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Deliverable 4.5 Report on the applicability of BIOBIO indicators beyond Europe – exemplified for three ICPC case study regions (Ukraine, Tunisia and Uganda)

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WP 4

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Executive Summary

The applicability of the BIOBIO indicators beyond Europe was tested in Tunisia, Ukraine and Uganda. Whilst the approach seems to be generally applicable, specific adaptations are still required. In Tunisia and in Uganda, the farm management questionnaire would require adaptation to the local conditions. The sampling design needs to be adapted, in particular in the Ukraine, due to different farming structures and farm size. Not all species groups could be addressed in all regions, i.e. spiders in Uganda, earthworms in Tunisia. The habitat mapping key and earthworm sampling would require adaptation to tropical conditions.

CONTENTS

INTRODUCTION 4

1. ICPC CASE STUDY REGIONS AND FARMS (TUNISIA, UKRAINE, UGANDA) 5

1.1. TUNISIA 5

1.2. UKRAINE 6

1.3. UGANDA 8

2. OVERVIEW AND APPLICABILITY OF THE BIOBIO INDICATORS ASSESSED IN THE THREE ICPC CASE STUDY REGIONS 11

2.1. HABITAT INDICATORS 11

2.2. SPECIES INDICATORS 12

2.3. GENETIC DIVERSITY INDICATORS 13

2.4. FARM MANAGEMENT INDICATORS 13

3. SPECIFIC ADAPTATIONS TO ICPC CASE STUDY REGIONS 13

3.1. TUNISIA 13

3.2. UKRAINE 14

3.3. UGANDA 14

4. STATUS OF THE BIOBIO INDICATORS IN THE ICPC CASE STUDY REGIONS AND PRELIMINARY CALCULATIONS 15

5. DISCUSSION AND RECOMMENDATIONS 24

6. REFERENCES 25

APENDIX 1 - 4

Introduction

The objective of the research project BIOBIO (Biodiversity indicators for organic and low-input farming systems, EU FP7, KBBE-227161, 2009–2012) was to identify a set of biodiversity indicators which are (i) scientifically sound, (ii) generic at the European scale and (iii) relevant and useful for stakeholders. In a first phase, candidate biodiversity indicators were tested in representative case studies across Europe. The main output of the BIOBIO project carried out in the European case study regions consists of guidelines for the assessment of biodiversity indicators in organic and low-input farming systems (Herzog *et al.* 2012a). In a second phase, the applicability and usefulness of the resulting indicator set was tested in three International Cooperation Partner Countries (ICPC; Uganda, Ukraine and Tunisia) in other agro-ecological zones and in a different policy context. The aim of this part of the project (WP5) was to identify:

- which indicators are generally applicable for low input and organic farming systems beyond Europe,
- which indicators can easily be replaced by similar indicators and
- which indicators would need to be developed in order to match the conditions of low input and organic farming in other agro-ecological zones and institutional settings.

The implementation of this work package (WP5) was based on the partnerships with the Institut National de Recherche en Génie Rural, Eaux et Forêts in Tunisia, with Bila Tserkva National Agrarian University in the Ukraine and with Makerere University in Uganda. These three case study areas showed a gradient of increasing difference to the European case studies:

- Similar low input non-organic and organic olive groves in Tunisia to the olive groves in Extremadura, Spain;
- Comparable mixed, low-input and intensive arable and livestock farming systems in Ukraine to the mixed farming system in Germany but with much larger fields and farms;
- Very different organic and non-organic subsistence farming in Uganda compared to the European case study regions.

To be able to test whether the European candidate indicators defined in BIOBIO are applicable in the three case studies, the partners participated in the process of conceptualising the criteria for indicator selection and the development of assessment methods. The following criteria were important when evaluating the indicators:

- indicators are generally applicable to the farming systems under investigation;
- indicators are user-driven;
- indicators are policy relevant;
- indicators are scientifically credible under the specific climatic and biogeographic conditions;
- indicators are easily understood by the target audience;
- data can be obtained at a reasonable cost;
- expertise and infrastructure for species identification and habitat mapping is available.

However, the requirements for the applicability of indicators in the three case studies did not influence the selection of indicators for the European case studies because the overall objective of BIOBIO was to propose an indicator set for Europe. As a consequence, the three teams assessed the same indicators as tested in the European case studies.

This report summarises the applicability of the indicators investigated in the European case studies to the ICPC case study regions. The ICPC case study regions in Uganda, Ukraine and Tunisia are presented and the application of the indicator survey is discussed. Preliminary results of indicator calculation are shown. Recommendations to implement and to improve surveys and monitoring programs on farmland biodiversity in countries outside the European Union are provided.

1. ICPC case study regions and farms (Tunisia, Ukraine, Uganda)

1.1. Tunisia

Tunisia is the northernmost country of the African Continent, midway between the Atlantic Ocean and the Nile Valley. The size of the Tunisian territory is 162.155 sqkm with an estimated population of just over 10.3 million. Tunisia enjoys a Mediterranean climate with mild rainy winters and hot, dry summers in the North and along its coast. The south of the country forms part of the Sahara desert and the regions of the centre and the south of Tunisia are subjected to an extremely hot even dry semi-arid climate. In summer, the temperatures sometimes exceed 40°C. Rain occurs in November in the form of heavy showers. On average, precipitation is between 1000 mm and 1500 mm in the north, and only between 100 mm and 200 mm in the south. The agriculture represented 14 % of the GDP in 2005. The main farm produces are: olives and olive oil, citrus fruits, cereals and dates. Tunisia is the most important olive-growing country in the south Mediterranean with more than 30 % of its arable lands devoted to oleiculture. Organic agriculture is relatively new in Tunisia. It began in the eighties with private initiatives and has grown significantly in the last years. Tunisia currently has around 285,000 ha of organically certified land.

The case study farms are located near the eastern cost of Tunisia (Fig. 1), in the districts of Monastir and Mahida between Sousse and Sfax. The average temperature of the area lies around 22 °C and annual rainfall lies between 200 and 400 mm per year. Soils are mainly Calcisols, Luvisols and Fluvisols.

Agriculture is an important economic activity covering more than 80 % of the area. The main crops are olives, pistachio, barley, almond, pomegranate prickly pear and some fodder crops. About 60 % of the agricultural land is planted with olive trees. Organic farming is an important part of the olive oil production- 40% of the land covered by olive trees is farmed organically and around 115,000 ha of olive plantations (in 2008) are no longer treated with chemical fertilisers and pesticides (Fig. 2 & Fig. 3). The production of vegetables under greenhouse also characterizes this region. The surveyed farms are specialized in the culture of the olive tree and can be classified as low-input farms.

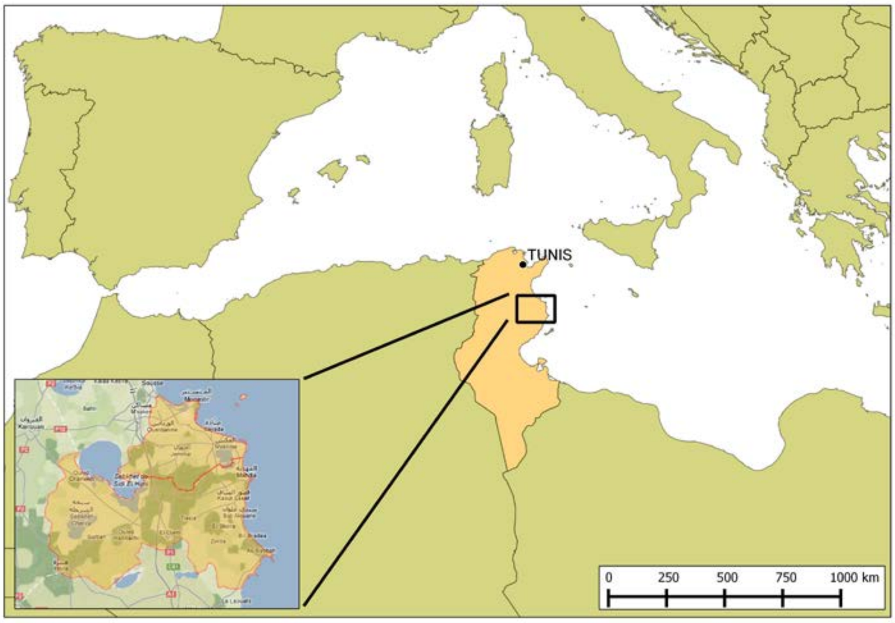

Fig. 1: Location of Tunisian case study

Fig. 2: Flowering plants on a Tunisian olive farm (photo: R. Kölliker)

Fig. 3: Vegetable crop between olive trees (photo: S. Garchi)

1.2. Ukraine

Ukraine with its area of 600.000 sqkm, is the second largest country in Eastern Europe The landscape consists mostly of fertile plains (or steppes) and plateaus, crossed by rivers such as the Dnieper, Seversky Donets, Dniester and the Southern Buh. The country's only mountains are the Carpathian Mountains in the west. Ukraine has a mostly temperate continental climate with an average annual precipitation of approximately 600 mm. The humus-rich black soils of the Ukraine create one of the most fertile regions in the world and hold great potential for agricultural production. However, these soils are also threatened by rapid erosion and lose of fertility if not managed properly.

Ukraine typically produced over half of the sugar beets and one-fifth of all grains grown for the former USSR. In 2007 there were around 90 organic farms in Ukraine with a total area of 255,000 ha, which is 0,7 % of the total agricultural land.

The investigated farms are located in the south of Kiev province in central Ukraine near the city of Bila Tserkva (Fig. 4). The case study region lies within the Forest-Steppe zone. The climate is temperate-continental. The annual precipitation is 550−580 mm and the average temperature is 7.7 °C. 84 % of agriculture lands in case study region have a chernozem soil with a humus content of 2,7-4,2 %. Large parts of the ecosystems in the case study region are maintained predominantly by extensive agriculture (Fig. 5). Agriculture occupies around 64 % of the land, and consists mainly of cereal (wheat, barley, maize), sunflower and sugar beet production (Fig. 6). Most of the farms have stock breeding (cattle, pigs). Woodland comprises about 20 % and nature protection areas about 3 % of the total area. The Ukrainian CS farms are large scale agricultural systems and were formerly cooperatives. This is common in many Eastern European and beyond.

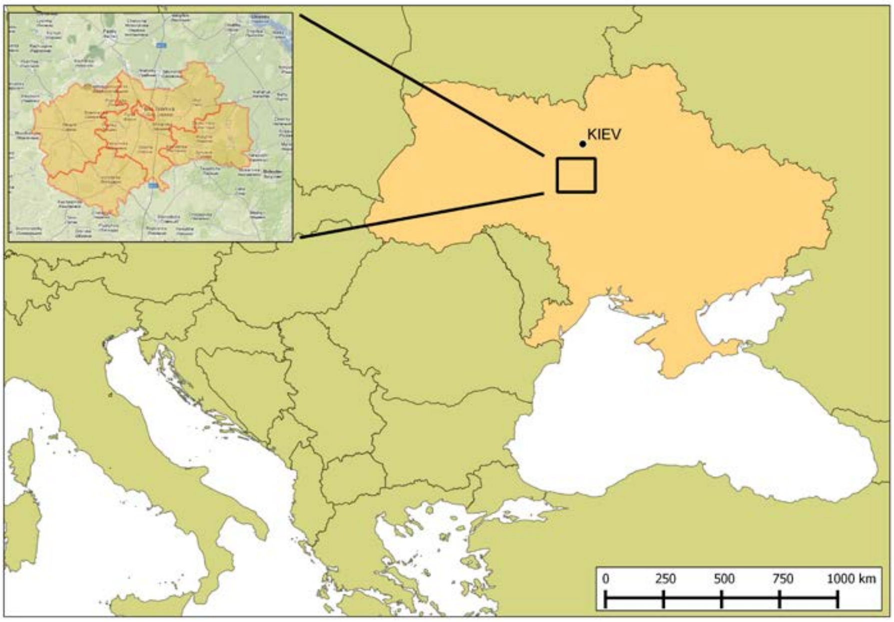

Fig. 4: Location of Ukrainian case study regions

Fig. 5: No tillage farming on an Ukrainian farm (photo: S. Yashchenko)

Fig. 6: Catching bees on a plot in a cereal field (photo: S. Yashchenko)

1.3. Uganda

Uganda is a landlocked country in East Africa. It covers a total area of 236,040 sqkm and has a population of about 27 million people. The country is located on the East African plateau at about 1100 metres above sea level. Although generally equatorial, the climate is not uniform due to the altitude which modifies the climate. Southern Uganda is more wet with rain generally spread throughout the year. Further to the north, a dry season gradually emerges. The north-eastern Karamoja region has the driest climate and is prone to droughts. Rwenzori in the southwest receives heavy rain all year round. One of the world's biggest lakes, Lake Victoria, heavily influences the south of the country. It prevents temperatures from varying significantly and increases cloudiness and rainfall. In Uganda about 50,000 certified smallholders practice organic farming. Organic export companies have increased from 5 in 2001 to 22 by 2005.

The case study region is located in the Kayunga district, which lies approximately 74 km northeast of Kampala (Fig. 7). The area has a modified equatorial climate, which means humid to sub humid conditions. Rain falls between March and June and between September and November, the precipitation is around 1228 mm per year. The average temperature lies between 22 and 25 °C. Kayunga District is characterised by gently rolling hills with wide valleys and an elevation ranging from 1300 m in the north to 950 m in the south. Soils are the sandy clay loams of Luvisols and some silty loams of Fluvisols. Agriculture is the main economic activity in Kayunga district and represents 90 % of the total employment. Many active farmers produce organic products. Kayunga practices two types of agriculture: (a) animal husbandry in the north and (b) crop husbandry of subsistence agriculture in the south where the BioBio Project site is located. Some of the crops produced in the district include vanilla, cassava, banana, coffee, maize, millet, watermelon, pineapple and passion fruit (Fig. 8 & Fig. 9). The district is the leading producer of pineapple in Uganda and the organic farms of the area export the fresh fruits.

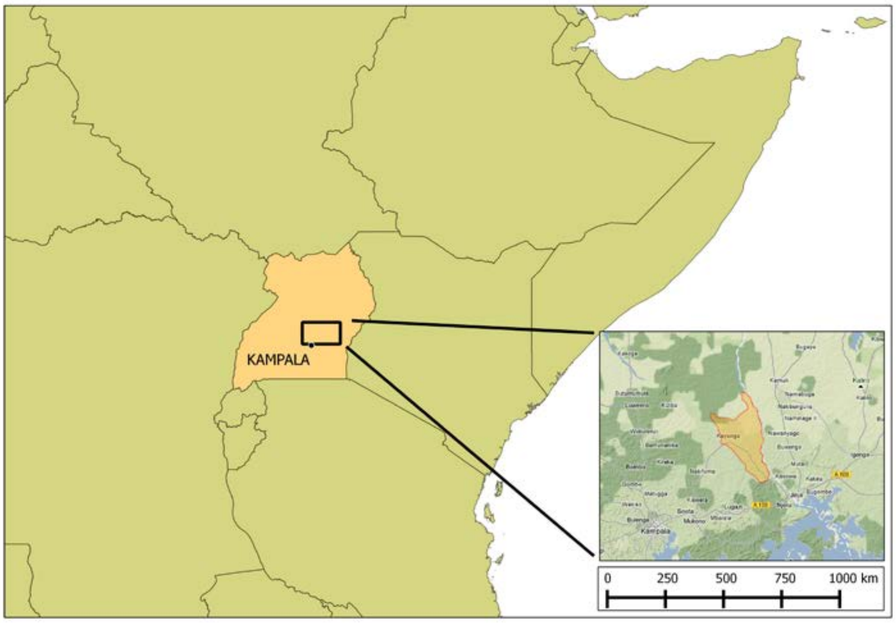

Fig. 7: Location of the Ugandan case study region

Fig. 8: Intercropping with maize and pineapple, banana plants on the field border in Uganda (photo: C. Nkwiine)

Fig. 9: Banana and pineapple field in Uganda (photo: C. Nkwiine)

Temperate farming in Europe is characterized by distinct seasonality: A growing season during spring – summer, which is interrupted by a cold season in the winter. In tropical farming in Uganda, this is not the case and there is no interruption of the growing season. In addition, the Ugandan farming is characterized by spatial and temporal intercropping. Mono-culture is the exception. On a specific field several crops occur at the same time and one of them may be gradually replaced by another. For example, whilst pineapples are planted in mono-cropping during the first 1-2 years, they may be gradually intercropped with e.g. banana and/or coffee in subsequent years. When after 5-6 years the pineapple plants are removed, the banana will be intercropped with coffee or/with trees.

2. Overview and applicability of the BIOBIO indicators assessed in the three ICPC case study regions

Candidate biodiversity indicators for organic and low input farming systems in Europe were selected (Herzog *et al.* 2012b, D4.3, available from www.biobio-indicator.org) following a major review of indicator theory and existing biodiversity indicators (Dennis *et al.* 2009, D2.1, available from www.biobio-indicator.org). The review included indirect biodiversity indicators based on farm management and farm accounts information and direct biodiversity indicators including the genetic, the species and the habitat levels. The candidate indicators identified were then recorded in a survey in 2010 in the European case study regions. Sampling design and methods are available from Dennis *et al.* (2012, www.biobio-indicator.org). The applicability of these candidate indicators beyond Europe was discussed with the WP5 members during meetings in Vienna, 15-16 December 2009, and in Placencia, 24-25 March 2010. Indicators listed in Appendix I were then assessed in the ICPC case study regions in a survey in 2011. Basic information on indicators and adaptations for the ICPC case study regions are detailed in the sections below.

2.1. Habitat indicators

BIOBIO adopted the standard habitat mapping procedure for the European scale developed in the EBONE /BIOHAB project (Bunce *et al.* 2008). This method of habitat/land use classification is based on a generic system of habitat definitions, General Habitat Categories (GHC) (see Dennis *et al.* 2012 available from www.biobio-indicator.org, and Bunce *et al.* (2010) available from www.ebone.wur.nl). The survey area is defined by the boundary of the farm under investigation and having established the limits of the farm property, the habitats on the farm are firstly identified using aerial photographs or satellite images. Subsequently, the habitats of the farm are mapped in detail during a field investigation and site, management and environmental conditions of the habitats are described using a series of predefined codes (see Bunce *et al.* 2010). The map forms the basis for the selection of the habitat types to be sampled for the species indicators. One habitat per type on the farm is randomly selected as a survey habitat for plant, bee, spider and earthworm species. The map is also essential for the calculation of many of the habitat indicators (Herzog *et al.* 2012a). Generally, the habitat mapping method applied in the 12 European case study regions was also applicable to the ICPC case studies but the following points have to be emphasized:

- The EBONE method was generally applicable in the Ukraine, Tunisia and Uganda. It was possible to map the case studies using the method, to verify the maps and to calculate indicators.
- As in the European case study regions more training would have been necessary for the partners to become familiar with the EBONE mapping method.
- As with the European case study regions this training would have been most effective if it had been undertaken in the region where the mapping was being undertaken. This would enable clarification of local questions/situations and also to adapt the mapping method where necessary.
- As with other partners there was some misunderstanding about the use of the various codes and it was necessary to clarify their application and to make corrections.
- Aerial photographs were not always available (e.g. Uganda) or were of poor quality (e.g. Tunisia).
- The use of GIS was sometimes limiting for the partners due to lack of availability and/or experience. Other partners were able to provide support, e.g. Germany for the Ukraine, Spain for Tunisia and Switzerland for Uganda.
- The indicator 'percentage of semi-natural habitat' was difficult to apply for some of the ICPC partners.

2.2. Species indicators

The sampling design and the methods used to record species data were fundamentally the same as for the investigations in the Eureopean case study regions (Dennis *et al.* 2012). However, necessary adaptations were applied during the surveys. They are specified in the next sections.

2.2.1. Vascular plants

There are many arguments for using vascular plants as indicators. These primary producers dominate most terrestrial ecosystems, shaping our physical environment and forming the basis of food chains. They constitute an important part of agricultural landscape biodiversity and provide food, shelter, breeding sites, refuges, etc. for a wide range of other organisms. Most mammals, birds, invertebrates and insects are directly or indirectly dependent on one or more species of vascular plants and diversity of vascular plants may therefore indicate diversity of other organisms. These relationships were not supposed to be different in the ICPC case study regions. Vascular plants were mapped according to the method proposed by Bunce *et al.* (2010). In ICPC case study regions, they were assessed following the same protocol as in the European case study regions.

2.2.2. Wild and bumble bees

Bees (Apidae) are recognized as promising indicators for ecological change of habitat quality. They are characterized by complex life histories and have specific requirements for nesting sites, such as dead wood, bare soil, plant stems or small rock cavities which should be close to feeding sites. Wild bee communities are first influenced by the land use intensity in a region, then by the landscape structure. Ricketts *et al.* (2008) emphasized the importance of conserving and managing sufficient resources for wild pollinators within the agricultural landscape to maintain the pollination services. A decline in bee diversity will affect the pollination of many insect-pollinated crops and wild plant species. With respect to farming systems, Holzschuh *et al.* (2007) demonstrated that organic farming increases bee diversity by enhancing flower availability. In addition, bee diversity was influenced by the landscape context and the interaction of both, organic farming being more effective in homogeneous landscapes. As for plants, bees were assessed following the same protocols in ICPC case study regions as in the European case study regions. In Uganda, in contrast to the other case study regions, *Apis mellifera* (honey bee) was not excluded from the analysis since *Apis mellifera* is not domesticated in the Ugandan case study region.

2.2.3. Spiders

Spiders are an abundant and form species-rich taxon occurring in (nearly) all terrestrial ecosystems including agro-ecosystems. In agricultural fields, responses of farmland spiders to agricultural practices and management intensity are well known and documented. Spiders occur in all agro-ecosystems at all levels (soil, grass/crop, trees) and can therefore be compared across them as well as among farming systems, farms, and case study regions in Europe and beyond. They are sensitive to agricultural practices and are important predators of invertebrate pests (biological control). However, while collection in fields can be done without particular expertise (e.g. by technicians), they need to be identified in the lab by taxonomists. In ICPC case study regions except Uganda, spiders were assessed following the same protocol as in the European case study regions. In Uganda, spider collection was not performed because it was known from the beginning that they could not be identified due to the lack of proper identification keys and taxonomy expertise.

2.2.4. Earthworms

Earthworms (Annelida, Oligochaeta) are key soil detritivores, essential for composting and recycling soil nutrients whilst contributing to the maintenance of soil structure anecic species which are large, vertically burrowing earthworms building up stable burrows play an important role in conservation and improvement of soil structure. The activity performed by earthworms allows the soil to reach a condition that hosts many other sorts of organisms, hence enhancing the overall soil biodiversity. Rich soil biodiversity and biomass, means a supply of higher amounts of resources for greater above ground trophic levels, so contributing directly to enhance the overall biodiversity of agro-ecosystems. In ICPC case study regions, earthworm recording methods surveys should be adapted, i.e. earthworms were not collected in Tunisia because they were missing in the olive plantations, and the AITC method not further applied in Uganda after first samples revealed poor success of the method there (see sections below).

2.3. Genetic diversity indicators

A comprehensive set of indicators for the detection of biodiversity in organic and low input farming systems must include measures of genetic diversity within crop species and within husbandry animals. However, reliable detection of genetic diversity is generally laborious, often technically demanding and can be difficult due to the lack of information about breeding pedigrees and seed sources. Therefore, in the framework of the BIOBIO project, a detailed analysis of genetic diversity of all aspects concerning agricultural ecosystems is not possible. The indicators rely mostly on information gathered through farmer interviews. In ICPC case study regions, they were assessed following the same protocol as in the European case study regions.

2.4. Farm management indicators

The Farm Management Questionnaire is the basis for data collection to assess farming intensity on BIOBIO case study (CS) farms. Management indicators address e.g. economical aspects, nitrogen, energy and pesticide inputs, livestock management, yield, etc. Generally for the ICPC case study regions, the same protocol and questionnaire as in the European case study regions was used. However due to the different structure and organization of farms in ICPC case studies only parts of the questionnaire were applicable (see sections below).

3. Specific adaptations to ICPC case study regions

Along with the conceptual foundation of the BIOBIO project, the same set of indicators and the same methods and protocols to collect data were planned to be applied in the three ICPC case study regions. However, specific adaptations to case study regions were necessary due to peculiarities encountered, and are recommended for further monitoring activities in these countries.

3.1. Tunisia

When testing the BIOBIO indicator set, we faced the following fundamental difficulties:

- Aerial photographs were available for the mapping process although they were partly of poor quality. Generally, it was possible to follow the habitat mapping protocol in Tunisia although development of further site and management qualifiers would be beneficial to account for the complexity of woody crop habitat types and also their farmed intensity. Furthermore, it was necessary to adapt the General Habitat Categories available for the cultivated crops to take better account of the complexity of the woody crop habitats. These adaptions were possible post-mapping using the information gathered during the field survey. The adaptions require a few additions to the EBONE method (see Appendix 2) but allow a much more detailed description of habitat types identified in BIOBIO (Appendix 3).
- It is difficult to identify whether the olive groves are intensively or extensively managed. Olive groves that are extensively managed would be classified as semi-natural in BIOBIO. The current measure applied for BIOBIO is the density of trees. Extensive olive groves were considered to have <200 trees per hectare. Tree density in the Tunisian context is an inappropriate measure as density is determined by soil water availability and olive density is always low irrespective of intensification and/or modernization. The size of the olive grove and the soil management between the tree rows (bare soil, intercropped) are potentially more appropriate crieteria to assess intensity together with clarification using regional experts.
- The farm management questionnaire was not adapted to some of the farms. Many farmers are not used to keep farm records and some of the indicators, e.g. energy consumption, could not be evaluated because records were not available.
- Plants, bees and spiders could be recorded by using the same sampling procedure as for the olive farms in Spain and the other European case studies. For identification, spiders and bees had to be sent to specialized taxonomists in Europe as expertise was not available in Tunisia. It was possible to collect the genetic diversity data using same questionnaire as the other BIOBIO case study regions.
- Earthworms were very rare and in fact, earthworm sampling was abandoned after investigations in a number of plots, when hardly any individuals could be detected.

3.2. Ukraine

All BIOBIO indicators could be measured, as for the European case study regions. Taxonomic expertise for arthropods and earthworms was available and the animals could be identified in the Ukraine. However, the following points have to be taken into account:

- A major adaptation concerned the habitat mpping and species sampling design. This is because the Ukraine farms were significantly larger than those in Europe with much larger individual fields (15 to 697 ha). Farm boundaries were also difficult to define as farmers were unclear about the limits of the property. For mapping and sampling a systematic approach was adopted. The location of one field of each of the six main crop types (buckwheat, soybean, barley, alfalfa, wheat, maize) of the farms and also one grassland was identified with the aid of the farmer, four linear habitats were also located. This approach differers from the other case study regions where the habitat mapping was firstly undertaken and then used as the basis to select one example of each habitat type for sampling. In the Ukraine due to the size of the farms it was only possible to undertake the habitat mapping using aerial photographs in the laboratory. Habitat types were then confirmed in the field by visiting the habitats selected for sampling and surrounding elements. This method was considered effective, however some of the linear elements identified were quite complex and further development of the General Habitat Categories would be required. For example it was necessary to define particular and differeing habitats as "Lines of Trees" because in practice they were quite different from each other.
- The species sampling design was also adapted due to field size. In the European case study regions, one example per habitat type was sampled for plants, earthworms, spiders and bees. In Ukraine, due to the large size of the habitats, it was decided to divide the habitat into three parts, and to sample the species indicators in each of these subdivisions. Thus, each survey habitat was sampled three times in the Ukraine as opposed to only once in the other case study regions.

3.3. Uganda

In Uganda, the application of the BIOBIO indicators led to the following difficulties:

- Aerial photographs were not available for Uganda. Instead, satellite photographs were used as a basis and then boundaries of habitats were defined by walking their boundaries and mapping with a GPS.
- The EBONE habitat mapping method was also generally applicable to the Ugandan situation and tropical habitats. However, the complexity of the Ugandan farms due to multiple inter-cropping required two vistits from the Swiss partner to provide support and brain storming. Modifications of the General Habitat Categories for cultivated crops (see Appendix 2) were proposed to take account of the intercropping situation in Uganda (e.g combinations of several woody crops with or without annual crops; plots partly laid fallow). Through the modifications more accurate BIOBIO habitat types could be defined (Appendix 3). The modifications would of course benefit from further investigation by the Ugandan team. Further environmental codes would be needed to account for the tropical situation. The management codes should also be further developed to take account of the various forms of inter-cropping and also the different tropical crops.
- In Uganda the concept of semi-natural habitat is not well understood. This would require further investigation and probably the intensity of land use would be a more appropriate measure. This would require expert knowledge and/or management qualifiers that capture this aspect. In the present analysis, mainly plots which were laid fallow were considered as semi-natural.
- The farm management questionnaire was not adapted to the farming system and could take account of only part of the management operations. The questionnaire did not fit the specific conditions of the Ugandan farms, in particular it is not able to capture the intercropping situation. It was partly adapted but would need additional revision. The indicators which can be calculated have hence to be treated with caution. Especially farm size was underestimated from the farm interviews and should be calculated from the GIS maps instead. Still, the farm questionnaires provided similar results to that of the official government statistics. Also Focus Group interviews were performed, which is an add-on to the Ugandan BIOBIO programme.
- It was decided before start of field surveys not to sample spiders in the case study of Uganda because of the lack of expertise to identify them, and also as identification keys are missing for some groups of species.

- The plant sampling protocol could easily be applied. Training was necessary to teach the Ugandan team the methodology but afterwards it worked well and was applicable. No modifications are proposed.
- In some habitat types sweepnetting was difficult as the plot was covered with large shrubs (however, observation revealed that in these habitats there were very few bees). The recommendation would be to combine sweepnetting with another capturing method, e.g. pan trapping. All catches (including honey bees *Apis mellifera*, a hardly domesticated wild species in Uganda) were sorted into morphospecies before final determination to species level.
- Methods needed adaptation for earthworms. The use of Allylisothiocyanate (AITC) to extract earthworms before the hand-sorting of soil cores, could not be applied due to the different structure of tropical soils that hardly allowed the chemical to spread beyond 10 cm deep. In contrast, the hand-sorting of soil cores was easily applied. In addition, from each plot a soil sample (0 - 20 cm) was taken and analyzed. Standard soil parameters (pH, soil texture, P, etc.) were measured. All catches were first sorted into morphospecies before final determination to species level.
- Taxonomic expertise for bees and earthworms was not available in Uganda and the animals were sent to Kenya for identification.

The overall results of the indicator assessment and thus an evaluation of the general applicability of the indicator set for the three ICPC case study regions are summarized in Table 2.

4. Status of the BIOBIO indicators in the ICPC case study regions and preliminary calculations

This chapter will give a more detailed evaluation of some of the individual indicators and whether they could be calculated. For that, the focus will be on the actual calculations and presentation of individual indicators. To investigate applicability of indicators some examples from the ICPC case studies analysis are shown.

At this stage, only preliminary results are available (Table 2). This is because the ICPC case studies were conducted at a later stage than the European case studies. As for the European case studies, preparation of data for analysis was often difficult and tedious work. After collection in the 3 ICPC case study regions, raw data were prepared in electronic spreadsheets. However, before indicators can be calculated, e.g. the gamma species richness of bees, the total nitrogen input on farms etc., data were checked for overall consistency, synonyms were identified for species, GIS data and habitat records were adjusted, etc. Although standardized methods were implemented in all the case study regions, and templates for electronic data format organized to help for correct preparation of the data, and despite experiences made with the European dataset, the work load for data check and correction was high. This caused important delays for the data analysis. However, it must be emphasized that data check and preparation is necessary to ensure proper analysis of data across case studies and should not be underestimated.

Table 1 summarizes the design adopted in the three ICPC case study regions, the number of farms investigated and their average sizes. Table 2 shows status and results of calculation for available indicators. The following sections show examples of on-going analysis.

Table 1: Number and type of farms investigated in individual ICPC case study regions.

Country	Farming system	No. of farms	Average farm size
Tunisia	olive groves	10 organic & 10 conventional	75.2 ha
Ukraine	mixed arable & livestock	3 low input & 3 high input	2626 ha
Uganda	small holders' arable farming	8 organic & 8 conventional	2.9 ha

Table 2: Applicability and results of BIOBIO indicator assessment in ICPC case studies ("not applicable" = indicator was not applicable in case study; "not yet available" = indicator was applicable in case study but results have not yet been analysed completely)

		Ukraine	Tunisia	Uganda
General Description				
Habitat	Habitat types (total)	11	26	37
	Habitat types (per farm)	10	7	6
Plants	Species (total)	91	145	249
	Species (per farm)	46	26.3	73.5
Earthworms	Individuals (total)	2018	not applicable	260
	Species (total)	10	not applicable	8 morphospecies
	Individuals (per farm)	336	not applicable	16.3
	Species (per farm)	8	not applicable	4 morphospecies
Spiders	Individuals	1508	248	not applicable
	Species	124	47	not applicable
	Individuals (per farm)	251	12.4	not applicable
	Species (per farm)	55	6.2	not applicable
Bees (*Apis mellifera* excluded in Ukraine and Tunisia)	Individuals	365	60	5629
	Species	59	9	133 morphospecies
	Individuals (per farm)	61	3	351.8
	Species (per farm)	21	1	29.2 morphospecies
Crop species/varieties		6 / 30	not yet available	17 / 92
Animal species/breeds		not yet available	not yet available	not applicable
Farm Management		not yet available	not yet available	not yet available
Indicator Assesment Costs		not applicable	not applicable	not applicable

4.1.1.Genetic indicators

The genetic indicators were derived from the farm interviews. Within the limitations of the general applicability of the interview contents, the information on crop and animal diversity was easy to acquire. Fig. 10 shows that e.g. all the BioBio farms investigated in Uganda cultivated pineapples, maize and beans but few cultivate sweet potatoes, cassava and pawpaws.

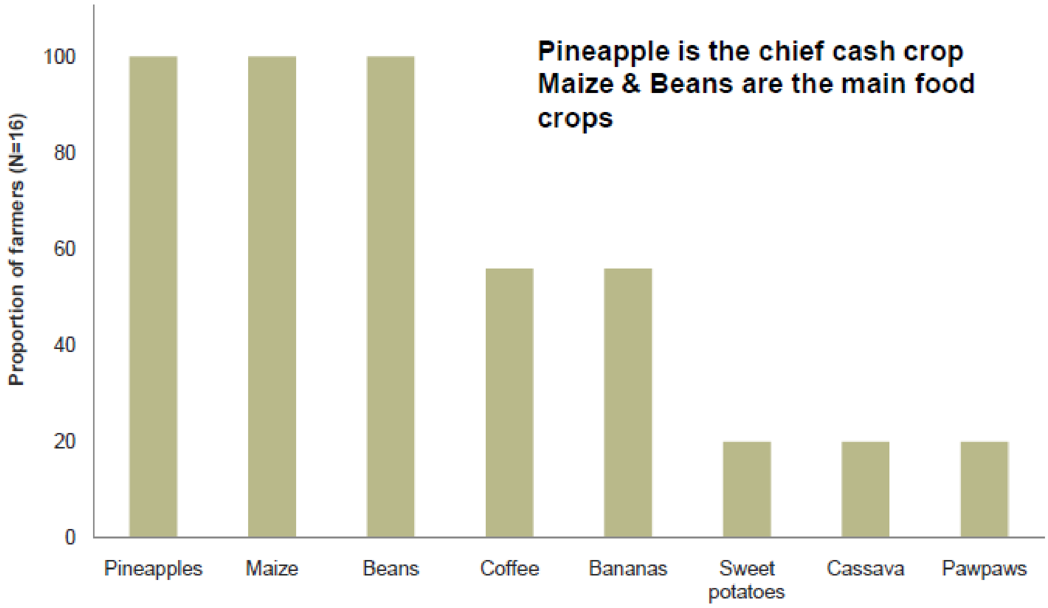

Fig. 10: Percentage of BioBio farms per crop species in Uganda.

The analysis of data showed that there were very few landraces in general in the BIOBIO European case studies, i.e. 5 landraces in all 195 farms of the case study regions (which occurred in Germany, Dehesas and Olive plantations in Spain) compared to the case study in Uganda where 37 landraces were found on only 16 farms. In Uganda, the use of landraces is very common and is an important part of agricultural production (see Fig. 11).

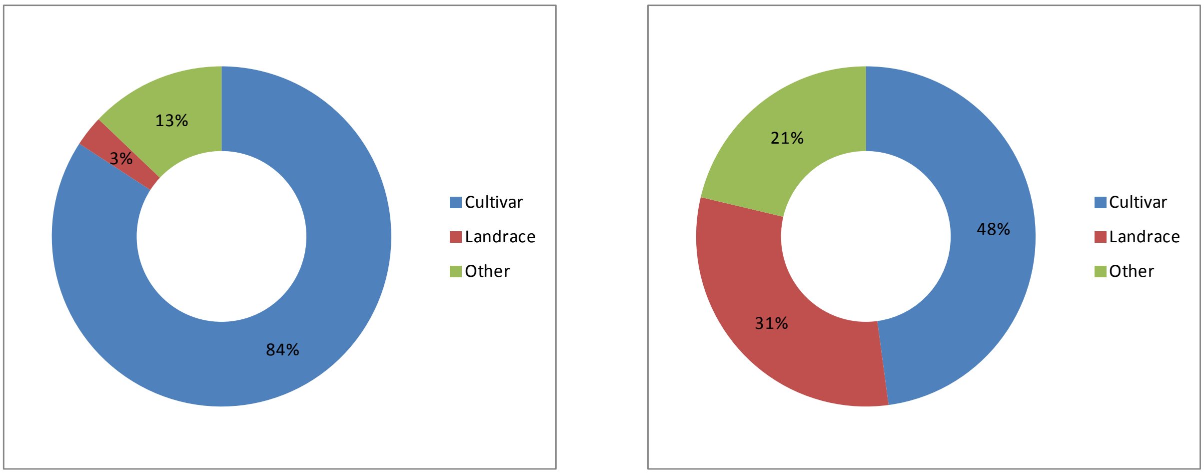

Fig. 11: Origin of accessions compared between (a) European case study regions (all varieties = 171), and (b) the case study region in Uganda (all varieties = 119).

4.1.2. Habitat indicators

The same habitat mapping to that applied in the 12 European case studies wad undertaken in Tunisia and Uganda. In Ukraine some simplifications and modifications were applied due to the large extent of the farms as described in sections above. Habitat indicators could be calculated for all three case studies, however for the Ukraine some comparisons may not be possible with the other case study regions due to the necessary adaptation of the sampling design for the flora and fauna surveys. Fig. 12 and Fig. 13 show habitat maps for Ukrainian and Ugandan farms, respectively. In Tunisa the maps were created together with the Spanish partneres using the proprietary software ArcGIS[1]. In Ukraine and Uganda OpenSource GIS (QGIS[2] and ILWIS[3]) were used to create digital maps of the case study farm structures and the habitats present on the farmland. In Ukraine the partners were adviced on the use of QGIS by TUM. The use of OpenSource GIS tools provides easy accessible and cheap resources for mapping in ICP countries. As can be seen in the figures the results are of high quality and provide good basic data for the calculation of BioBio habitat indicators. Appendix 4 shows some examples of preliminary results of the basic analysis performed with habitat data from the ICPC case study regions.

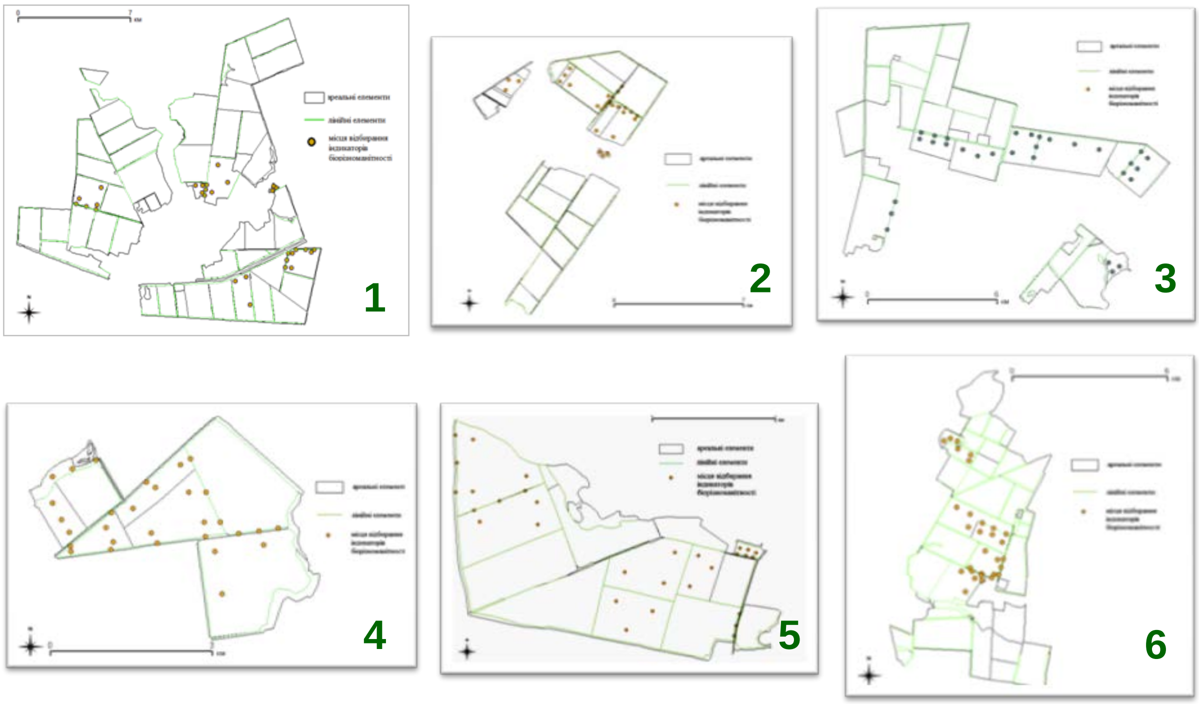

Fig. 12: Habitat maps of the Ukrainian farms showing also the species sampling locations (brown dots).

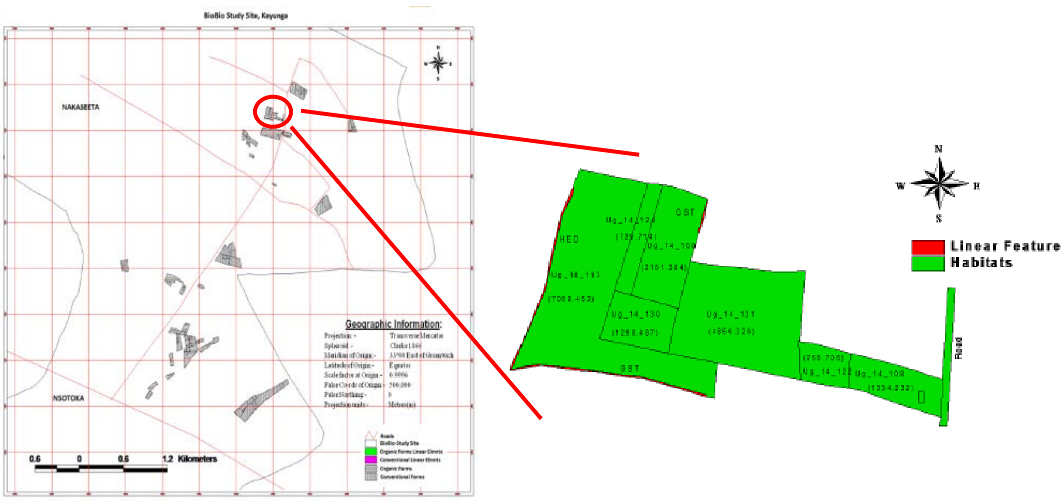

Fig. 13: Overview GIS map of the Ugandan case study region and detailed habitat map of a farm

The habitat indicators were calculated for Uganda (Fig. 15) and also partially for Tunisia (Fig. 14). As can be seen from the following figures, indicators such as "Habitat richness per farm", Proportion of area with trees", "Length of linear elemts per farm" and "Average patch size per farm" could be easily calculated from the GIS habitat data. However, some indicators in particular case study regions have not

[1] Available from ESRI (http://www.esri.com/)

[2] Freely available at http://www.qgis.org

[3] Freely available at http://www.ilwis.org

yet been calculated. For example, in Tunisia the discrimination between intensively farmed olive groves and semi-natural olive groves was currently not possible. This was because the intensity of farming at the ground level (e.g. annual crops) is often different to that of the tree layer. Thus, this issue would require further analysis, research and consideration from regional experts. Currently, no indicator involving semi-natural elements was calculated for Tunisia. For the Ukraine no habitat indicators have yet been calculated. Checking and analysis is still in progress.

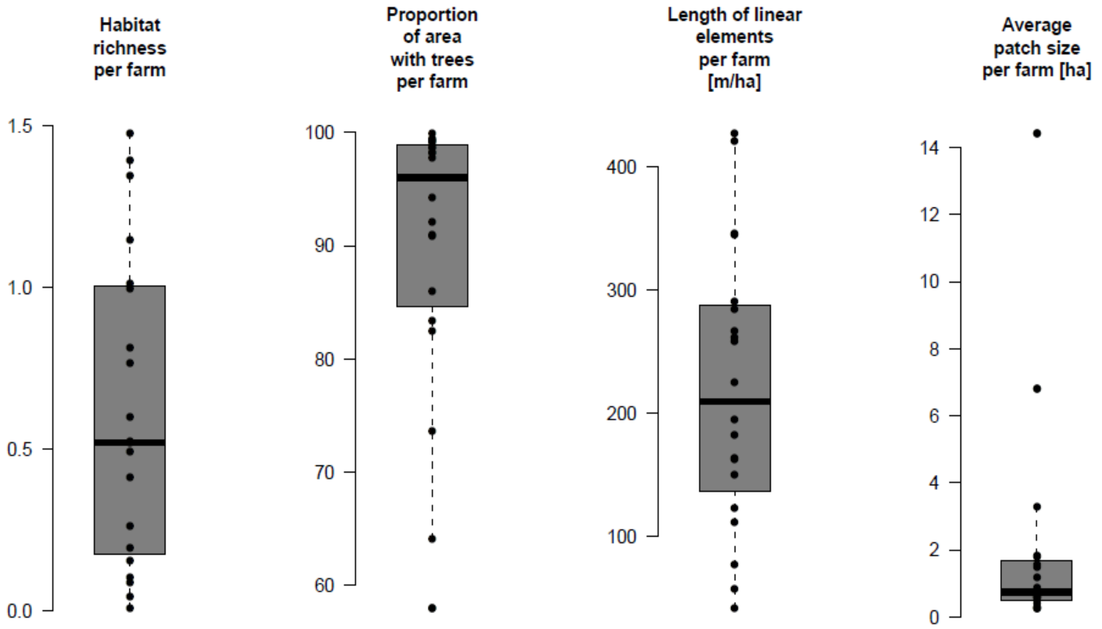

Fig. 14. Distribution of four habitat indicators in Tunisia (Habitat richness [Number of habitat types per ha], Proportion of area with trees per farm [%], Length of linear elements per farm [m/ha] and Average patch size per farm [ha]). Boxplot with lower quartile (25% of the farms), median (50% of the farms), upper quartile (75% of the farms), and individual farms (black dots).

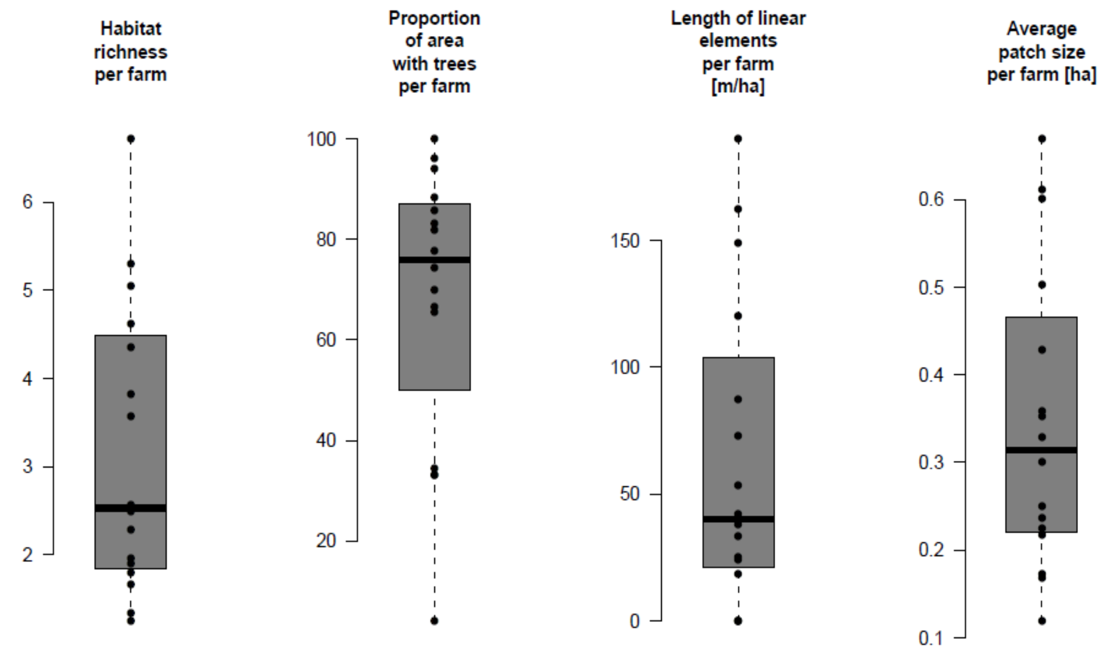

Fig. 15. Distribution of four habitat indicators in Uganda (Habitat richness [Number of habitat types per ha], Proportion of area with trees per farm [%], Length of linear elements per farm [m/ha] and Average patch size per farm [ha]). Boxplot with lower quartile (25% of the farms), median (50% of the farms), upper quartile (75% of the farms), and individual farms (black dots).

4.1.3. Species indicators

In Ukraine the four species groups could be assessed. In Tunisia, close to 60 plots were sampled and very few earthworms were found, therefore earthworms were discarded as an indicator. In Uganda spiders were not sampled due to missing taxonomic knowledge; also it was difficult to find taxonomists for bees and earthworms. For this reason a first screening of diversity of these species groups in Uganda was undertaken by using the morphospecies concept, i.e. individuals are not identified with identification keys but separated in groups, the morphospecies, according to simple morphological visible differences. Species data were firstly gathered by each individual ICPC partner institute. There the data were prepared in cooperation with the European partners and basic analyses were undertaken. Appendix 4 shows some examples of preliminary results of the basic analysis performed with species data from the ICPC case study regions. Afterwards data were transferred to ART, where species diversity parameters were then calculated as for the 12 European case study regions (Jeanneret *et al.* 2012). As an example Fig. 16 shows the results for the indicator "Alpha richness" of species groups in Uganda applying the morphospecies concept. Results for another indicator, the "Gamma richness" of species groups in Uganda applying the morphospecies concept, are shown in Fig. 17.

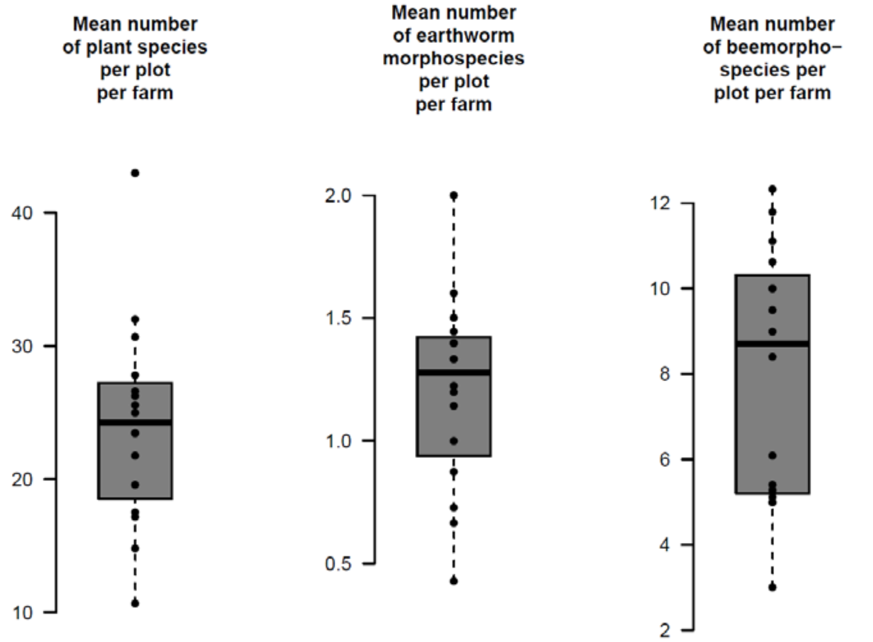

Fig. 16. Alpha richness of species groups in Uganda. Boxplot with lower quartile (25% of the farms), median (50% of the farms), upper quartile (75% of the farms), and individual farms (black dots).

The calculated species indicators were then used for further analysis and evaluation as for the 12 European case study regions (Jeanneret *et al.* 2012). Fig. 18 to Fig. 20 show the Spearman correlations of the gamma richness in farms of the four species indicator groups in each of the three ICPC case study regions. The results could be used to find surrogate species. However this is not recommended as in conjunction with the European case studies most correlations are small and patterns are not consistent over the studies.

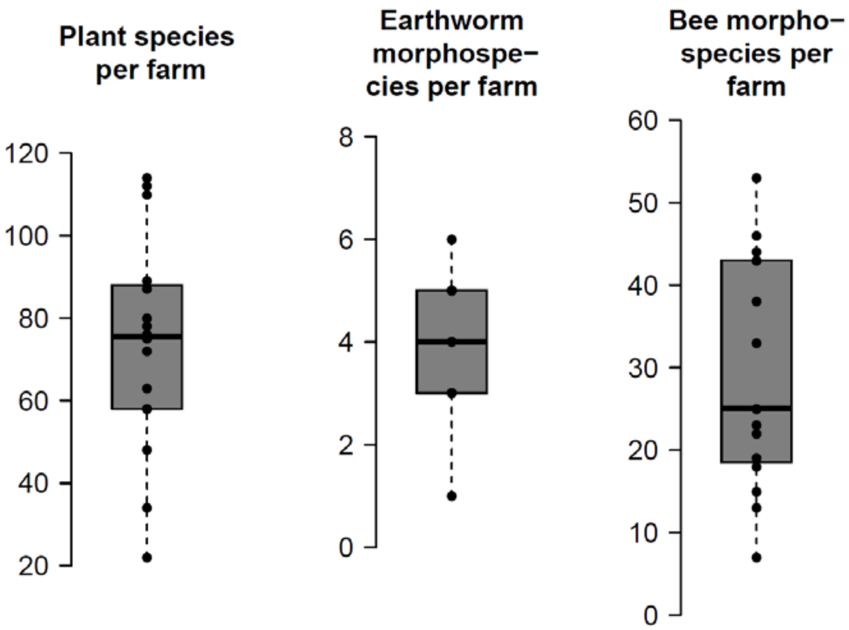

Fig. 17. **Gamma richness of species groups in Uganda. Boxplot with lower quartile (25% of the farms), median (50% of the farms), upper quartile (75% of the farms), and individual farms (black dots).**

Fig. 18 shows the Spearman correlations of the gamma richness in farms of the four species indicator groups in the Ukrainian case study region. There is a small negative correlation between plants and earthworms and a small positive correlation between plants and spiders, plants and bees and earthworms and bees. All other correlations were only very small. None of the correlations were significant.

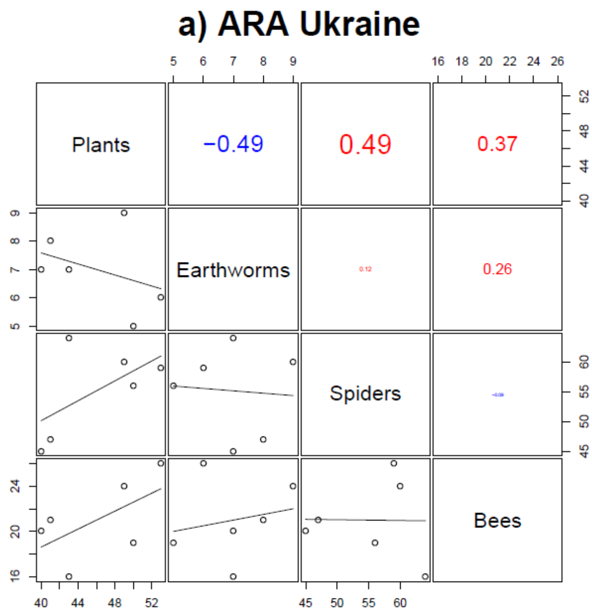

Fig. 18: Spearman correlations of the gamma richness in farms of the four species indicator groups in the Ukrainian case study region. Relationships between indicators are graphically shown below the diagonal. Correlation coefficients with significance (stars) are given above the diagonal. The font size is proportional to the coefficient value.

Fig. 19 shows the Spearman correlations of the gamma richness in farms of the three species indicator groups in the Tunisian case study region. There is a tendency of a positive correlation between plants and spiders. Surprisingly, there was no correlation between plants and bees. Between spiders and bees a significant positive correlation was detected.

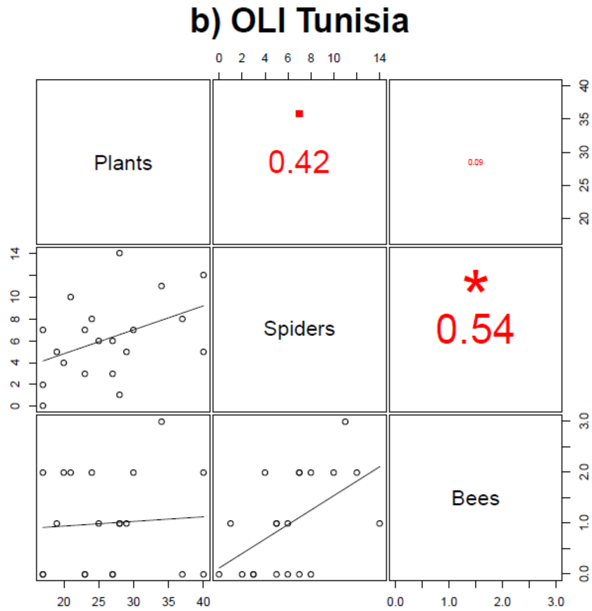

Fig. 19: Spearman correlations of the gamma richness in farms of the four species indicator groups in the Tunisian case study region. Relationships between indicators are graphically shown below the diagonal. Correlation coefficients with significance (stars) are given above the diagonal. The font size is proportional to the coefficient value.

Fig. 20 shows the Spearman correlations of the gamma richness in farms of the three species indicator groups (bees and earthworm only as morphospecies) in the Ugandan case study region. There is a significant positive correlation between plants and bee morphospecies. Between plants and earthworm morphospecies no correlation was detected. The relation between earthworm and bee morphospecies tended to be positive, but there was no significant correlation.

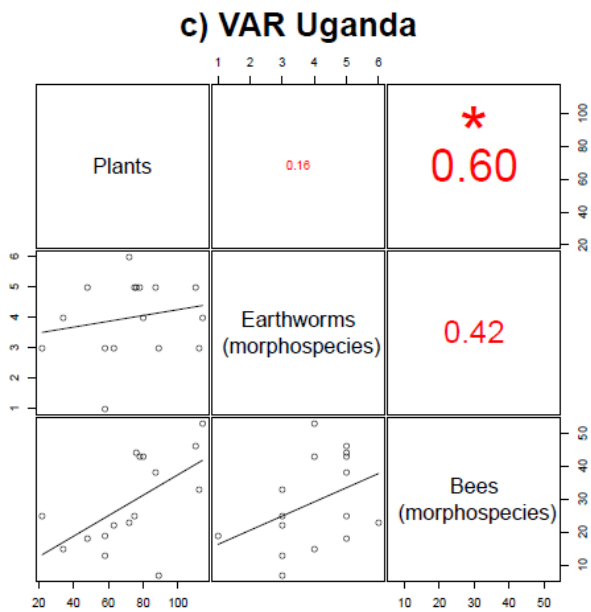

Fig. 20: Spearman correlations of the gamma richness in farms of the four species indicator groups in the Ugandan case study region. Relationships between indicators are graphically shown below the diagonal. Correlation coefficients with significance (stars) are given above the diagonal. The font size is proportional to the coefficient value.

Due to the results shown above it is recommended to keep all proposed species indicators for the ICPC countries as far as they are generally applicable.

4.1.4. Management indicators

The management indicators were derived from the farm interviews. Within the limitations of the general applicability of the interview, which would need some adoptions for Tunisia and Uganda, the information on the management and structure of the farms was more or less accessible.

Table 3 and Table 4 show results for the farm management indicators from the Ukrainian case study derived from the interviews. For each farm information on area, landuse/crops and lifestock is given. Additional information on inputs, like energy, fodder, fertilizers and pesticides, and outputs, like yield of crops or milk, are shown in the tables. The numbers can either be used as indicators directly or as input for further calculations of farm mamagement indicators.

Table 3: Basic data on crops and livestock on Ukrainian farms.

Indicator	High-input farms			Low-input farms		
	1	2	3	4	5	6
Total area, ha	14665	4563	6180	1081	2613	3939
Arable land, ha	13659	4242	5569	936	2364	3260
Grassland, ha	18	20	19	28	18	18
Area, ha / crop yield, centner/ha						
Wheat	2625/40	793/31	876/33	52/40	513/40	711/50
Soya	805/33	254/14	216/28	401/25	297/38	102/25
Maize	4291/100	1275/55	2361/86	282/110	213/72	491/100
Barley	2619/30	399/45	390/28	53/28	102/18	709/30
Buckwheat	600/18	120/14	522/16	138/22	311/20	485/20
Livestock (n° of animals)						
Cattle	2000	1664	2300	–	1400	227
Swine	3100	1448	–	–	1500	548
Sheep	–	50	–	–	–	120
Chicken	2500	–	–	–	–	500
Horses	21	32	–	–	21	20
Milk yield, kg/year	8000	7772	7500	–	7200	4000

Table 4: Data on inputs of fuel, fertilizers, pesticides, concentrates and electricity in Euro per farm in Ukraine.

CS farm	€/ha/year				Electricity (kWh)
	Fuel	Fertilizer and Pesticides	Concen-trate fodder	Total	
1	127.6	91.9	142.5	362.0	2 534 213
2	135.8	69.8	58.0	263.6	1 242 132
3	187.1	101.4	2358	524.3	937 433
Average in high-input farms	**150.2**	**87.7**	**145.4**	**383.3**	**1 571 259**
4	1.3	7.3	0	8.6	42 143
5	19.0	10.8	34.9	64.7	721 321
6	4.1	44.0	0.7	48.8	375 763
Average in low-input farms	**8.1**	**20.7**	**11.9**	**40.7**	**379 742**

As long as suitable data were available, indictors could readily be calculated. In the Ukaraine it was difficult to assess the total area of the farm and the actuall proportion of farmed area due to the historic development of the farm structures which were created during the socialist time. However, these numbers are vital as a reference for the calculation of most of the farm management indicators. Another problem was that farmers in ICP countries are not usually used to keeping very detailed records of their farming operations and in- and outputs. It is recommended to provide some form of "farm-diary" to the farmers during such projects and give some training as to how to do the recording in order to guarantee continous and high quality data.

5. Discussion and recommendations

It is possible to draw some general conclusions from the results of ICPC case studies. The case study in Tunisia was similar to the olive groves in Spain and all indicators except earthworms were applicable. It is then recommended to select another (or several) indicator(s) that can show soil conditions as screened under Dennis *et al.* (2009) during the initial phase of the BIOBIO project, e.g. microorganisms, macrofauna (collembolla, insect larvae, etc) if applicable. In the Ukraine, the sampling design for species surveys had to be adapted to the farm and plot size. As a consequence, analysis of data have to be performed with different statistical models to investigate e.g. correlations. Uganda was most different from the European systems making the implementation of the BIOBIO indicators more difficult. In particular, taxonomic knowledge of many species groups is lacking. Species can consequently not be identified at the species level in Uganda but need to be sent to Kenya. It is then recommended to use morphospecies.

The major problem is the availability of adequate resources for establishing e. g. a monitoring scheme based on the selected indicators. For practical implementation it would be necessary to adapt the indicator set to lower levels of available resources (funding, knowledge, infrastructure and institutions). One solution could be to put more emphasis on the simplicity of methods or low cost approaches when it comes to the implementation of indicators and sampling schemes (see e. g. Coddington J. A. *et al.* 1991; Danielsen *et al.* 2000). Also the use of new methods and approaches like morphospecies (Krell 2004), DNA barcoding (Huang *et al.* 2007), rapid biodiversity assessment (Obrist & Duelli 2010, Tzoulas & Philip 2010) or citizen science approaches (Lawrence 2010) might be investigated. Connected to this is the importance of knowledge transfer to empower the local expert, e.g. through the use of Open Source GIS or taxonomy. Another way to cope with deficiencies in human resources and institutions could be a more integrated biodiversity monitoring which combines social and natural science aspects like for example those achieved with participatory monitoring methods (see Danielsen *et al.* 2005; 2006). The discussion of Yoccoz et al. (2001; 2003), Rodríguez (2003) and Danielsen *et al.* (2003a; 2003b) on the relation of scientific background of biodiversity indicators for monitoring and the potential of participatory approaches for developing countries provide a good starting point for the development of adapted indicators based on the BIOBIO findings.

Finally, if the BIOBIO methods are used to develop a biodiversity monitoring at the farm level, the question arrises about how the data can be upscaled to higher and more general levels, e. g. for national reports. These issues have been considere in BIOBIO for the European context (Herzog *et al.* 2012a). However these recommendations would surely need some adaption especially for tropical conditions. An example of a pragmatic approach that might be useful in this context was developed and discussed by DeFries et al. (2010).

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Appendix 1 – BIOBIO indicator set. These indicators have passed scientific and practical testing as well as the stakeholder audit.

Habitat Diversity Indicators		**Species Diversity Indicators**	
HabRich	Habitat richness	Plants	Vascular plants
HabDiv	Habitat diversity	Bees	Wild bees and bumblebees
PatchS	Average size of habitat patches on farm	Spiders	Spiders
LinHab	Length of linear elements	Earthworms	Earthworms
CropRich	Crop richness		
TreeHab	Tree cover		
ShrubHab	Percentage of farmland with shrubs		
SemiNat	Percentage of semi-natural habitats		
Indicators for the Genetic Diversity of Livestock and Crops		**Farm Management Indicators**	
Breeds	Number and amount of different breeds	EnerIn	Total direct and indirect energy input
CultDiv	Number and amount of different varieties	IntExt	Intensification/Extensification Expenditures on fuel, pesticides, fertiliser and animal fodder
CropOrig	Origin of crops	MinFert	Area on which mineral N-fertiliser is used
		NitroIn	Total nitrogen input
		FieldOp	Field operations
		PestUse	Pesticide use
		AvStock	Average stocking rate
		Graze	Grazing intensity

Appendix 2 – Adaptations to the classification system of crop habitats to take account of conditions in Uganda and Tunisia

The following GHCs have been defined to cover crop elements (from Bunce *et al.*, March 2011). An updated version of the GHCs was also provided by Alterra in May 2011 (see Figure) and we rely on this later version of the key here:

– **Cultivated bare ground (SPA):** elements with no crops planted or less than 30% cover of vegetation, including volunteers (self-seeded crop plants). Includes therefore only bare fallow or recently ploughed land.

– **Cultivated herbaceous crop (CRO):** includes both annual e.g. barley, fodder crops and sunflowers and perennials, e.g. Lucerne and sown clover.

– **Cultivated Perennial Herbaceous crops (PER):** Newly available in the Alterra key from May 2011

– **Cultivated woody crops (WOC):** includes all elements with cultivated trees or shrubs, e.g. orchards, vineyards and olive groves.

– ALL COMBINATIONS (The sequence above provides the precedence rules for combinations, e.g. SPA/CRO rather than CRO/SPA). The following combinations are possible: SPA/CRO, SPA/PER, SPA/WOC, CRO/PER, CRO/WOC, PER/WOC

The following adaptations were made in the BIOBIO project:

– **Cultivated herbaceous crop (CRO):**

→ *In the BioBio project this category was further subdivided into 4 crop categories in order to sample more crop habitats (see Dennis et al. 2012 and Herzog et al. 2012a). This was originally as follows:*

- Not entomophyllic and/or bee attracting *(CODES for FIELD 5 of the HABITAT RECORDING SHEET, (see Bunce et al., 2012 for further explanaitions of the habitat recording method)*
  - CAN1 (Winter crops – temperate, e.g. beans, winter oats)
  - CAN 2 (Spring crops – temperate, e.g. beans, spring oats)
- Entomophyllic and/or bee attracting *(CODES for FIELD 5 of the HABITAT RECORDING SHEET)*
  - CFL (applicable for both temperate/tropical environments, e.g. sunflower, rape)
- Perennials *(CODES for FIELD 5 of the HABITAT RECORDING SHEET)*
  - CFO (applicable for both temperate/tropical environments, e.g. forage crops

→*To take into account the tropical situation in Uganda we have added the following categories to the* **Not entomophyllic and/or bee attracting category***:*

  - CTR1 (Tall lignified crop – tropical, e.g. cassava, sugar cane)
  - CTR2 (Herbaceous – tropical, e.g. beans, yams)

→*According to the Alterra key from May 2011 the category CFO has been moved to* ***Cultivated Perennial Herbaceous crops (PER)*** and we have applied this to the ICPC countries. *We consider that it is applicable to both temperate and tropical environments and that it includes crops such as fodder crops and pineapple.*

– **Cultivated woody crops (WOC):** Cover cannot be used as a criterion to determine this GHC because of pruning in this category. Therefore the rule is that there should be at least 20 trees/shrubs per ha. Any vegetation cover, e.g. of annual species, below or beneath the woody crop, over 30% should be recorded with appropriate life forms in field five of the habitat mapping recording sheet.

→ *WOC is not defined by the percentage of the cover but by the number of trees per ha. This is a big difference to all other categories. We decided FOR THE SUPER-CATEGORY CROPS (CUL) to record WOC ALSO AS PART of the GHC column if the life form WOC covers at least >10 % in the field 5 of the habitat recording sheet.*

Assigning this rule, we give a high priority to WOC. However, this applies ONLY within the super-category CUL. Thus, if a habitat has =>70% of a GHC from another super-category, e.g. CHE (grasses) and less than 20 trees per hectare it would be classified as a grassland habitat and the WOC habitat would be recorded as a life form in field 5 and a percentage would be estimated. Thus, we used the following rules:

- >=70 % of a Crop GHC = a pure GHC, e.g. PER **//Unless there is at least 10 % woody crop, then the GHC becomes a combination, e.g. 10 % WOC and 90 % CRO = CRO/WOC. //**
- For non-woody crops combinations we followed the usual 60:40 rule, e.g. 60 % SPA and 40 % PER would give a GHC combination of SPA/PER
- >=70 % of a GHC from another super-category, e.g. CHE (grasses) and less than 20 trees per hectare would be classified as a grassland habitat and the WOC habitat would be recorded only as a life form in field 5 and a percentage would be estimated. If less than 10 % WOC the global qualifiers OPE (1-10 % trees) or SCA (<1 % trees) should be applied.

GHC Key provided by Alterra (May 2011):

Key to GHCs

- 1) If the element answers the definition of URBAN
  - Artificial (ART)
  - Urban Non-Vegetated (NON)
  - Urban vegetables (VEG)
  - Urban Herbaceous (GRA)
  - Urban Woody (TRE)
  - All possible combinations
- 2) If the element answers the definition of CROPS: (CUL)
  - Cultivated bare ground (SPA)
  - Cultivated Annual Herbaceous Crops (CRO)
  - Cultivated Perennial Herbaceous Crops (PER)
  - Woody/shrubby Crops (WOC)
    - Stem Rosette (WSR)
    - Bamboos (WBA)
    - Cauliferous (WCA)
    - Evergreen (WEV)
    - Deciduous (WDE)
    - Coniferous (WCO)
    - Cacti (WCA)
    - All feasible combinations
  - All possible combinations
- 3) If the element has over 70% bare ground: Sparsely Vegetated (SPA)
  - Sea (SEA)
  - Aquatic (AQU)
  - Ice and snow (ICE)
  - Bare Rocks (ROC) +
  - Boulders (BOU) +
  - Stones (STO) +
  - Gravel (GRV)
  - Sand (SAN)
  - Earth (EAR)
  - All possible combinations
- 4) If the element has over 30% tree/shrub: (TRS)
  - Dwarf Chamaephytes (DCH) <0.05m
    - Evergreen (EVR)
    - Deciduous (DEC)
    - Coniferous (CON)
    - Leaf succulents (LUS)
    - Cactae (CAC)
    - Non Leafy Evergreen (NLE)
    - All possible combinations
  - Shrubby Chamaephytes (SCH) 0.05-0.3m
    - Evergreen (EVR)
    - Bamboos (BAM)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Deciduous (DEC)
    - Coniferous (CON)
    - Cactae (CAC)
    - Stem succulents (SUC)
    - Leaf succulents (LUS)
    - Non Leafy Evergreen (NLE)
    - Summer Deciduous (SUM)
    - All feasible combinations
  - Low Phanerophytes (LPH) 0.3-0.6m
    - Evergreen (EVR)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Deciduous (DEC)
    - Coniferous (CON)
    - Cactae (CAC)
    - Stem succulents (SUC)
    - Leaf succulents (LUS)
    - Non Leafy Evergreen (NLE)
    - Summer Deciduous (SUM)
    - All feasible combinations
  - Mid Phanerophytes MPH 0.6-2m
    - Evergreen (EVR)
    - Bamboos (BAM)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Stem succulents (SUC)
    - Leaf succulents (LUS)
    - Deciduous (DEC)
    - Coniferous (CON)
    - Cactae (CAC)
    - Non Leafy Evergreen (NLE)
    - Summer Deciduous (SUM)
    - All feasible combinations
  - Tall Phanerophytes (TPH) 2-5m
    - Evergreen (EVR)
    - Bamboos (BAM)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Cactae (CAC)
    - Stem succulents (SUC)
    - Leaf succulents (LUS)
    - Deciduous (DEC)
    - Coniferous (CON)
    - + Non Leafy Evergreen (NLE)
    - Summer Deciduous (SUM)
    - All feasible combinations
  - Forest Phanerophytes (FPH) 5-30m
    - Evergreen (EVR)
    - Deciduous (DEC)
    - Bamboos (BAM)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Cactae (CAC)
    - Stem succulents (SUC)
    - Leaf succulents (LUS)
    - Buttress trees (BUT)
    - Coniferous (CON)
    - Non Leafy Evergreen (NLE)
    - Summer Deciduous (SUM)
    - All feasible combinations
  - Mega Phanerophytes (GPH) >40m
    - Evergreen (EVR)
    - + Stem Rosette (SRO)
    - + Cauliferous (CAU)
    - Buttress trees (BUT)
    - Deciduous (DEC)
    - Coniferous (CON)
    - Summer Deciduous (SUM)
    - All feasible combinations
- 5) If the element has less than 30% tree/shrub cover: herbaceous (HER)
  - Wet land
    - Submerged Hydrophytes (SHY)
    - Emergent Hydrophytes (EHY)
    - Heliophytes (HEL)
    - Floating Hydrophytes (FLO)
    - Floating leaves hydrophytes (LEA)
    - All possible combinations
  - Other herbaceous
    - Leafy Hemicryptophytes (LHE)
    - Caespitose Hemicryptophytes (CHE)
    - Tussock Caespitose Hemicryptophytes (TUS)
    - Deciduous Caespitose Hemicryptophytes (CAE)
    - Therophytes (THE)
    - Geophytes (GEO)
    - Herbaceous Chamaephytes (HCH)
    - Bryophytes (BRY)
    - Lichens (LIC)
    - All possible combinations

Appendix 3 – Further development of the BioBio Habitat Types to take into account of intercropping and the complexity of crop/woody crop habitats in Uganda and Tunisia

As was the case for the 12 European case studies, the BIOBIO habitat types take into account the life forms recorded in field 5 of the habitat mapping recording sheet. This is particularly pertinent for the super-category crops (CUL). This is because for cultivated herbaceous crops the GHC 'CRO' is applied in column two of the habitat mapping recording sheet but in field five is sub-divided further into different crop categories (CAN1, CAN2, CFL, CTR1, CTR2). These are counted as separate BIOBIO habitats types for species sampling and for the calculation of some habitat indicators.

The following adaptions were made to take account of the complexity of crop/woody crop habitats:

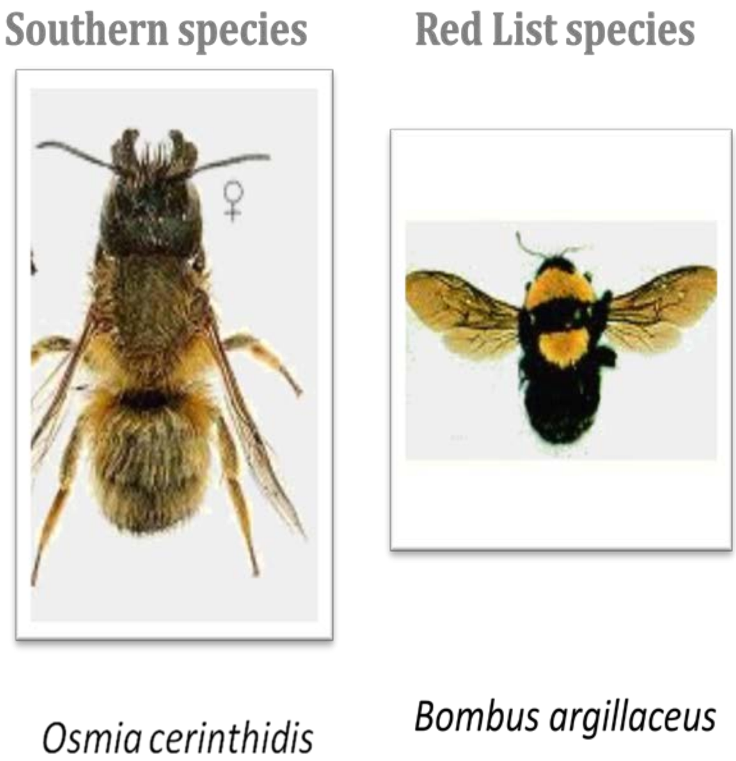
- Combinations of up to 3 GHC's in the crop category were allowed in order to account for the complex situations found in Uganda and partly Tunisia, e.g. CAN1/CFL, CTR1/CTR2/CFL. A combination is applied if more than one crop group occurs **and** the individual crop groups forming part of the combination have a cover of at least 30 % of the area covered by the life form CRO.
- Woody crops include the species name in the habitat type, e.g. WOC/BAN (woody crop banana) or WOC/COF (woody crop coffee).
- Where there is a mix of woody crops WOC/MIX is defined as the BioBio habitat type. This is applied if more than one woody crop species occur **and** woody species forming part of the combination have a cover of at least 30 % of the area covered by the life form WOC.
- If an understory(ies) beneath the WOC has a cover of more than 30 % it is mentioned in the BioBioHabtype as follows: e.g. CTR1_ WOC/COF, CFL_WOC/MIX, SPA_WOC/OLI.
- For the GHC, column two of the habitat mapping recording sheet, it is not possible to mix super-categories, however for the BIOBIO Habitat types we take account of the understory (ies) in the case of woody crops. For example, especially in Uganda, habitats can consist of a combination of trees or herbs and woody crops. In the GHC no mixture of super-categories is allowed. However in the BIOBIOHabtype it will be accounted for as follows, e.g. TRS_WOC/COF or HER_WOC/VIN. Only the super-category is mentioned, i.e. TRS (for trees) and not the individual GHCs from this category, e.g. MPH/DEC (Mid Phanerophytes, deciduous). This is to prevent the definition of numerous BIOBIO habitat types. A consequence of this rule is that it is possible to identify many more woody crop/intercropping habitat types. This is necessary especially in the case studies of Tunisia and Uganda where the combination of crops and woody crops can be very complex. It would have also been useful to apply this rule to the olive case study in Spain.

Appendix 4 – Examples of collected data and preliminary results of the basic analysis performed with habitat and species data from the ICPC case study regions

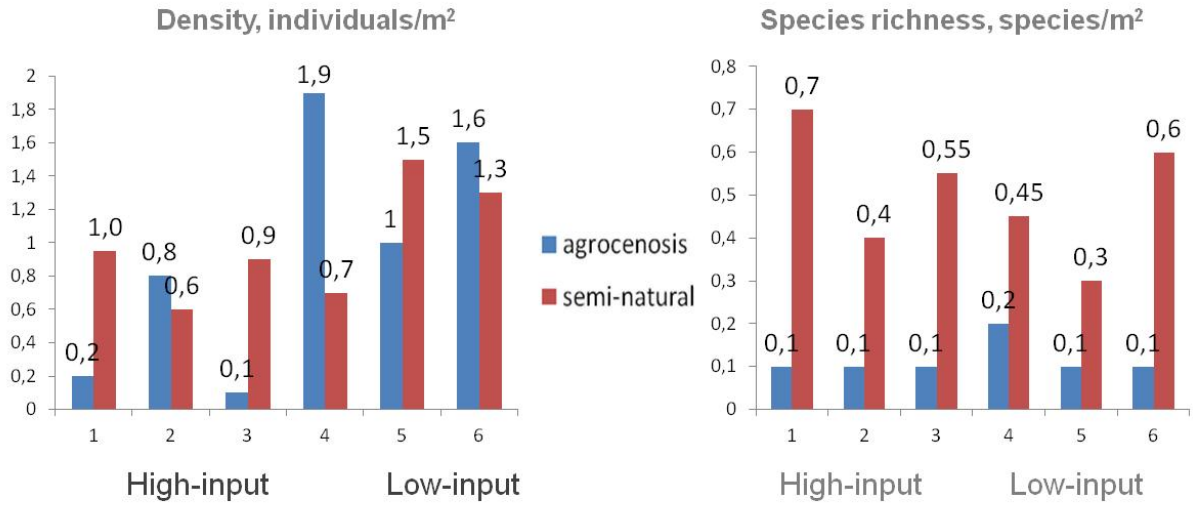
The following figures and tables show results for the ICPC case study data calculated by the ICPC partners. The statistics calculated may be different from the final BIOBIO standard indicators calculated by ART.
The two tables below show examples of calculations of landscape metrics and indicators in Ukraine.
The proportion of agrocenosis is the percentage of farm area covered by cultivated forage and food crops. The index of landscape mosaicity describes how homogeneous a landscape is. For a farm, it is calculated by dividing the number of all habitats of that farm by the farm area. The index of landscape diversity is the number of habitats per ha. It is calculated by dividing the number of different habitat types in a farm by the farm area.

CS farm	Proportion of agrocenosis, %	Proportion of semi-natural habitats, %	Index of landscape mosaicity $x10^{-3}$	Index of landscape diversity $x10^{-3}$
High-input farms				
1	92.73	6.14	19	1
2	92.96	5.82	22	5
3	90.10	6.17	3	1
$\bar{X}\pm S_{\bar{x}}$	**92±1.1**	**6±1.1**	**15±7.1**	**2±1.6**
Low-input farms				
4	85.65	11.81	5	2
5	90.48	8.05	3	1
6	82.76	13.73	26	3
$\bar{X}\pm S_{\bar{x}}$	**86±2.8**	**11±2.0**	**11±8.9**	**2±0.6**

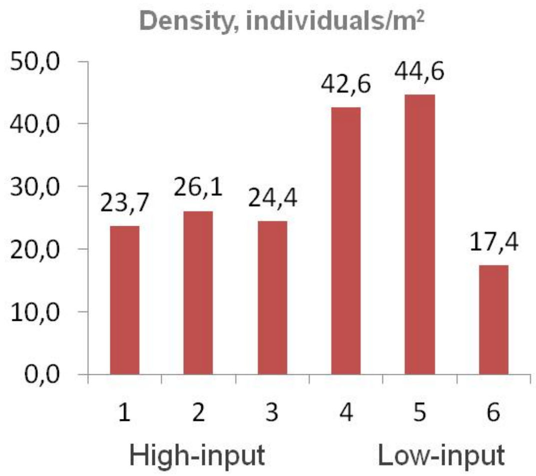
CS farm	Area of habitats, ha (in average)	Index of landscape mosaicity	Index of landscape diversity
High-input farms			
1	95,9	0,2	0,1
2	73,1	0,2	0,1
3	97,3	0,1	0,04
$\bar{X}\pm S_{\bar{x}}$	**89±9,6**	**0,2±0,03**	**0,1±0,02**
Low-input farms			
4	46,5	0,2	0,1
5	89,3	0,2	0,1
6	44,7	0,2	0,1
$\bar{X}\pm S_{\bar{x}}$	**60±17,9**	**0,2±0,01**	**0,1±0,01**

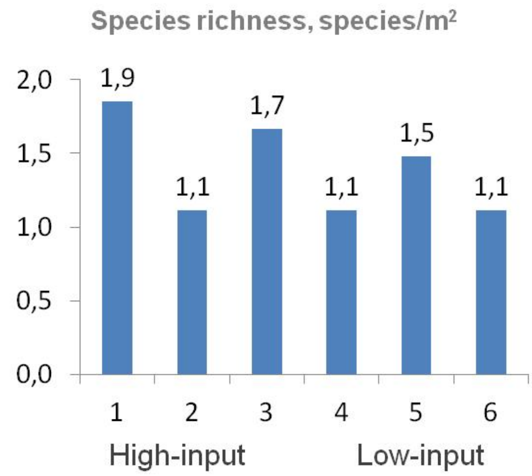


Photographs of bees found on Ukrainian farms.

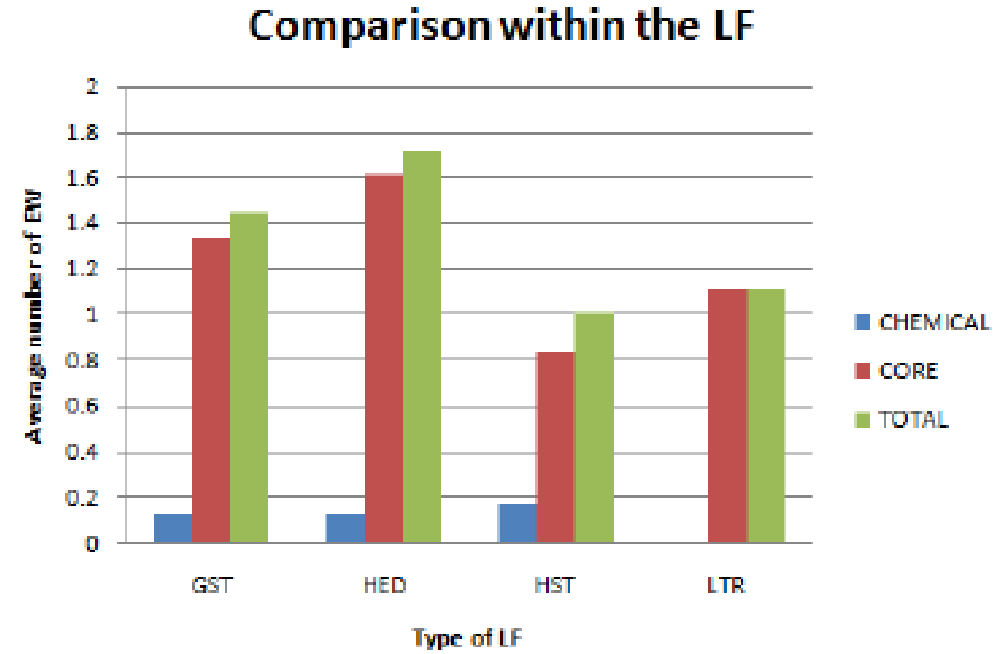


The two figures above show results of basic analysis for bees found on Ukrainian farms. On left hand: Number of bee individuals/m^2 found in cultivated forage and food crops (agrocenosis) (blue) and in semi-natural habitats (red) per farm. On right hand: Number of bee species/m^2 found in cultivated forage and food crops (agrocenosis) (blue) and in semi-natural habitats (red) per farm, 1 – 3 were high-input farms, 4 – 6 were low-input farms.





The two figures above show results of basic analysis for earthworms found on Ukrainian farms. On left hand: Number of earthworm individuals/m^2 found in farms (area is the whole farm). On right hand: Number of earthworm species/m^2 (area is the whole farm), 1 – 3 were high-input farms, 4 – 6 were low-input farms.



The figure above shows the average number of earthworms in Ugandan farms in linear elements for different extraction methods (LF = linear feature). GST = grass strip, HED = hedgerow, HST = herbaceous strip, LTR = line of trees. "Chemical" and "Core" mean average number caught with the application of AITC solution and by hand sorting, respectively (see Dennis *et al.* 2012).