica



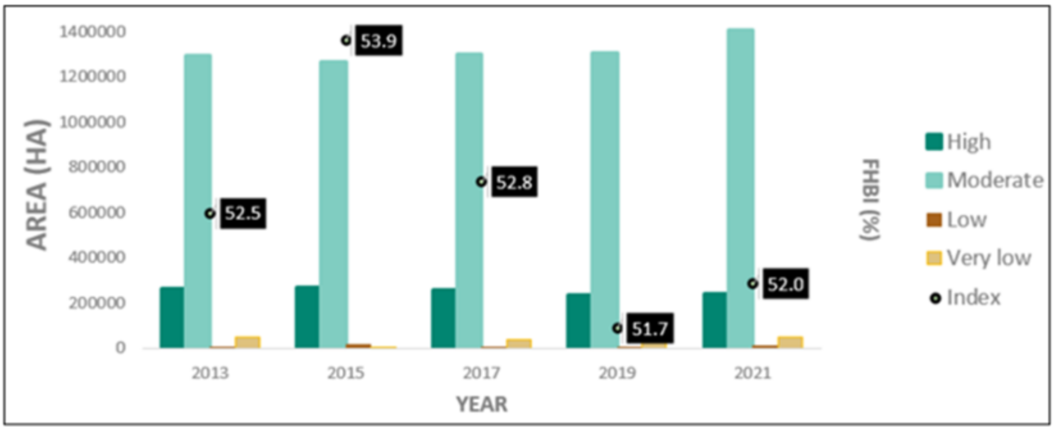
Source: Costa Rican pilot country experts.

33. Based on expert assessment, annual crops were classified as having a moderate value for biodiversity as frequent rotation can limit ecosystem stability, resulting in a reliance on chemical inputs and intensive practices. In contrast, perennial crops were assigned a high value for biodiversity as under good agricultural practices, they can contribute to soil and ecosystem stability.

34. Based on expert assessment, grasslands, primarily used for livestock grazing, were also classified as having moderate value. Although they require intensive management, they are commonly associated with live fences and shade trees, which allow them to support a moderate diversity of species. On the other hand, artificial bare lands were classified as having very low biodiversity value, as these areas are heavily intervened by human activity and are subject to ongoing intervention. Meanwhile, natural bare lands were considered to have low biodiversity value due more to their intrinsic characteristics than anthropogenic intervention.

35. The calculation of the FHBI followed the proposed approach by Bayr et al. (2023[1]) (Section 2) and is reported in Figure 3.4. This index reflects the proportion of agricultural lands that support biodiversity and can be used to measure the environmental impact of agricultural practices. In terms of spatial scale, Costa Rica could consider reporting this index at the national level, with updates aligned to the periodic publication of land cover maps generated by the REDD+ Secretariat, generally every two years.

Figure 3.4. Farmland habitat biodiversity index for Costa Rica



Source: Costa Rican pilot country experts.

3.1.4. Strengths and weaknesses of the Costa Rican FHBI

36. The FHBI in Costa Rica presents both opportunities and limitations in its implementation. Regarding strengths, the country has a solid infrastructure for land use monitoring, which includes advanced remote sensing tools and GIS: (a) SIMOCUTE system (*Sistema Nacional de Monitoreo, Cobertura, Uso de la Tierra y Ecosistemas* in Spanish), (b) the periodic land cover maps from SINAC (Sistema Nacional de Áreas de Conservación in Spanish), and (c) the monitoring efforts by FONAFIFO (*Fondo Nacional de Financiamiento Forestal* in Spanish), are examples of the existing capabilities to carry out accurate and periodic evaluations of agricultural habitats. Additionally, national initiatives such as Sustainable Agro-landscapes Policy (by the Ministry of Environment and Energy) and the implementation of the standard Biodiversity Check Agrícola (by the Ministry of Agriculture and Livestock) support the integration of biodiversity into agricultural planning. These efforts align with the country's commitment to sustainable development and environmental conservation.

37. However, several weaknesses limit the full implementation of the FHBI. One of the main challenges is the lack of systematised and accessible information. Moreover, technical issues related to the geometry and topology of geospatial data layers complicate the appropriate use of the data. It is also crucial to integrate more detailed criteria to accurately classify the biodiversity value of the different agricultural habitats. The limited biodiversity classification criteria introduce uncertainty in the index estimates, which could affect its precision and usefulness in political decision-making.

38. Despite these limitations, Costa Rica has a great opportunity to improve the FHBI and use it as a key harmonised monitoring tool. The integration of biodiversity classification criteria, improvement of data systems, and strengthening of inter-institutional cooperation are crucial steps to ensure the successful implementation of the indicator.

3.2. Finland

3.2.1. Key characteristics of farmland habitats and land use

39. In Finland, arable land covers 2.27 million ha, accounting for 7% of the total land area. The share of agricultural land varies between counties, being highest at around 30% in southwestern and lowest in northern Finland. The average field size is 3.18 ha. Agricultural production is dominated by cereal production, which comprises 47% of the

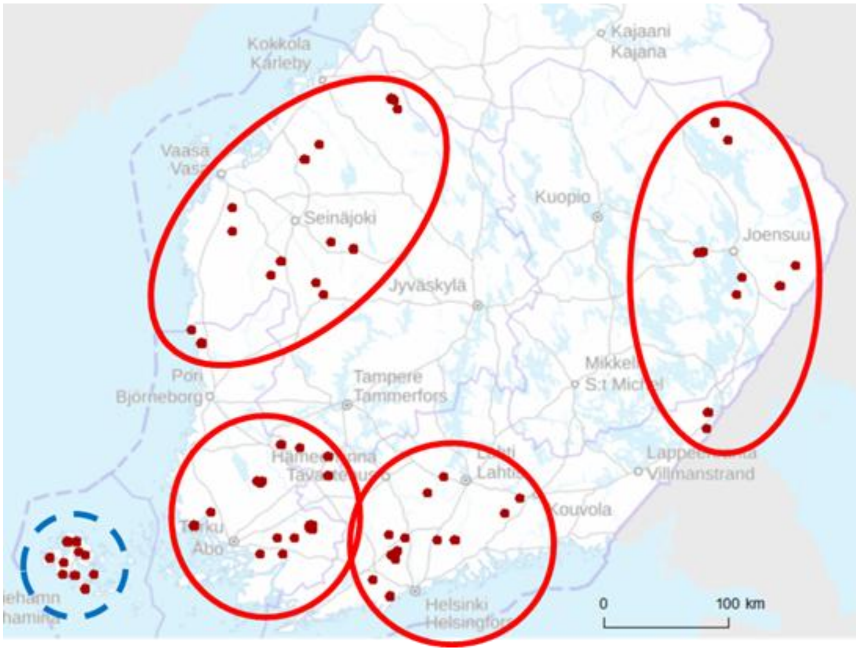
total arable area. The most important crops are barley and oats, followed by wheat and rye, and the majority of cereals are spring-sown. Grasslands comprise 36% of the arable area. In 2022, 15% of the total farmed area in Finland was farmed organically.

40. Forests dominate the Finnish landscape, covering 75% of the land area. Agricultural environments are usually a mosaic of farmlands and forests. Biodiversity-supporting habitats include various semi-natural habitats such as forest-field ecotones (Law and Dickman, 1998[17]), field margins (Tarmi, Helenius and Hyvönen, 2011[30]), meadows and set-aside fields (Alanen et al., 2011[31]; Hyvönen et al., 2021[32]; Toivonen et al., 2022[33]). The most species-rich habitats are traditional rural biotopes (Raatikainen, Heikkinen and Pykälä, 2006[34]), which are dependent on grazing. At present, these habitats are supported by agri-environmental support schemes. Organic farming can support biodiversity of arable fields (Hyvönen et al., 2003[35]; Hyvönen and Salonen, 2002[36]).

3.2.2. Data

41. Habitat data is extracted for a collection of stratified randomly selected, permanent 1 km x 1 km study squares. Strata for the selection, i.e. suitable subareas from the whole country, had been defined to guarantee the inclusion of most important characteristics of the Finnish agricultural landscape as well as to emphasise certain hot spot areas identified in previous studies. Within the strata, the final squares were selected randomly, but required at least a 20% proportion of cultivated fields within each square and certain minimum distances between the distinct squares (Kivinen et al., 2006[37]).

Figure 3.5. Regions of agri-environmental monitoring in Finland



Note: Area marked with blue circle not included in the Farmland Habitat Biodiversity Indicator.
Source: Finnish pilot project experts.

42. The main data source for habitat extraction from the study squares are aerial images, which are acquired operationally throughout the whole country in three-year intervals by the National Land Survey of Finland. Images are available at 0.5 m pixel resolution, and false colour composites are used in habitat delineation. The newest summertime images are preferred, but late spring images may be selected if no recent

summertime images are available. Early spring images (i.e. leaf-off time without ground vegetation), should be avoided; however, using early spring images may be considered if they are the most recent and if later season images are several years old. Additionally, recent forest resource and topographic maps are used to assist delineating other land cover/land use classes than agricultural areas.

43. The sampling scheme is based on seven main classes, which are meaningful for Finnish agricultural biodiversity and cover all the land cover/use types in the study squares. The classes in brackets are not considered as farmland but will be used to fill in the remaining areas of the study squares; they can be used to identify class changes (e.g., from forest areas to field margins), and enable interpretation of the surrounding land use heterogeneity at a meaningful level.

1. Intensive agriculture
2. Extensive agriculture
3. Field margins
4. Farmhouses and surroundings
5. (Infrastructure)
6. (Forest areas)
7. (Water areas)

44. The main classes are partially divided into subclasses, which further specify the habitat type. In Table 3.1, these subclasses with their tentative habitat classification are presented. The data allows biodiversity assessments primarily at Tier II level. The temporal resolution of the indicator is 5-10 years depending on the resources available.

Table 3.1. Habitat classes used in the FHBI calculation for defining farmland habitats

Main Class	Subclass	Tentative Habitat Class
1 Intensive agriculture	-	Low
2 Extensive agriculture	Meadows	High to very high
	Abandoned fields or meadows	Moderate to high
	Tractor trails, clearance cairns	Low to moderate
3 Field margins	-	High to very high
4 Farmhouses and surroundings	Residential buildings and gardens	Moderate to high
	Barns and surroundings	Moderate
	Hedgerows and belts of trees	Moderate
(5 Infrastructure)	-	(Very low)
(6 Forest areas)	-	(Very low)
(7 Water areas)	-	(Very low)

Source: Finnish pilot project experts.

3.2.3. Calculation of the FHBI

45. Delineation of the habitat patches from aerial images is conducted in three steps:

1. *Manual digitisation*: The most important habitat classes related to agriculture and semi-natural land use are digitised manually by visual interpretation based on the aerial images. Digitisation is assisted by documented interpretation keys for each habitat class, as well as recommended minimum mapping units to prevent overly detailed and time-consuming work.

2. *Semi-automatic digitisation*: This considers principally forest areas. Forest resource maps (development class, canopy cover, basal area) are used as assisting data when delineating relatively homogeneous forest patches. Similar to manual digitisation, interpretation keys and minimum mapping units are applied.
3. *Automatic digitisation*: During this phase, the remaining areas are filled mainly by extracting them automatically from existing digital maps, possibly applying a suitable buffer around the linear or narrow elements. These are mainly areas of low biodiversity values.

46. Once these steps have been completed, the entire landscape is covered by habitat patches according to the applied classification scheme. Each delineated subclass is also assigned a biodiversity quality value according to the OECD guidelines (from very low to very high) based on expert evaluation of the corresponding habitat types and their significance for Finnish agricultural biodiversity. The highest values are assigned to meadows and field margins as they are expected to better support biodiversity relative to the biodiversity value baseline of cultivated fields. Proportions of these scores are then used to calculate the overall index value. Finland suggests and intends to report the FHBI in ten-year intervals, which is regarded as a sufficiently long time period to observe changes in landscape structure.

3.2.4. Strengths and weaknesses of the Finnish FHBI

47. Strengths of Finnish FHBI lie in the detailed information on landscape structure connected with the biodiversity data. Data on plants, farmland birds and pollinators are collected from the same study squares. This enables interpretation of the impact of landscape change on biodiversity. Another strength is the repeated sampling over three decades. Weaknesses of the indicator lie in the limited spatial extent and laboriousness of the data collection. The Finnish FHBI is based on sampling of 58 squares of 1 km^2 in size, representing different farmland types. Biodiversity sampling in field is laborious and expensive. It is not possible to study biodiversity of all elements in the landscape. This limits the evaluation of the variation in biodiversity values of elements in the landscape.

3.3. Germany

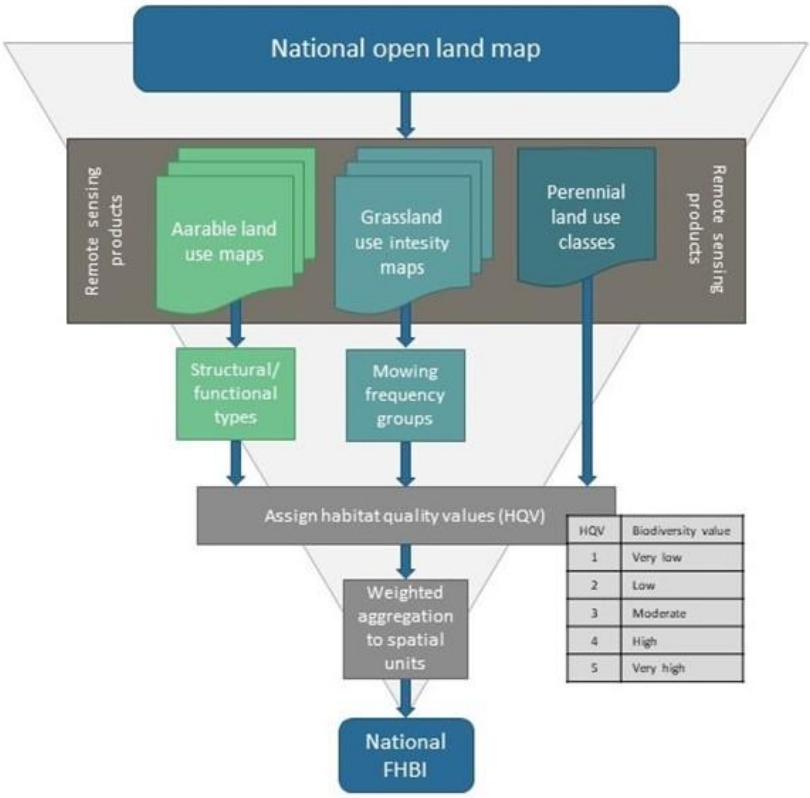
3.3.1. Key characteristics of farmland habitats and land use

48. Agricultural land accounts for approximately half of the land area in Germany (about 16.5 million ha). This area mainly consists of arable land (~70%) and managed grassland (~28%). Only a small share of land is used for the cultivation of permanent crops such as orchards, vineyards and hop plantations. The main crops grown in Germany are cereals (wheat, barley and rye) and maize, followed by rapeseed, sugar beet and potatoes. The north-eastern part of Germany is characterised by large agricultural fields (average farm size > 280 ha), while the south is dominated by farms with comparably small agricultural fields. Large areas of intensively managed grasslands are mainly located in the northwest and the pre-alpine areas in the south. Linear landscape elements, such as hedgerows, and shrubs/trees outside forests, are widely distributed in the agricultural landscape with highest shares in the northwest and central Germany. Around 13.4% of the agricultural utilised land is currently considered as High-Nature-Value farmland (HNV; (Hünig and Benzler, 2017[38])).

3.3.2. Data

49. A summary of the workflow and data sources for the calculation of the FHBI for Germany is given in Figure 3.6. The FHBI pilot study for Germany builds on a wall-to-wall mapping of land use from high resolution satellite data.

Figure 3.6. Schematic workflow of the calculation of the German FHBI



Source: German pilot project experts.

50. The first step outlined the reference area for the calculation of the FHBI, i.e., the definition of agricultural land in a wider sense. This includes:

- all agriculturally used areas, including croplands, grasslands, fallow fields
- Small woody features, e.g. hedgerows and patches of shrubs/trees outside forests
- Perennial land use areas, such as orchards, plantations and vineyards
- Peatlands, heathlands, and swamps were included if they are under agricultural use

Settlements, built-up and impervious areas, as well as forests and water areas, were not considered.

51. The main input data for the calculation of the FHBI is an annual mapping of agricultural land use, following the methods described by Blickensdörfer et al. (2022[39]) . The experts derived annual agricultural land use maps from time series of Sentinel-1 and -2, Landsat satellite imagery, and additional environmental data at a spatial resolution of 10 m by 10 m. The maps cover the entire agricultural area in Germany and comprise 24 classes. While the user and producer accuracies of the agricultural land use maps vary between the

individual classes, the overall accuracy is consistently above 83% for all years in the study period (2017 to 2023).

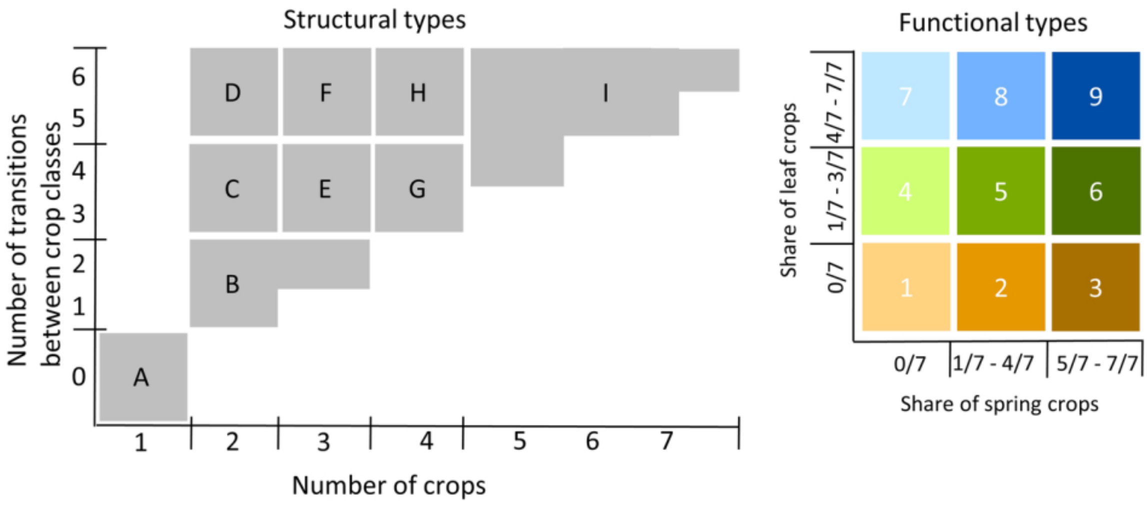
52. In a second step, German experts further characterised permanent grassland areas according to management intensity. For this, a set of annual satellite-based (Sentinel-2, Landsat) maps were used that contain estimates of the number of mowing events as a proxy for grassland use intensity following the approach described in Schwieder et al. (2022[40]). In this approach, experts compared dense time series (i.e. frequent observations ensuring minimal gaps in temporal data) of vegetation indices against an approximated undisturbed grassland phenology and interpret larger deviations, using an adaptive threshold and a set of rules (i.e. mowing events). All input data were available for the seven years between 2017 and 2023.

3.3.3. Calculation of the FHBI

Cropland

53. Maps of seven years of agricultural land use were used for all of Germany (2017 to 2023) to approximate the structural and functional diversity of cropland, following the approach proposed by Stein and Steinmann (2018[41]) and Jänicke et al. (2022[42]). Crop sequences were characterised by their structural diversity (number of crop types and transitions within the study period) and functional diversity (share of leaf and spring crops, in contrast to cereals and winter crops; Figure 3.7). Non-cropland classes (permanent grassland, vineyards, orchards) and small woody features were excluded, because they are not assumed to be part of a crop cycle.

Figure 3.7. Schematic overview of structural and functional crop sequence types for arable land in Germany



Source: Jänicke et al. (2022[42]).

54. Subsequently, experts combined and translated the maps of structural and functional diversity to habitat quality values (HQVs) per grid cell, following the key in Table 3.2. This key was defined assuming that a higher number of crops and transitions within the study period indicates a higher variation of structural diversity, resulting in higher habitat quality being beneficial for biodiversity. It is further assumed that a balance between spring and winter crops, and between cereals and leaf crops, also is beneficial for biodiversity (Figure 3.7). Thus, higher HQV’s were assigned to the most balanced

functional crop sequence types (Table 3.2). The final HQV for each cropland pixel is the truncated mean of both values.

Table 3.2. Assignment of habitat quality values (HQV) based on structural and functional crop sequence types following the scheme in Figure 3.7

Crop sequence types		HQV	Combined types	Combined HQV
Structural types	S1: A, B, C, D	1	S1F1	1
	S2: E, F	2	S1F2	1
	S3: G, H, I	3	S1F3	2
Functional types	F1: 1,3,7,9	1	S2F1	1
	F2: 2,4,6,8	2	S1F2	2
	F3: 5	3	S2F3	2
			S3F1	2
			S3F2	2
			S3F3	3

Source: German pilot project experts.

Permanent grasslands

55. For permanent grasslands, experts calculated the median of detected mowing events for each grid cell across all years of the study period (2017 – 2023). Subsequently, the experts derived three classes of grassland use intensity and assigned HQVs from three to five (Table 3.3), according to their management intensity. Grasslands characterised by low management intensity (i.e. maximum one mowing event on average) received the highest HQV as these are assumed to promote biodiversity. In contrast, grasslands characterised by medium management intensity, i.e. two or three mowing events per year, and high management intensity, i.e. four or more mowing events on average, received lower HQVs. The higher HQV values compared to cropland are based on the assumption that permanent grasslands in general are at least as beneficial for biodiversity as the most diverse cropping systems.

Perennial crops

56. All perennial crops in the agricultural land use maps, such as Grapevine, Hops and Orchards were assigned low HQVs, as most of these systems are assumed to be intensively managed with a high degree of inputs (Table 3.3).

Small woody features

57. Based on the agricultural land use maps, all areas of small woody features were extracted. A high FHBI value was assigned to all small woody features, such as hedgerows and small patches of shrubs and trees, as these areas provide a wide range of ecosystem services and habitats for a wide range of species, thereby promoting biodiversity (Table 2.1).

Table 3.3. Defined key for the translation of grassland use intensity values

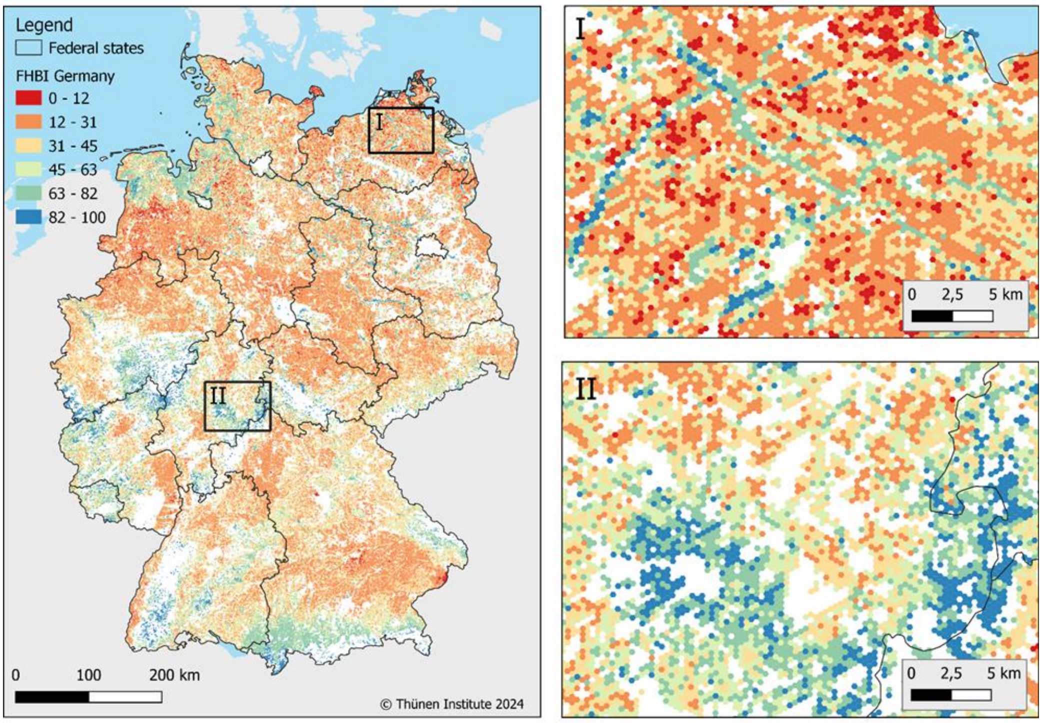
Median number of mowing events between 2017 and 2023) and permanent land use classes to habitat quality values (HBV)

Category	Mowing frequency	Land use	HQV
Grassland	0 – 1	Grassland 1	5
Grassland	2 – 3	Grassland 2	4
Grassland	4 +	Grassland 3	3
Stable land use class	-	Small woody features	4
Stable land use class	-	Grapevine	2
Stable land use class	-	Hops	1
Stable land use class	-	Orchard	2
Other land use class	-	Other areas	3

Source: German pilot project experts.

58. The FHBI was calculated by combining the individual layers of habitat quality for cropland, grassland, perennial crops and small woody features into one raster covering the entire agricultural area of Germany, with each grid cell representing a habitat quality value ranging from one (very low) to five (very high). Following Bayr et al. (2023[1]), experts aggregated the habitat quality map to the spatial reporting unit (100 ha hexagons) using weighted sums, resulting in FHBI values ranging from 0% to 100% for each spatial reporting unit (Figure 3.8).

Figure 3.8. Map of the national FHBI for Germany based on 100 ha hexagons with a share of at least 20% agriculturally used land



Source: German pilot project experts.

3.3.4. Strengths and weaknesses of the German FHBI

59. Based on the Tier level concept as outlined in Bayr et al. (2023[1]), the proposed FHBI can be considered a Tier II indicator. It enables to frequently capture the farmland habitat diversity using wall-to-wall information on heterogeneity and intensity of agricultural land use as proxies for habitat biodiversity. The combination of different input data sets enables that all dominant land use types and intensity proxies that are relevant for the assessment of farmland habitats are included in the calculation. Another strength of the proposed German FHBI methodology is that it is based on satellite data only; therefore, the approach can be adapted to regions with limited farm-level data, and archived satellite data could enable experts to calculate historical indicator values for long-term trend assessment.

60. However, due to the spatial resolution of the input data used, the indicator failed to accurately include small but critical elements such as hedgerows and flowering strips in the proposed indicator. Here, the inclusion of products derived from very high-resolution imagery or field surveys could help to overcome this limitation in the future. In the FHBI calculation, habitat quality values for arable land were assigned based on crop sequences of the previous seven years, using the diversity in terms of structural and functional types as proxy for land use intensity. Therefore, this approach does not at this stage allow trends to be analysed but it does reflect the current status. It is not designed to assign higher quality values to individual crop types like flowering crops or crops that need less input that are more beneficial for biodiversity. Another limitation is that at this stage, due to a lack of data, the German methodology does not differentiate grassland types (pastures and meadows), which also have a different influence on biodiversity.

3.4. Japan

3.4.1. Key characteristics of farmland habitats and land use

61. Japan is a long archipelago stretching from north to south. Its total land area is 37.79 million ha, and approximately 70% of the land is forested. Farmland accounts for about 10% of the land area and about half of that is rice paddy field. Satochi-satoyama, an area consisting of rice paddies, fields, reservoirs, secondary forests, and grasslands around human settlements, is spread across the country. Such agricultural landscapes with the mosaic arrangement of habitats, consisting of paddy fields as alternative wetland habitats, field margins or levees as grassland habitats, and water canals and irrigation ponds as water habitats, nurture a variety of organisms and result in high biodiversity. In addition, the majority of paddy fields are small scale not only in Japan, but also in the broader Asian region. Japan hopes that the knowledge and experience gained from this project, with a strong focus on small-scale paddy field, will have implications for and contribute to the development of the FHBI in the Asian monsoon region.

3.4.2. Data

62. This project examines how to categorise the biodiversity value of each agricultural land typology based on the statistical data and expert advice. Whilst the biodiversity data is best for rice paddies, the experts assigned approximate biodiversity value to all farmland. The agricultural land covered by this classification in this project is farmland in the statistics of the Ministry of Agriculture Forestry and Fisheries (MAFF) and does not include forests or coarse grassland. Of the data examined for this FHBI project (Table 3.4), the statistical data on cultivated area to be used in the calculation cover national, prefectural and municipal levels in a uniform manner and are regularly updated (every year or every five years). Additionally, statistical data on agricultural practices which could conserve biodiversity such as organic farming, integrated pest management (IPM), and winter-

floodings were used. The MAFF investigates the areas which are subsidised to promote such biodiversity-friendly practices every year. That said, biodiversity monitoring data are not used in the calculation because the data do not fully cover all the farmlands.

Table 3.4. Types of available data

Types of data	Notes (Frequency etc.)	Suitability for FHBI
Statistical data on cultivated area (Tier II or III)		
Paddy field / upland field(non-flooded)	Every year	National data but covers uniformly at prefectural and municipal levels Updated regularly **To be used in this project**
Flat area / hilly and mountainous area	Every 5 years	
Area under the direct payment for environmentally friendly farming (organic farming, IPM, winter-flooding, etc.)	Every year	
Biodiversity monitoring data (Tier I)		
Monitoring implemented as part of land improvement projects for agriculture	Only with the land improved projects	Difficult to use because it is partial
Monitoring project by the Ministry of Environment (Monitoring 1000)	Not within farmlands	

Source: Japanese pilot project experts.

3.4.3. Calculation of the FHBI

63. The potential categorisation of biodiversity value for agricultural lands based on statistical agricultural area typologies is: For paddy fields, statistical agricultural area typologies could potentially be used to classify the biodiversity value of these farmlands: urban farming area, flat farming area, hilly farming area and mountainous farming area (Table 3.5). For farmlands other than rice paddies (fields, orchards, and grasslands), currently, the knowledge on biodiversity is limited, and it is difficult to classify their biodiversity value based on topography, crops, and other factors.

Table 3.5. Overview of the statistical agricultural area typology

Typology	Description
Urban farming area	Municipalities and former municipalities with a DID area of at least 5% of inhabitable land and a population density of at least 500 persons/km^2 or a DID population of at least 20 000 persons. Municipalities and former municipalities where the ratio of residential land to inhabitable land is 60% or more and the population density is 500 persons/km^2 or more. However, those with forest land ratio of 80% or more are excluded.
Flat farming area	Municipalities and former municipalities with a cultivated land ratio of 20% or more and a forested land ratio of less than 50%. However, those whose total area ratio of rice fields with a slope of more than 1/20th and fields with a slope of more than 8 degrees is more than 90% are excluded. Municipalities and former municipalities that have a minimum of 20% arable land and 50% forested land, and where the total area of rice fields with a slope of at least 1/20th of a degree and fields with a slope of at least 8 degrees is less than 10% of the total area of the municipality.
Hilly farming area	Municipalities and former municipalities with less than 20% of arable land, other than urban and mountainous farming areas. Municipalities and former municipalities with more than 20% of arable land, other than urban areas and flat farming areas
Mountainous farming area	Municipalities and former municipalities with forestland coverage of 80% or more and arable land coverage of less than 10%.

Source: Japanese pilot project experts.

Potential impact of agricultural practices on biodiversity value categorisation of farmlands

64. Agricultural practices such as organic farming, reduced use of pesticides and chemical fertilisers, winter flooding of paddy fields and other efforts to conserve biodiversity have been implemented. A meta-analysis in rice paddies has shown that these practices and efforts have contributed to an increase in a variety of species (Katayama, Baba and Okubo, 2020[43]). Therefore, such biodiversity-friendly farming practices are taken into account when classifying the biodiversity value of farmland for this project.

Calculation of tentative FHBI

65. For the calculation of the tentative FHBI, paddy fields are categorised according to the statistical agricultural area typologies: 'High' for mountainous or hilly areas and 'Moderate' for flat or urban areas. For farmlands other than paddy fields, while it is difficult to categorise biodiversity value by topography due to lack of knowledge, the categorisations with a range are given for fields ('Very low' to 'Moderate'), orchards ('Low' to 'Moderate'), and pastures ('Very Low' to 'Moderate') based on the consultation with experts. In addition, the categorisation of farmlands where biodiversity-friendly agricultural practices are implemented is upgraded to a higher level ('High' to 'Very High', 'Moderate' to 'High', etc.). In detail, biodiversity-friendly farming practices are applied on 2.3% of the total farmlands and therefore, for example, 2.3% of the paddy fields in the mountainous area are categorised as Very High. The draft classification of the categorisation of each habitat with its proportion is shown in the table below. The preliminary value of the FHBI calculated on the basis of the categorisation in this project is 34.1-55.4.

Table 3.6. Categorisation of habitats and assignment of habitat quality values (HQV) for the calculation of the FHBI for Japan

Habitats		Area (ha)	Proportion	HQV (General Categorisation)	HQV (Agricultural practices considered)
Paddy field	Mountainous/Hilly farming area	839 233	19%	High (0.75)	Very High (1)
	Flat farming/ Urban area	1 512 852	35%	Moderate (0.5)	High (0.75)
Field		1 123 000	26%	Very Low (0) ~Moderate (0.5)	~High (0.75)
Orchard		258 600	6%	Low (0.25) ~Moderate (0.75)	~High (0.75)
Pasture		591 300	14%	Very low (0) ~Moderate (0.5)	~High (0.75)

Source: Japanese pilot project experts.

3.4.4. Strengths and weaknesses of the Japanese FHBI

66. One strength of the indicator is the flexibility to adapt to country-specific considerations and data availability; however, considering diverse scopes, data and methodologies of the indicator, interpretation of results should ensure that FHBI values are not compared between countries erroneously, and the results should only be used to indicate changes over time in each country.

67. A strength of the indicator is its use for policy assessments, not only at the national level, but also at prefectural and municipal levels once integrated into existing agricultural

mapping and statistical data. In particular, the indicator could help assess the impacts of policies which promote practices which support biodiversity; for example, the MAFF has formulated the MIDORI Strategy for Sustainable Food Systems in 2021 to enhance both productivity potential and sustainability. The Strategy aims to achieve the targets by 2050, including reducing the risk-weighted use of chemical pesticides and chemical fertilisers, and expanding the area of organic farming area to 25% of agricultural land (1 million ha).

68. The results of the pilot study from Japan may serve as a reference to implement the concept of the FHBI for other Asian monsoon countries with farming systems dominated by small-scale paddy rice cultivation.

3.5. Latvia

3.5.1. Key characteristics of farmland habitats and land use

69. Latvia is located in the Northeastern part of Europe and has a size of 64 594 km². The landscape is dominated by (mainly coniferous) forests, which often occur in mosaics of mixed land uses (Figure 3.9). Farmlands constitute slightly more than 30% of the total land area of the country, of which 67% are arable land. Over the last 20 years, both the arable land and the intensity of land use have increased. Crop farms dominate the farm structure in Latvia, accounting for roughly two-thirds of the total number of farms. The share of dairy farms is 11%, farms with a mixed cropping and livestock system account for 11%, while grazing livestock farming (without dairy farming) make up 7%. Changes in farmland structure are spatially heterogeneous and impacted by land abandonment (marginalisation), as well as agricultural centres with increasing intensity (polarisation) can be observed.

Figure 3.9. Location of Latvia in Europe and shares of agricultural land use

Source: Latvian pilot country experts Pēteris Lakovskis and Linda Ieviņa.

3.5.2. Data

70. In Latvia, several types of biodiversity monitoring and specific research case studies (Rūsiņa, Lakovskis and Ieviņa, 2024[44]) have been carried out. The most significant being the recently implemented project "Nature Census" (Dabas skaitīšana), during which country-wide field work for assessing habitat biodiversity was carried out. The results provide high definition/resolution data on biodiversity of grassland habitats. However, biodiversity monitoring in agricultural areas is limited and it is unclear whether monitoring efforts will continue in the future, which makes it challenging to develop a long-term FHBI. That said, Latvia has reasonably good availability of area-wide geodata that contain information on land cover, land use and habitats, which enabled the development of a national FHBI at Tier level II. Five spatial data layers were used as sub-indicators, which include information on protected grassland habitats from a national habitat monitoring (two

sub-categories: rare and frequent), grassland areas supported by agri-environmental measures (AEM, maintenance of biodiversity in grasslands and organic farming in grasslands), permanent grassland areas, as well as small woody features of agricultural land (Table 3.7).

Table 3.7. Overview of available data and assigned habitat quality values (HQV)

Sub-indicator	Tier Level	Year	Data type	Source	Weight of habitat quality value
Protected grassland habitats, rare	Tier I	2024	Spatial data layer	Nature conservation agency, habitat field monitoring	1
Protected grassland habitats, frequent	Tier I	2024	Spatial data layer	Nature conservation agency, habitat field monitoring	0.75
AEM area: maintenance of biodiversity in grasslands (BDUZ)	Tier I	2023	Spatial data layer	Rural support service	0.5
AEM area: organic farming in grasslands (BLA)	Tier II	2023	Spatial data layer	Rural support service	0.75
Permanent grasslands	Tier II	2023	Spatial data layer	Rural support service	0.5
Small woody features	Tier III	2018	Spatial data layer	CORINE Land Cover	0.75

Source: Latvian pilot country experts.

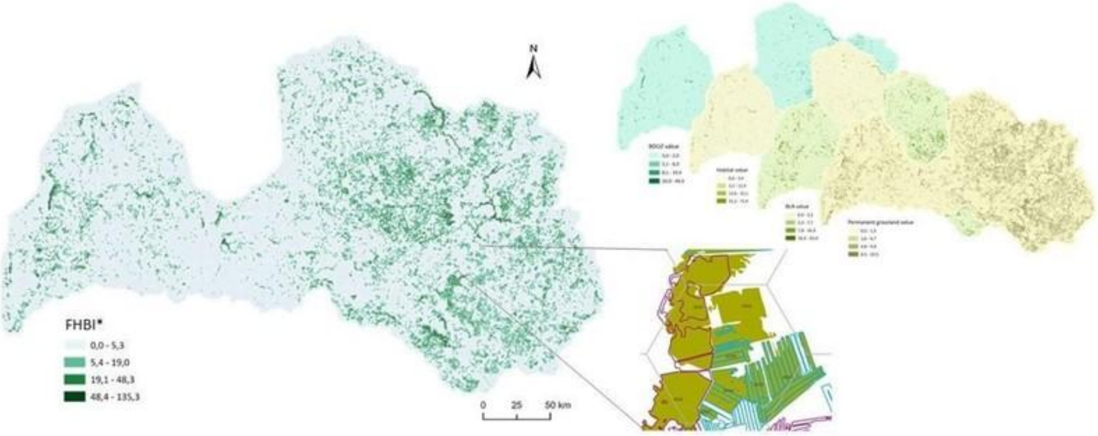
3.5.3. Calculation of the FHBI

71. The FHBI was calculated based on the selected sub-indicators, to which Latvian experts assigned habitat quality values weights expressing their importance for biodiversity based on expert knowledge (Table 3.7). Protected grassland habitats, for example, were assigned a very high value. However, some of these habitats are only present in very small areas, providing rare habitats for plant and animal communities; therefore, they are considered even more important for biodiversity and were assigned the highest value. Additional weight for each sub-indicator was assigned according to its data resolution – for Tier I, resolution weight is 1, Tier II – 0.75, Tier III – 0.5. Thus, each sub-indicator value was calculated as a multiplication between the sub-indicator area, its indicator value, and its resolution weight. As a spatial aggregation and reporting unit, experts defined hexagons with a size of 100 ha each, which cover the entire area of Latvia. For the data of Tier II and Tier III, only hexagons with a farmland share of 5% or higher are considered. This approach was taken to consider the agricultural importance of a hexagon and to eliminate the presence of low FHBI values that can appear due to the lack of farmlands instead of their low importance for biodiversity. However, the 5% farmland share threshold does not apply to the data of Tier I because of the possible discrepancy between data of the monitored areas and data of farmlands registered in the national database.

72. Based on this data, the first step calculated individual sub-indicator values for each hexagon, based on the assigned habitat values (weights) and the respective area shares within each hexagon. For the protected grassland habitats, the values were, for example, based on the share of rare habitat area multiplied by its indicator value (1) and resolution weight (1) plus the frequent habitat area multiplied by its indicator value (0.75) and resolution weight (1). The resulting maps show the total habitat indicator values for each hexagon and allow to identify potential hotspots of biodiversity, in this example, based on the share of protected grassland habitats (here: mainly grasslands in floodplains). Finally, all sub-indicators were combined on the hexagon level to the final FHBI value for Latvia. This was however challenging, due to overlapping of the individual sub-indicator areas; for example, the same area of permanent grassland may also be a protected grassland habitat,

thus creating an overlap in the FHBI value and highlight *hotspots* of farmland biodiversity (see zoom-in in Figure 3.10). Therefore, the indicator represents at this stage the absolute and not the relative values, which can exceed 100 due to the overlapping regions.

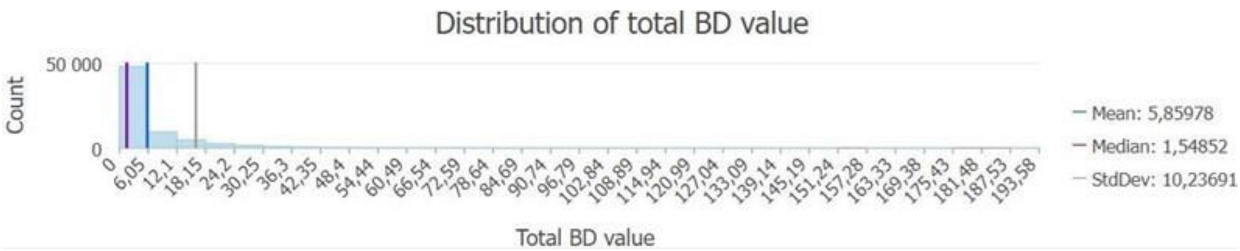
Figure 3.10. Overview and zoom-in of FHBI values for Latvia. In the top right the individual input layers are shown



Note: Double counting has not been considered.
Source: Latvian pilot project experts.

73. Still, the indicator enabled experts to identify potential hotspots of biodiversity based on the combined sub-indicators (Figure 3.10). The range of indicator values is wide, while the distribution is very skewed (Figure 3.11). The biggest shares of hexagons were assigned with very low values (mostly under 10), which in a great part is related to the lack of farmland in many hexagons, but also shows that areas of high value for biodiversity are quite rare. Furthermore, the main agricultural area of the country (Zemgale region – in the central part of Latvia) is mostly represented by very low indicator values.

Figure 3.11. Range of FHBI values for Latvia



Source: Latvian pilot project experts.

3.5.4. Strengths and weaknesses of the Latvian FHBI

74. The greatest strengths of the FHBI for Latvia is the relatively good data availability of farmland management, which is precise and spatially explicit. This allows for an area-wide mapping of FHBI hotspots in farmland using land use information as a proxy. A weakness of the indicator is that it is sometimes difficult to assess the different data for biodiversity importance in only five categories thus experts included extra weight of habitat quality value for chosen sub-indicators. This avoided the situation where sub-indicators with a relatively similar importance, but still significant differences in terms of biodiversity

potential and data resolution, were assigned the same value. To further improve the indicator, it is planned to supplement it with additional sub-indicators related to landscape elements (e.g. woody landscape features and water bodies) which enrich the farmland with different types of habitats for plant and animal species. Also, additional data may be added about farming practices that support biodiversity (field margins and buffer zones). Considering the diverse landscape characteristics of Northern Europe in general with relatively high forest cover at the ecosystem (landscape) level, Latvian experts recommend including the length of the ecotone between agricultural and forest lands as a sub-indicator.

75. In general, the inclusion of farmland-specific biodiversity monitoring data (Tier I) would enhance the informational value of the indicator. However, such data are yet not available on a national scale. Regarding the overall project methodology, Latvian experts advise further consideration of the definition of data resolution levels (tiers); they recommend defining resolution levels in line with the general methodology applied in environmental and nature research (e.g. GHG inventory methodology), where Tier I represents low resolution, and Tier III represents high resolution. This would ensure a unified methodological approach and prevent potential misunderstandings when interpreting bioindicator data values.

3.6. Norway

3.6.1. Key characteristics of farmland habitats and land use

76. Agriculture in Norway is small-scale compared to many OECD Member countries. Small and medium-sized family farms dominate, and the average farm size is 26 ha. This small-scale structure is mainly due to the country's topography, soil and geology. Only around 3% of Norway's land area is arable land (808 000 ha) and this is scattered throughout the country. The cold climate and short growing season limit which crops can be grown, especially in the North. Only a third of the arable land produces cereals and vegetables for human consumption. The rest is used for growing fodder crops, mainly grass. Livestock is the main agricultural product.

77. In addition to the arable land, there are large areas in the mountains and forests that are used for grazing animals. It has been estimated that 45% of Norway (13.8 million ha) can be used for grazing, and 10% of the country provides high quality grazing. However, these so-called "outfields" are not included in the official definition of agricultural land. There are statistics about the number of animals that graze in the outfields, and there are detailed maps in some regions, but there is no single updated map of the outfield grazing areas. There is a sample survey that could be repeated to provide national statistics of change in the outfield condition (Bryn et al., 2018[45]; Strand, 2013[46]); however, at present there are no plans to repeat the survey. These outfield areas are important for biodiversity because they often represent areas of low intensity, semi-natural habitat that support many species. They are also under threat due to abandonment. Nevertheless, due to the lack of maps, the outfields could not be included in the FHBI.

78. Statistics and maps for the infield agricultural land are much better. From 1989 to 2023, the number of agricultural holdings declined from 99 400 to 37 561. However, much of the agricultural land was taken over by the remaining farms, so the agricultural area did not decrease significantly overall. Today, almost half of all agricultural land is rented. Detailed statistical data are available for the arable land, including the area under different crops (Statistics Norway).

79. It is a political aim of Norway to reach 50% self-sufficiency in food production. Currently, when corrected for imported animal feed, domestic food production covers 42%

of the population's calorie needs (Svennerud et al., 2023[47]). There are therefore strong policies in place to prevent loss of agricultural land, in addition to agri-environmental policies to protect biodiversity and the cultural heritage of the agricultural landscape. One tool to monitor the development of the agricultural landscape is the Norwegian Monitoring Programme for Agricultural Landscapes, known as the 3Q Programme. The 3Q Programme was used to calculate the OECD FHBI.

3.6.2. Data

80. The 3Q Programme provides detailed map data that is systematically updated (Dramstad et al., 2002[48]; Stokstad and Fjellstad, 2019[49]) . The 3Q Programme is based on a sample of 1 000 monitoring squares of 1 x 1 km^2. The squares are a random sample of all squares in Norway that contain agricultural land and the sample is considered representative of the agricultural landscape in Norway. All agricultural land and all land within 100 m of agricultural land is mapped, based on interpretation of aerial photographs (Engan and Bentzen, 2017[50]). The mapping uses a classification system with about 100 classes. The minimum mapping size for land adjacent to farmland is 100 m^2, or 40 m^2 if the land is totally surrounded by farmland or forms a field margin, e.g. a road verge. The minimum width for digitising a polygon is 2 m.

81. Small landscape features that are below the minimum polygon mapping size are mapped as points and lines. Points have a minimum area of 4 m^2, except for posts in fields that are mapped regardless of how small they are. Lines are defined as being from 0.5–2 m wide and at least 20 m long. Some linear features are recorded regardless of how narrow they are, provided they are visible in the aerial photo, e.g. grass strips between fields.

3.6.3. Calculation of the FHBI

82. To test the OECD indicator, expert-based valuations were made of each of the classes in the 3Q-classification system: polygons, points and lines (Table 3.8). However, the experts recognised that each class in reality contains objects with considerable variation in their value to biodiversity. For example, cultivated land may be a weed-free monoculture of wheat, or may be a cultivated fodder crop, perhaps containing clover that would have considerable value for pollinators. Therefore, the biodiversity score is simply a coarse reflection of the most common relative value of the land type in the context of biodiversity in the agricultural landscape.

Table 3.8. Overview of the 3Q-classification data used as input to calculate the FHBI

Line/point	3Q code	Description	Value
Line	LST	Path	2
Line	LSG	Stone wall	4
Line	LTR	Line of trees	4
Line	LBU	Line of bushes	3
Line	LVE	Vegetation line	3
Line	LTE	Terrace	3
Line	LGR	Ditch/ canal	3
Line	LBE	Stream	4
Point	PRO	Pile of stones	4
Point	PBL	Boulder	3
Point	PRU	Solitary tree	4
Point	PST	Post in arable field	2
Point	PMA	Pylon	2
Point	PBY	Building	1
Point	PBR	Ruin	2
Point	PBJ	Large barn/ agricultural building	1

Source: Norwegian pilot country experts.

83. First, the FHBI was calculated for the entire monitoring area, i.e. both agricultural land and the 100 m buffer zone. Then, to test the effects of buffer width, experts reduced the buffer zone to 10 m and re-calculated. To quantify the effect of the small landscape features, they converted points and lines to "areas" by adding a 2 m buffer, i.e. point features became a circle with 4m diameter and line features became polygons that were 4 m wide.

84. The final biodiversity value was defined as whichever was highest of the values for areas, points and lines. For example, a post on arable land would raise the biodiversity score from 1 to 2, but a post in an area of semi-natural grassland (biodiversity value 4) was not considered to lower the biodiversity value and the score of the land type would be selected. This means that if small landscape features are added to areas with a low biodiversity score, the index will increase, whereas their removal will have a negative impact on the index.

85. The GIS steps involved were:

- From the 3Q polygon maps, select all agricultural land (fully cultivated land and pasture) and add a 10 m buffer zone.
- Based on the 3Q land type codes, add (join) values for biodiversity.
- For the same area, take the point data, add a 2 m buffer to make a polygon layer for the points, and add (join) values for biodiversity.
- For the same area, take the line data, add a 2 m buffer to make a polygon layer for the lines, and add (join) values for biodiversity.
- Overlay (union) the three datasets: land types, buffered points and buffered lines and re-calculate the area for each object in the union.
- Calculate the final value for biodiversity as the highest value of areas, points and lines, except for building points (PBY, PBJ), where the final biodiversity value is "1", regardless of which land type the building is on.
- Summarise the area in each value class (from 1 = very low to 5 = very high).

- Calculate the indicator: (% Very low x 0) + (% Low x 0.25) + (% Moderate x 0.5) + (% High x 0.75) + (% Very high).

86. When the buffer zone around agricultural land is reduced from 100 m to 10 m, the proportion of low-scoring agricultural land changes from less than a third of the total monitoring area to almost two thirds and the index value is halved. Using the data from the 3Q-Programme, the difference in the indicator value from the first to the second round of monitoring is just 0.01. The trend within this area is positive, whilst the trend with the 100 m buffer zone was negative (Table 3.9).

Table 3.9. Percentage distribution between the classes of biodiversity value and indicator values

	Round 1	Round 2	Round 1	Round 2	Round 1	Round 2	Example
Biodiversity value	100 m buffer	100 m buffer	10 m buffer	10 m buffer	10 m buffer, points & lines	10 m buffer, points & lines	Move 10% from very low to low
Very low	30.5	30.5	61	61.1	60.9	61	54.9
Low	7	7	8.1	7.9	8	7.8	13.9
Moderate	21.4	21.6	12.4	12.4	12.4	12.5	12.5
High	36	35.6	18.1	18.2	18.3	18.4	18.4
Very high	5.2	5.2	0.4	0.4	0.4	0.4	0.4
	100	100	100	100	100	100	100
OECD FHBI	44.63	44.53	22.17	22.18	22.33	22.34	23.86

Note: First (Round 1) and second (Round 2) monitoring cycles of the 3Q Programme using the three different methods of calculation: agriculture + 100 m buffer, agriculture + 10 m buffer, and a version with the 10 m buffer where points and lines were also included. The last column shows a theoretical example where 10% of the area in class 1 is moved to class 2.
Source: Norwegian pilot country experts.

87. When the small landscape features were included (points and lines), the indicator increased by 0.16. This is a very small change considering the generally accepted value of such small features for biodiversity. Experts expect that small landscape features have a larger impact than would be expected from their small area. Perhaps this could be simulated by increasing the width of the buffer zone, i.e. artificially giving the small features a larger area of influence than their actual physical area. However, there is little empirical evidence for what this area should be.

88. In the theoretical example, of moving 10% of the area in the class “very low” value to the class “low” value, a change of 1.52 in the indicator value was observed. Clearly the indicator does capture positive change, but it must be recognised that the change in index value will be very small.

3.6.4. Strengths and weaknesses of the Norwegian FHBI

89. The main weakness of the indicator is that the value for biodiversity is linked entirely to the land type. No data is available to confirm the relative classification even though management and condition of the land type can dramatically change the value for biodiversity. For example, the 3Q classification does not allow us to distinguish between cereal and cultivated grassland. On the big scale of things, the distinction between these two is not great in terms of value for biodiversity. Also, they are often in rotation on the same areas. Nevertheless, many management options that would benefit biodiversity, such as reductions in pesticides and fertilisers, or under-sowing with clover, would not change the land type and therefore would not change the indicator value. Although data at the level

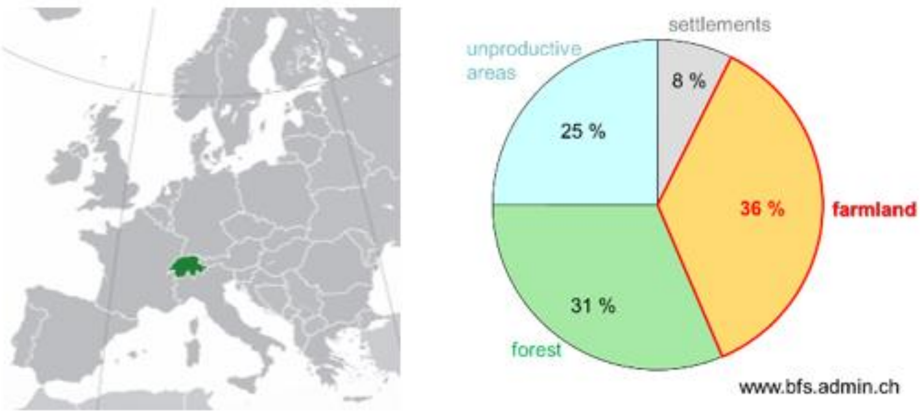
of the land parcel for management practices is not available, national statistics are available on the types of crops grown, and the area under any management scheme that qualifies for subsidies. These data could be used to calculate the proportion of area with different biodiversity scores and re-calculate the indicator.

3.7. Switzerland

3.7.1. Key characteristics of farmland habitats and land use

90. In Switzerland, agriculture plays a significant role in preserving biodiversity, as agricultural land accounts for more than a third of the country's total area (Figure 3.12). In contrast, forests cover a slightly smaller proportion of the land, followed by unproductive areas such as rocks, scree, glaciers, and water bodies. Settlements, on the other hand, occupy less than 10% of the country's surface. Agriculture, as the largest land user in Switzerland, has thus a particular responsibility for biodiversity (BAFU and BLW, 2008[51]).

Figure 3.12. Location of Switzerland within Europe, and proportion of its the major land cover classes



Source: Swiss pilot country experts.

91. Grassland (meadows and pastures) account for about two-thirds of the agricultural area, while arable land accounts for 26%. Fruit, wine and horticulture account for only a small part (3%) of the agricultural area. Biodiversity-promoting habitats on agricultural land are primarily ecological focus areas (EFA). Two types of contributions are made for EFAs: quality contributions (two quality levels: Quality Level 1: management requirements; Quality Level 2: management and result requirements) and for connectivity (EFAs are created and managed in a spatially targeted manner). The quality contributions are fully financed by the federal government. In the case of the connectivity contributions, the federal government covers a maximum of 90%, with the remaining financing provided by cantons, municipalities or private sponsors. The intensity of land use increases from higher to lower altitudes. At higher altitudes, the aim of EFA is therefore to maintain the existing biodiversity by retaining traditional extensive management, and at lower altitudes, particularly in arable farming areas, to create refuges in the intensively used agricultural area.

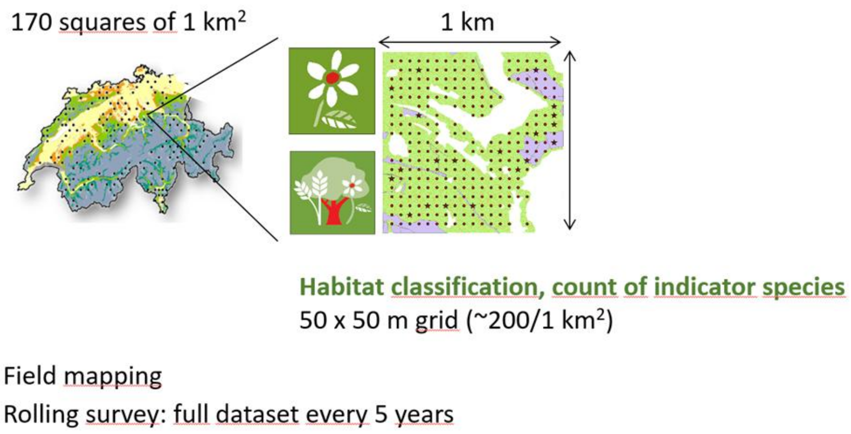
3.7.2. Data

92. Biodiversity in Swiss farmland is monitored by the ALL-EMA programme (acronym for the German/French combination meaning “Agricultural Species and Habitats”). The ALL-EMA programme is a pan-Swiss, agricultural biodiversity monitoring programme. ALL-EMA is carried out by Agroscope on behalf of the Federal Office for the Environment (FOEN) and the Federal Office for Agriculture (FOAG). The aim of ALL-EMA is to observe and document the state and changes of biodiversity in the agricultural landscape, to investigate the factors influencing this biodiversity pattern and thus to contribute to the further development of agricultural and environmental policy measures for the protection of biodiversity.

93. The ALL-EMA programme monitors habitats and species in 170 1 km² squares distributed across all agricultural zones in Switzerland (BLW, 2021[52]), thus covering the entire agricultural area of Switzerland (see Figure 3.13; (Meier et al., 2021[53]; Meier, Lüscher and Knop, 2022[54])). As the data are collected in a rolling survey, a comprehensive data set for the entire Swiss territory is compiled every five years. The ALL-EMA programme was initiated in 2015, so data from the first survey, 2015-2019, are fully available. It includes information on habitats, bird, butterfly and plant species.

94. Habitats are surveyed on 10 m^2 plots located on a 50 x 50m grid within the agricultural area of the 1 km^2 squares. The habitat data comprise two elements: the habitat type itself and the presence of species characteristic of that habitat type. The habitat types were classified in the field using the Swiss Habitat Type Classification developed by (Delarze, 2008[55]), which is comparable to the EU Habitat Type Classification “EUNIS”. According to this classification, approximately 80 different habitat types were identified for agricultural land. In addition to the habitat types, the occurrence of indicator species for each habitat type is assessed in the field. This involves the identification of approximately 25 species that are specific to a given habitat type and are typically found in a habitat type when it is in good condition.

Figure 3.13. Overview of the data collected in the framework of the ALL-EMA programme, distributed over the agricultural zones of Switzerland



Note: Yellow: plains; orange: hills; light green: lower mountains; dark green: upper mountains; purple: summering areas.
Source: Swiss pilot project experts.

3.7.3. Calculation of the FHBI

95. The Swiss contribution to the development of the OECD FHBI is based on the results and experiences of the ALL-EMA programme. It follows the guidelines proposed by the OECD Bayr et al. (2023[1]).

96. The Farmland Habitat Biodiversity Indicator Switzerland (FHBI CH) is calculated exclusively on the basis of the ALL-EMA habitat data, with particular emphasis on the plant species typical of the different habitat types. These data are crucial because the abiotic and biotic site conditions exhibit a gradient-like distribution that varies both between habitat types and within a defined habitat type.

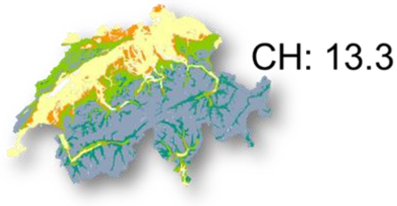
97. To calculate the FHBI CH:

1. The number of habitat-specific plant species found in the field is counted for each habitat plot.
2. The number of habitat type-specific plant species found is then divided by the maximum number of habitat type-specific plant species ever found in this habitat type in the entire ALL-EMA field survey. This is necessary in order to compare the characteristics between the different habitat types. These index values therefore range from 0-100%.
3. The values of this index ranging from 0-100% are then assigned equally classified to the values of the FHBI habitat categories, i.e. index values of 0-20% to the habitat category “very low quality” with a value of “0”, index values of 20-40% to the habitat category “low quality” with a value of “0.25”, index values of 40-60% to the habitat category “moderate quality” with a value of “0.5”, index values of 60-80% to the habitat category “high quality” with a value of “0.75”, and index values of 80-100% to the habitat category “very high quality” with a value of “1”.
4. Based on these classifications, the FHBI CH is calculated based on the respective proportions of these habitats within the landscapes per 1 km^2 square (agricultural land only).
5. The FHBI CH values of the squares can then be averaged per agricultural zone (Figure 3.13) or over the whole of Switzerland.

98. Based on the ALL-EMA data from 2015 – 2019, more than half of Switzerland’s total agricultural area was classified as “very low” for the FHBI. A fifth was classified as “low”, one-tenth as “moderate” and only a very small share of the area was classified as “high” or “very high”.

99. The differentiation between the different agricultural zones in Switzerland showed that the FHBI was significantly lower in the lower agricultural zones (plains, hills, lower mountains) than in the higher zones (upper mountains, summering areas; Figure 3.14). This indicates a clear deficit of biodiversity in the lower zones, which is also reflected in other biodiversity indicators (Meier et al., 2021[53]; Lachat et al., 2010[56]). The main reason for this is probably that the intensity of land use is particularly high in the lower zones (Meier et al., 2021[53]; Meier, Lüscher and Knop, 2022[54]).

Figure 3.14. Proportions of the agricultural area of Switzerland in each habitat category and results on the state of the FHBI CH



Habitat category	% of agricultural area of CH
Very low	66.0%
Low	21.0%
Moderate	9.0%
High	3.0%
Very high	0.9%

Plains	3.9
Hills	8.0
Lower mountains	8.7
Upper mountains	21.1
Summering area	23.1

Note: Based on the ALL-EMA data from 2015-2019
Source: Swiss pilot project experts.

100. The second survey of ALL-EMA was finalised in 2024; in 2025 a first comparison of the evolutions of the ALL-EMA indicators and thus also the FHBI CH will be available.

3.7.4. Strengths and weaknesses of the Swiss FHBI

101. The main feature of the FHBI CH is that it presents directly measured biodiversity characteristics. Because the collection of these data requires continuous work in the field, it guarantees immediate assessment and rapid detection of significant changes. However, its calculation comprises also normative steps, such as – to some extent – the definition of the habitat types (there are often no clear limits between similar habitat types, e.g. in grassland) and the requirement of the share of habitat indicator plants that need to be present for them to be categorised into a certain class. The process of testing the robustness of the indicator with different approaches to these normative decisions is currently underway. In principle, the FHBI CH can be easily transferred to other countries and adapted to local conditions. The ongoing tests may provide additional insights for a broader application. A particular advantage of the FHBI is its integration into a national biodiversity monitoring programme. As part of ALL-EMA, the FHBI CH can be placed in the context of other biodiversity indicators, its robustness can be tested and its results can be used in a complementary way.

102. A potential weakness of the Swiss FHBI is that the collection of the data is relatively costly, as compared to other approaches, due to the data collection in the field. Yet, the Swiss FHBI is based on data collected in an already ongoing monitoring programme (www.allema.ch), which has been initiated to monitor the degree to which the goals of the Swiss agri-environmental policy are reached and if the agri-environmental measures are effective. While the data collection in the field is laborious, the actual cost of the ALL-EMA monitoring amounts to only about 0.25% of the annual direct payments that the farming sector obtains for stabilising and improving the status of farmland biodiversity. ALL-EMA informs about the effectiveness of the agri-environmental measures (Meier et al., 2024[57]) and the Swiss FHBI can be computed at minimum additional cost.

3.8. Brazil (conceptual approach)

3.8.1. Key characteristics of farmland habitats and land use

103. Brazil has an enormous variety of land use types, from large to small properties, including diversified agriculture and monocultures. Also, large portions of the agricultural landscape are used for alternate crops, such as soybean and corn, producing two crops in the same year. Cattle ranching is also conducted in extensive manner in native grasslands, as well as technologically advanced and also intensive (confined) beef production. Mono-specific forestry is also present alongside managed native forests. Small farms are mainly specialised in the cultivation of fruit, legumes, vegetables, coffee, and dairy products. All of these land use types are required to comply with environmental legislation, setting apart portions of the land for conservation purposes. Biodiversity in cropland is thus influenced directly by the presence of such protected areas, comprising a landscape with relationships and environmental services relevant for both agriculture and biodiversity.

3.8.2. Data

104. Brazil has several land cover mapping initiatives, as well a series of maps over decades, such as the service provided by the MapBiomas Consortium. The maps are available in a 10m resolution and are updated on a yearly basis. Additionally, many states also have spatial data on crop types. This will provide the basis for adoption of a Tier III approach. Another relevant source of spatial information is the Programa Brasil Mais, which provides land cover maps at 3 m spatial resolution, covering the entire country. All rural properties in Brazil are also required to register in the Rural Environmental Cadastre (CAR, established by the Federal Law 12.651/2012), enabling assessments at property level. This is relevant, as the decision-making process on agriculture and conservation is conducted at the level of production units. The pilot project in Brazil will adopt indicators of landscape quality for biodiversity in a random sample of rural properties, as well as in circular random plots of at least 10 km in diameter. As patch area, connectivity, and integrity of the native vegetation patches, as well as the occurrence of disturbances and the type of agriculture and cropland practices matters for biodiversity potential, the pilot project will rely on published studies focusing on species-habitat, species-landscape relationships, and the response of taxonomic groups to “habitat” fragmentation, to obtain values for biodiversity. These values will then be evaluated by experts to produce a final table of values.

3.8.3. Calculation of the FHBI

105. The data produced by a literature review and expert consultation will be used to model agricultural landscapes and to predict the potential for biodiversity, using the standard calculation from OECD to obtain a single composite indicator of biodiversity in agricultural land, in a Tier III approach. As the plan is to obtain predictive models of biodiversity potential in rural landscapes, estimates with standard errors will also be obtained. However, the formula proposed by OECD to obtain a single composite indicator still requires the establishment of a statistical path to estimate uncertainty, based on the approach Brazil is planning to adopt. Given the large size of the country, producing a final spatial demonstration of the farmland value for biodiversity will be challenging, as maps at the country scale will need to be at low resolution. However, the data and outcomes may be presented as numerical reports and samples of the agricultural landscape at regional and local scales in higher resolution. At this stage, Brazil has no illustration of the outcomes of the biodiversity assessments in agricultural landscapes.

3.8.4. Strengths and weaknesses of the Brazilian FHBI approach

106. In Brazil, the agricultural landscape is defined by the boundaries of the rural property, in which Permanent Preservation Areas (PPAs), Legal Reserve Areas (LRAs), and Restricted Use Areas (RUAs) need to be set aside in order to license the agriculture activities. As such, protected native vegetation in the rural properties are inseparable components of the whole agriculture landscape, as the presence of wild species in cropland are highly dependent on the presence of native vegetation patches. Also, land-use practices may benefit or negatively impact biodiversity in both natural and managed areas. Environmental services, such as pollination, also depend on the native vegetation in the rural landscape. In this context, the strength of the Brazilian approach focused on assessments in landscape and "habitat" (land cover types) rely on this integrative interpretation. The existence of a Rural Environmental Cadastre offers a relevant opportunity, as the registry of each property requires the mapping of agriculturally used areas and areas set aside for conservation purposes. In terms of weaknesses, it is important to mention the absence of biodiversity data at finer scales, especially data obtained following a standard protocol, with uniformity in time, space and across taxonomic groups. This situation may prevent adequate modelling of biodiversity in agricultural landscapes. However, a large number of local studies have been published, providing information on the responses of species and taxonomic groups to habitat quality and landscape structure and composition. These studies enable the approximation of biodiversity values for different "habitats" (in the sense of land cover types) in agriculture landscapes. Finally, the experience currently being made in the Pantanal wetland, including biodiversity assessments based on eDNA, iDNA, and acoustic monitoring, modelling and automatised diagnosis with AI, could serve as a model for Brazil to reach a Tier I level in the future, by adopting similar approaches in the different regions of the country.

4. Lessons learned and guidelines for implementation

107. The pilot implementation of the FHBI by seven OECD Members plus Brazil has revealed a high degree of heterogeneity in terms of data sources, availability, and approaches to adapting the concept to country-specific conditions (e.g. bio-climate, agricultural systems) and requirements (e.g. spatial scale, thematic detail). In evaluating the pilot studies, this paper identifies remaining key issues for the specific approaches used, regardless of the level of detail, which can provide insights to assist other OECD Members in developing strategies for assessing and monitoring farmland biodiversity.

108. First, low levels of thematic, spatial, and/or temporal detail often result in high levels of uncertainty, highlighting the need for caution when working with FHBI. Given that new data become available for FHBI mapping, potentially leading to changes in tier levels, pilot country experts emphasise the need for methodological consistency to allow for recalculating the indicator following methodological/data improvements.

109. The pilot project further highlights the importance of dialogue and exchange between countries, as indicator development and implementation are still ongoing, especially with respect to standardisation of definitions and methods. National indicators strongly depend on contextual factors, which necessitates careful interpretation of FHBI products for the design of context-specific policies/measures.

110. When implementing and interpreting the FHBI, it is important to remember that the FHBI is designed for capturing habitat quality changes within a country (Bayr et al., 2023[1]) As such, only the sign of trends (positive, negative or unchanged), and rate of change of trends (e.g. if positive trends are slowing) can be compared across countries. At

the same time, a key strength of the FHBI is that it raises awareness of the status of biodiversity in agricultural landscapes across OECD Members. Additionally, the indicator can help shed light on the range of factors that need to be taken into account in different contexts, as well as the shared nature of some of the measurement challenges. Being asked to measure the indicator can lead to a greater focus on collecting data that is needed to make more informed decisions to support biodiversity on farmland. Importantly, the FHBI, as a single composite indicator, cannot be expected to provide all answers to the complex agriculture-biodiversity relationship.

111. The pilot projects have explored and demonstrated the practical feasibility of implementing individual approaches to calculating the FHBI. The approaches mostly rely on land-use data and expert-based definitions of their habitat quality to proxy farmland biodiversity. However, the resulting FHBI scores have not been compared with other measures of biodiversity (e.g. floristic or faunistic) to explore the extent to which the FHBI provides an accurate, reliable, and useful measure of farmland biodiversity at appropriate scales (from landscape to country). This report and the work that has been done by the pilot countries introduces approaches to map habitat quality. Hence, its focus is on the technical implementation of the workflow by Bayr et al. (2023[1]), not on the validation with *in situ* biodiversity data. This is therefore an important task for future refinement of the FHBI.

112. The following four subsections consider different challenges highlighted by the pilot projects. Subsection 4.5 identifies action points for future work and subsection 4.6 closes the paper by outlining synergies and complementarities with other indicators.

4.1. Definition of farmland habitats

113. To map changes in the FHBI over time, it is important that national indicators ensure consistency in their methods, e.g. that the definitions of farmland area and farmland habitats are consistent within countries. The country-specific definition of farmland area includes a decision about which features of the landscape are considered relevant for the assessment of habitat diversity. Here, the FHBI pilot countries followed diverse approaches that are mainly driven by their preconditions, e.g. national regulations that are implemented in existing monitoring programmes or overall data availability. Farmland area might be defined in a strict sense by only including land that is currently under agricultural use (agricultural land use), land that is or can potentially be managed (agricultural land), or all vegetated land outside forest, i.e. all open areas and settlements. Some pilot countries, such as Finland, Latvia, and Norway, suggest including forest land and other non-agricultural land types that are in the vicinity of farmland area, thereby explicitly considering the impact of ecotones and surrounding habitats outside farmland (in a strict sense) on farmland biodiversity.

114. The definition of farmland habitats also shows a high degree of heterogeneity in the underlying concepts of the pilot countries. Similar to the definition of farmland area, farmland habitats were mostly defined in relation to the available data from existing monitoring programmes or initiatives at the national level. The proposed mapping schemes cover a wide range, from a few and rather broad land cover categories to a detailed mapping of agricultural land use, woody features, and other farmland habitats of biodiversity value. Here, countries with a well-established farmland survey, such as Switzerland, can develop a very detailed FHBI as they have access to a large and consistent database. As a straightforward solution, Bayr et al. (2023[1]) recommend the adaptation of a hierarchical classification system based on a global land cover classification and the harmonisation of country-specific habitat definitions using such systems. It is acknowledged that such classification systems, e.g. the Land Cover Classification System (LCCS) of the UN Food and Agriculture Organisation, can be used to translate different classification systems

(e.g. due to specific national characteristics) into a harmonised structure. However, the LCCS builds on broad land cover categories and is not suitable for harmonising agricultural land use or farmland habitats. Other data models, such as the EIONET Action Group on Land monitoring in Europe (EAGLE), may provide more flexibility for harmonising and characterising land use information from different countries. However, harmonisation of data sources, farmland area, or habitat definitions is not a high priority objective of the OECD FHBI, since this would considerably delay the implementation of the indicator.

4.2. Definition of habitat quality

115. The assignment of quality values to farmland habitats is a key component within the FHBI calculation structure and has been subject to debate within and between the FHBI pilot countries. The overall idea of the habitat quality value is to rate each farmland habitat according to its potential biodiversity value. Ideally, the derivation of such biodiversity values builds on existing monitoring data across multiple taxa and the underlying relationship between species diversity and habitat occurrence and characteristics (e.g. management). Field data are essential to verify that presumed positive management practices are having the intended positive effects on biodiversity. As field data is very costly to acquire, it cannot be a prerequisite for the calculation of the FHBI. Of the seven pilot countries, only the Swiss pilot study was able to use habitat quality values based on species data recorded in the field. All other countries rely on expert knowledge of the relations between potential biodiversity value and land use in their habitat quality assessments, accepting that these are likely to be highly variable. As standardisation of habitat quality assessments for biodiversity among OECD Members is still a long-term endeavour, it is critical to further continue the exchange and dialogue to best harmonise the quality assignments.

116. Where field data is lacking, refining the FHBI by using information on management practices (e.g. number of mowing events) or landscape context (e.g. landscape heterogeneity) is likely to improve the FHBI compared to only using land use/cover (but see Section 4.3 for potential limitations). Some pilot countries proposed to include contextual information in the process of assigning farmland habitat quality values. Germany, for example, proposed to include information on land-use intensity by differentiating agricultural grassland into three levels of grassland use intensity based on a remote sensing-based mapping of mowing frequency. Other countries, such as Norway, discuss the limited representativeness of habitat quality values for cropland if only the crop type is considered, and propose to include information on cropland management practices and intensity in habitat quality assessments. For example, Latvia and Japan suggest including the grassland conservation status as well as the share of organically managed arable land in the proposed indicator, which might lead to a confusion of state and response and hinders the evaluation of the effectiveness of policies to support biodiversity (see Section 4.3).

117. Further, several pilot countries suggest that they could improve their FHBI by considering the diversity in agricultural land-use in the index calculation. This could include both compositional heterogeneity, i.e. the number and share of different land use types, or configurational heterogeneity of land use, i.e. the arrangement of patches within farmlands or landscapes. Both compositional and configurational heterogeneity are well-known to correlate with the abundance and diversity of organisms. Spatially targeting policies to improve biodiversity status at the landscape level is a key motivation for the OECD FHBI. Given the importance of heterogeneity in farming landscapes, Bayr et al. (2023[1]) could hence refine the FHBI, e.g. by increasing habitat quality values for farmland that is more heterogenous (for example with a bonus score). However, it has to be taken

into account that the relation between higher habitat heterogeneity and increasing biodiversity is affected by issues of scale, spatial resolution, thematic resolution.

118. It has to be noted that expert opinions have resulted in very different values for some apparently similar land types across pilot countries. For example, in Finland, forest was given a low score, because there is a large area of forest in Finland with limited positive impacts on agricultural biodiversity. However, in the Norwegian pilot, trees within 10 m of agricultural land were assumed to provide valuable habitat that increased the value of the agricultural landscape for biodiversity. Many species use multiple resources for feeding, nesting, or raising young, among others. Therefore, in Norway "natural" habitats in close vicinity to agricultural land were scored as valuable. Indeed, both Finland and Latvia emphasise the importance for biodiversity of forest-field ecotones, so the apparent difference in biodiversity score likely reflects the degree to which proximity to farmland is included or not in the workflow.

119. This leads to the question if and how the surrounding landscape can be consistently included in the FHBI calculation. Here, several pilot countries, which use spatially-explicit data for their habitat quality assessments, suggest going beyond an isolated assessment of habitat quality based on farmland habitats and adding the landscape context to the assessment, for example by including the quality of surrounding land cover types (e.g. forest, settlements) as well. Norway tested the inclusion of surrounding landscape patches using different buffer sizes and emphasised the large impact of including non-farmland habitats on FHBI values (yet strongly dependent on the buffer size). However, harmonisation on the type of land covered in the indicator is necessary as the indicator is intended to focus on farmland, and large inclusion of surrounding land cover types may change the scope and approach of the indicator.

4.3. Sensitivity of the FHBI to changes in land use and habitat quality

120. As outlined in Section 2, the FHBI is designed to be sensitive to changes in both the proportion of different farmland habitats categorised by their biodiversity value, and the quality value of a habitat (i.e. an increase in the habitat quality value as a consequence of the successful implementation of policy instruments or a decrease in quality as a consequence of land use intensification or land degradation). However, the work of the pilot countries revealed that the FHBI concept might be too simplistic to adequately account for efforts of farmers or communities to increase habitat quality or to replace low quality habitats by new habitats of higher quality; additionally, sensitivity is dependent on may factors including they type and quality of data used. Furthermore, sensitivity and robustness testing of the indicator has not yet been conducted to ensure that potential land use changes that would have the same impact on the FHBI would indeed have comparable impacts on overall biodiversity.

121. Another significant issue is that processes of habitat amelioration mainly occur on small patches and mostly only cover linear features at field margins and, thus, have only limited impacts on the FHBI value. On the other hand, quality-improving activities such as planting new hedgerows, cultivating perennial flower strips, or establishing field margins have proven to have positive impacts across the farmland. This issue is very well illustrated in the study from Norway that compares the FHBI calculation with and without linear features and emphasised that the impact of the linear features on the final FHBI value is close to zero. One possible solution in the pilot countries could be to give greater weight to small areas or those with very high natural value in the FHBI calculation. Lastly, the method to calculate the FHBI conceptually allows for improvements in habitat to 'offset' degradation in other areas, but does not currently ensure that this is accurate and the resulting biodiversity impacts of such offsetting would be neutral.

122. Another point that the pilot countries addressed relates to the question of how the FHBI can be used to monitor target achievement in the context of political frameworks. As with most other dimensionless indicators, the FHBI allows the interpretation of differences in spatial patterns and of changes through time. However, the FHBI is not a normative indicator of farmland habitat biodiversity but, on the other hand, can be used to report positive/negative trends with regard to a benchmark landscape or baseline (reference year).

123. Following the OECD structure for agri-environmental indicators (OECD, 1999[58]), biodiversity is listed as a *State* indicator within the DPSIR (Driver-Pressure-State-Impact-Response) framework. However, some pilot countries propose an FHBI that contains elements of both, *State* and *Response*. Such approaches deviate from the DPSIR framework, impeding assessments focussing on the effectiveness of policies to support biodiversity via the FHBI. For example, using the share of organic farming to define habitat quality without "ground-truthing" (i.e. an increase in species diversity) does not allow differentiating *State* from *Response*. In other words, such approaches can indicate a successful implementation of a policy measure (e.g. achieving a policy goal of 1 million ha of organic farming), yet are not able to indicate the positive impacts of policies on species diversity.

4.4. Selection of tier-level for data acquisition, analysis and reporting

124. An important prerequisite for transparent FHBI monitoring and reporting workflows is the definition and assignment of tier levels. Bayr et al. (2023[1]) define such tier levels based on the assumption of large differences in data availability and quality between countries, and propose that each country should report the tiers they are using to be able to make a rough assessment of the state, and prospectively trends, of farmland habitat biodiversity. The decision for a tier enables a consistent monitoring over time based on a defined set of criteria. It further allows for movements between tiers when a country decides to refine their data sources or methods, e.g. by using data with higher spatial or temporal resolution, or from different sources.

125. The definition of tiers in Bayr et al. (2023[1]) builds on the two criteria of (1) data availability and (2) quality of available (monitoring) data for the FHBI (Table 2.1). The work of the pilot countries has shown that a clear allocation to one of the three tiers is difficult in most cases. This is mainly due to ambiguities in the current definitions of the criteria (e.g. the consideration of remote sensing data in all three tiers) and led to considerable variation and uncertainty in the countries' decision to assign their pilot study to one of the tiers. While the approach and the overall concept of tiers remain undisputed, it was necessary to expand and concretise the number and selection of criteria for the description and definition of tier levels. Further, it is not important for each country to be assigned to one level. Rather, it is crucial that the defined criteria comprehensively describe the approach chosen by a country.

126. Based on this, this paper recommends multiple criteria that characterise the level of detail at which each country reports its farmland habitat biodiversity. Each criterion is assigned to a tier, and all criteria can be compared as a whole or individually between countries. The list of criteria results from the evaluation of the FHBI calculation approaches of the pilot member countries and summarises the most important factors that enable a transparent and comprehensible description of country-specific implementations of the FHBI calculation.

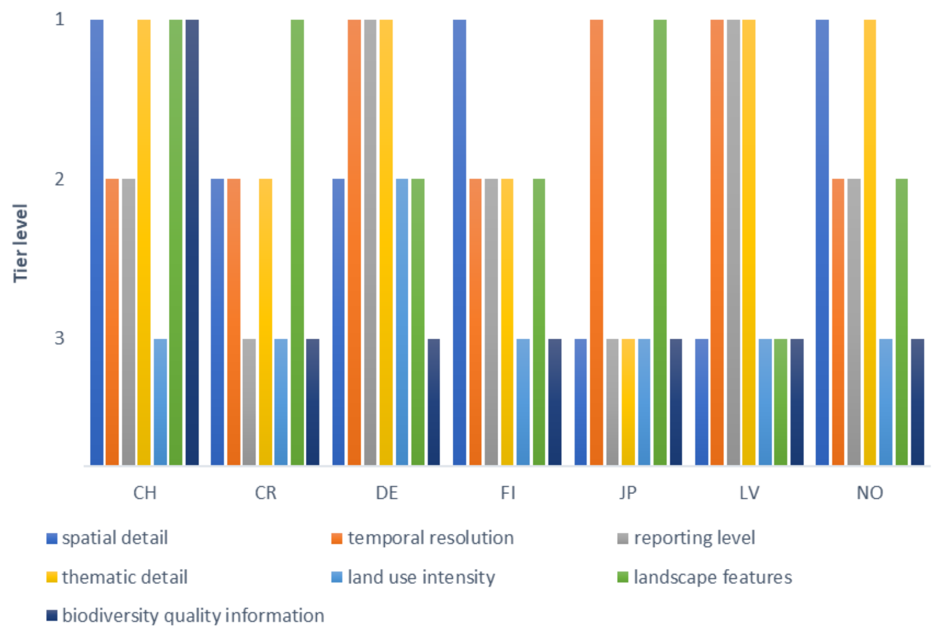
127. Table 4.1 summarises the set of criteria that is suggested. It can be split in two main categories, (1) technical level of detail (spatial detail, temporal resolution, reporting level), and (2) contextual level of detail (thematic detail, land use intensity, landscape features,

biodiversity information). The diagram in Figure 4.1 suggests a way of illustrating the multi-criteria assessment using the example of the pilot countries. It shows that each pilot country meets a subset of criteria at tier I level (i.e., highest accuracy), while other criteria differ between pilot countries. In summary, some pilot countries (e.g. Switzerland, Norway) have an overall higher share of criteria that meet tier I definitions, compared to other countries characterised by higher proportions of less detailed tier levels.

Table 4.1. Multi-criteria definition of tier levels for FHBI calculation

	Criteria	Tier I	Tier II	Tier III
Technical	Spatial detail	UAV, VHR, aerial imagery, field data	High resolution remote sensing data (e.g. Sentinel-2)	Medium to coarse remote sensing/ statistical or other (Geo-) data
	Temporal resolution	Annual or higher	Periodical	Static
	Reporting level	Area-wide grid	Administrative regions, irregular sample	National
Contextual	Thematic detail	Detailed ag LU classes	Broad LULC categories	Landscapes/archetypes
	Land use intensity	Direct measurement	Derived indicator	None
	Landscape features (e.g. hedges, ponds, flowering strips, and native vegetation)	Presence and quality information	Presence	None
	Biodiversity quality information	Species monitoring data	Species distribution maps, known habitat associations	Expert opinion, "most probable value"

Figure 4.1. Multi-criteria evaluation of data and methods for the calculation of the FHBI by pilot countries



CH: Switzerland; CR: Costa Rica; DE: Germany; FI: Finland; JP: Japan; LV: Latvia; NO: Norway.

4.5. Open questions and action points for future mapping, testing and reporting FHBI

128. Based on the developed methods for mapping FHBI by the eight pilot countries, this paper identifies challenges and requirements for FHBI workflows (bullet points not ranked by priority). These especially pertain to the assignment of habitat quality values to farmland habitats, i.e. their potential biodiversity value.

- Compare preliminary FHBI scores with other measures of biodiversity (e.g. floristic and faunistic), especially over large geographic scales and over time as the FHBI is a trend indicator.
- How to ensure that the categories of habitat quality and associated scores create a system that can robustly compare different changes in land use, avoiding offsetting by land-use changes?
- How to consistently include the surrounding landscape in habitat quality values and FHBI calculations? This pertains to selection criteria determining which additional habitats should be considered in the FHBI calculation, until which distance from farmland habitats should they be considered, and how the inclusion of the surrounding landscape would affect the indicator value based on the proposed formula by (Bayr et al., 2023[1]).
- What level of sensitivity is expected from the FHBI at a distinct tier level to respond to changes in the amount of land (i.e. habitat area) in different habitat value categories, ensuring that the indicator adequately reflects improvements in biodiversity-supporting habitat? Is it possible to derive comparably sensitive indicators across countries (e.g. sensitive to a minimum area change)?
- How does the choice of spatial aggregation units influence the FHBI value? This pertains to potential issues of scaling and the modifiable area unit problem (MAUP), which can result in different FHBI values for different aggregation levels (e.g. national vs. administrative levels).
- How to account for scale effects? The value of habitat locally may not translate linearly to the overall value on a regional or national scale. For example, large-scale impacts might be influenced by the relative abundance of different habitats, connectivity between habitat types and food system effects.
- How to make the FHBI more sensitive with regard to gross and net changes? The aggregation of the FHBI at reporting units (e.g. administrative areas, grid cells) might mask out substantial gross changes within those units.
- Is it necessary to apply a consistent definition of farmland area for FHBI mapping across OECD Members?

129. Moreover, the pilot countries identified the following overarching action points for enhancing the calculation of country-level FHBIs.

- Strengthen data integration and sharing
  - Improve data accessibility and ensure the integration of national biodiversity data into public and international systems.
  - Promote enhanced data sharing and collaboration across countries to improve biodiversity monitoring and decision-making.
- Invest in technology and standardisation

  - Invest in advanced tools like remote sensing and AI, and the competency to use them, to improve the accuracy and granularity of farmland biodiversity data.
  - Improve the accuracy, resolution and consistency of input data for area-wide (e.g. EO-based) mapping of farmland habitats and its change while ensuring individual property rights and data privacy concerns are respected.
  - Standardise methodologies across regions for more consistent and comparable data collection and analysis.
  - Clarify and harmonise the spatial and temporal aspects of the reference state (e.g. native state, potential habitat, habitat value relative to adjacent lands) for habitat value categories.
- Address data gaps and broaden scope
  - Address the lack of field-level biodiversity (species) data representative for their agricultural habitats.
  - Ensure the inclusion of more diverse land cover/use types (e.g. forest borders, semi-natural areas).
  - Potentially include biodiversity-friendly farming practices in monitoring efforts (no consensus across FHBI pilot countries).
  - Integrate management-related data such as pesticide use and organic farming to reflect their importance in supporting biodiversity – noting that the FHBI should then not be used to demonstrate the benefits of such practices, as this would be a circular argument.
- Enhance temporal and spatial coverage
  - Expand monitoring to cover additional OECD Members, also enabling non-OECD Members to calculate and map FHBI.
  - Archive data for long-term trend analysis to better understand farmland habitat biodiversity changes over time.
- Robustness and collaboration for testing future adaptation and reporting
  - Continue testing the robustness of the FHBI by its integration in existing monitoring programmes, and assessing its results in a complementary way to other biodiversity indicators.
  - Focus on inter-institutional cooperation to streamline indicator implementation and promote policy relevance.

4.6. Synergy and complementarity of indicators

130. The pilot studies highlight synergies in method development amongst countries and point to the broader potential of the FHBI beyond OECD goals. Intensified agricultural production systems are widely recognised as a pressure on biodiversity, making sustainable agricultural management essential for ecosystem resilience, Nature’s Contributions to People, and food security. Target 10 of the Kunming-Montreal Global Biodiversity Framework (GBF) outlines a monitoring framework to enhance biodiversity in agriculture, where the FHBI concept could support the headline indicator, “Proportion of agricultural area under productive and sustainable agriculture”. Additionally, the FHBI complements the “Agrobiodiversity Index” among other indicators, showcasing its adaptability for both national and global biodiversity monitoring efforts; this supports capacity building for

OECD Members, particularly those who have had less focus on biodiversity associated with agricultural landscapes.

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