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9 Conservation of oligotrophic grassland of high nature value (HNV) through sustainable use of *Arnica montana* in the Apuseni Mountains, Romania

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9 Conservation of oligotrophic grassland of high nature value (HNV) through sustainable use of *Arnica montana* in the Apuseni Mountains, Romania

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1. INTRODUCTION

During the last decades, the globalisation of markets has strongly influenced the prices of agricultural products and their position in the market, leading to changes in land use practices (Foley et al. 2005) and the transformation of landscapes (Fuchs et al. 2014, Fuchs et al. 2013). Fertile, high-yielding land underlies more and more intensification and specialisation for production, performed by agro-technical businesses instead of family farmsteads. Less productive or remote sites underlie abandonment and subsequent natural succession, or active reforestation. This has led to serious regional inequalities in living conditions, associated with an exodus from remote or mountainous rural regions towards urban areas (Figueiredo and Pereira 2011, Foggin 2008, McKinney 2002). In Europe, at least 30% of grasslands had been left abandoned, especially in the mountainous and Mediterranean areas (Peyraud and Peeters 2016). A side effect is that valuable habitats of the traditional cultural landscape become increasingly endangered (Emanuelsson 2009). A significant decline of semi-natural grassland of high nature value (HNV) has been observed in many places in Europe (Vaida et al. 2021, Tokarczyk 2018).

In Eastern European countries in transition, large agricultural and grassland areas were abandoned after 1989 (Peyraud and Peeters 2016). This affected oligotrophic hay meadows and extensively grazed pastures, which belong to the endangered key habitats in Europe. The agro-environment measures supported by the Common Agricultural Policy (CAP) of the European Union are not sufficient to maintain these habitats with their characteristic biodiversity (McGurn et al. 2017). The 2014 CAP reform strengthens low-input grasslands, but it is unlikely that the level of support is sufficient to reverse their overall decline (Luick and Roeder 2016).

There are strategies to counteract this, to maintain traditional landscape structures and to provide adequate livelihood for the people; for example, by designation of protected areas such as biosphere reserves, and establishing related payment opportunities for specific land uses. In some regions of the Carpathians, for example, the CAP measures have improved the management of semi-natural grasslands and their biodiversity (Rotar et al. 2020, Halada et al. 2017).

Another option is to promote further grassland ecosystem services besides the natural production for animal livestock (e.g., landscape beauty for tourism), nectar provision for pollinating insects, or providing medicinal plants. This requires innovative approaches built on ecology, economic potential and interactive social learning processes. All these are important elements in the effort

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of maintaining semi-natural mountainous grasslands in a sustainable way in the context of climate change, rural demographic changes and farm abandonment (Darnhofer et al. 2017).

In South-Eastern Europe, especially in Romania, traditional farming systems still exist, which include arable farming, animal husbandry and grassland management. Since 2007, when Romania became a member of the European Union, major structural changes to the economic and societal system were initiated. At the end of 2017, Romania had a population of 19.6 million people, of which 5.5 million were active employees, 9.1 million were pupils, students, pensioners or unemployed and approximately 5 million of the population had left the country to work abroad (Otovescu and Otovescu 2019). Particularly in rural regions receiving less allocation of direct payments for rural development, the exodus has been immense. This has led to a considerable socio-economic marginalisation of landscapes, in correlation to the agrarian production (Galluzzo 2018, Galluzzo 2017).

In Romania, there are still important large areas of oligotrophic grasslands of HNV, which are subject to traditional extensive management (Păcurar et al. 2020, Vîntu et al. 2011), totalling about 2 million ha (out of a total of 4.8 million ha grassland) (MADR 2022, pp 9–10). Our study aims to present the potentials – and difficulties – of further conservation of these habitats through sustainable management, and focuses on the perspective of using medicinal plants to enhance income and profit contribution.

2. *ARNICA MONTANA* – A FLAGSHIP SPECIES

Arnica montana is a perennial herbaceous plant of the Asteraceae family, which has been used as a herbal medicinal plant for centuries. The underground parts develop rootstocks (rhizomes); the hairy stem reaches 20–60 cm; the leaves are elliptical and lanceolate, opposite distributed and crowded on the base forming a rosette. The yellow-orange florets, with a delicate characteristic fragrance, result from 1–3 up to seven flower heads per stem with a diameter of 5–7 cm. The flowering period in Central Europe is between May and August, depending on geographical distribution and altitude. The morphology differs with respect to the habitat; it grows as a hemicryptophyte in grasslands and pastures, and becomes a tall forb on fallow ground (Titze et al. 2020, Radušiene and Labokas 2007, Schwabe 1990).

2.1. *Arnica montana* and its medicinal use

Arnica montana has been used for hundreds of years as a medicinal plant against rheumatic pains, skin inflammations, bruises and other complaints. Today it is one of the most commonly used phytotherapeutic (allopathic) and homeopathic medicines. The plant extracts have anti-bacterial, anti-tumour, anti-oxidant, anti-inflammatory, anti-fungal and immunomodulatory effects. In the different parts of the plant, a wide range of chemical compounds (150 therapeutically active substances) can be found, including sesquiterpene lactones and their short-chain carbonic acid esters, flavonoids, carotenoids, essential oils, diterpenes, arnidiol, pyrrolizidine alkaloids, coumarins, phenolic acids, lignans and oligosaccharides (Kriplani et al. 2017, Kos et al. 2005). The flower heads have greater medicinal value and are used as anti-phlogistic, inotropic, anti-biotic, anti-inflammatory, immunomodulatory, anti-platelet, uterotonic, anti-rheumatic and analgesic in febrile conditions (Oberbaum et al. 2005). *Arnica montana* can be used to obtain tinctures, creams, ointments, oils or gels or in the form of wet poultices consisting of a solution that has been valued for curing osteoarthritis, alopecia and chronic venous insufficiency (Clair 2010).

It has also been reported that decoction, infusion or macerated extracts of *Arnica montana* flowerheads, leaves or aboveground parts of the plant can be used for the treatment of numerous ailments such as bowel ache, cough, contusion, cuts, haematomas, headaches and rheumatism. It also has soothing and healing properties for the hair or skin (Kriplani et al. 2017). In addition, it

has been shown that the sesquiterpene lactones from flowers and roots of *Arnica montana* heal inflammations of the human body (Meyer and Straub 2011). In particular, the two components, helenalin and 11α, 13-dihydrohelenalin, are responsible for an increased potential medicinal effect (Lyss et al. 1997, Schröder et al. 1990). They inhibit the NF-κB transcription factor, which is necessary for the transcription of some immune-specific genes. Among other things, these genes are responsible for the synthesis of inflammatory cytokines, which trigger the inflammatory reaction with typical signs such as pain, heat, redness, swelling and loss of function.

2.2. *Arnica montana* and its habitat

Arnica montana is a temperate European plant species growing in grass- and heathlands, from lowlands near sea level up to alpine regions (Duwe et al. 2017). The species is mainly distributed in Central Europe (Hultén and Fries 1986), reaching to Scandinavia in the north, to Poland, Lithuania and southern Russia in the east, Belgium in the west and the Pyrenees, Portugal and Spain in the south (Meusel and Jäger 1992, Dapper 1987, Hegi 1987). Important arnica populations exist in south-eastern Europe, in Romania, Bulgaria, Serbia and Ukraine (Fig. 1). *Arnica montana* occurs in mountain grasslands on moderately acidic, nutrient-poor soils (Maurice et al. 2012, Michler 2005, Kahmen and Poschlod 2000, Luijten et al. 1996, Sugier et al. 2019), managed in a traditional way (Păcurar et al. 2009, Reif et al. 2008, Reif et al. 2005, Michler et al. 2005). These oligotrophic grasslands are rich in plant diversity and listed in Annex I of the Natura 2000-Program of the European Union as "*Nardus stricta* grasslands" (code R 6230) and "mountain hay meadows" (code R 6520). Their conservation is therefore of high public interest.

Arnica montana populations at lower altitudes are more threatened than those at higher altitudes (Duwe et al. 2017, Titze et al. 2020). The main reasons for their decline are: (1) the abandonment of mowing and grazing on low-productivity grasslands, followed by succession towards forest, and (2) agricultural intensification leading to eutrophication with the consequence of significant changes in species composition (Michler et al. 2005, Korneck et al. 1998, Korneck et al. 1996, Fukarek et al. 1978). The flowers are widely collected for domestic medicinal purpose and for commercial trade,

FIGURE 1 Oligotrophic grassland rich in *Arnica montana* – Apuseni Mountains/Romania – Photo © Arnica System.

which has been recognised as another threat factor (Korneck et al. 1998, Korneck et al. 1996), even though the harvesting impact on *Arnica montana* populations is not clear (Schippmann et al. 2002).

Although the arnica populations have declined significantly on a local level, they are still large on a global level. The decrease in population density has not yet led to a reduction in distribution areas. However, *Arnica montana* is a protected species in Europe, being listed in various categories of Red Lists depending on the country (e.g., as "endangered" in Romania, or "critically endangered" in the Netherlands). The species is listed in Annex V of the Nature 2000-Program – FFH directive (Council Directive 92/43/EEC). In the IUCN Red List, it is assessed as "of least concern" (Bilz et al. 2011).

3. *ARNICA MONTANA* – HABITAT PROTECTION THROUGH USE

In the Romanian Carpathians, the characteristic landscape is formed by forest areas and open lands dominated by grasslands. Grasslands are hardly subject to intensification, but many of them, especially in remote areas, are now threatened by abandonment or have already been abandoned (Maruşca 2016). Their continued existence depends on the management applied.

In the Apuseni Mountains, in the upper Arieş Valley, the local people (called 'moţi') have traditionally lived from subsistence production, including grassland management, livestock farming, forest exploitation and craft work as their livelihoods (Păcurar et al. 2014, Auch 2006). Their traditional land use system has created a landscape characterised by its peculiarity and typical biodiversity, which makes it a unique cultural landscape in Romania and Europe (Ruşdea et al. 2005). The open land is dominated by grassland, which is managed as meadow, pasture or in a mixed system. Since about 1995, serious changes in land use have taken place and are still ongoing. Farmers living in mountainous areas with a high proportion of HNV grasslands are most at risk in terms of economic vulnerability (Jitea and Arion 2015). Many people have left the Apuseni Mountains, and marginal-yield grassland sites in particular face abandonment and subsequent succession towards forests, despite the subsidies provided by the agro-environmental schemes of the CAP (through the Agency for Payments and Intervention in Agriculture – APIA). Therefore, other sources of enhancing income are needed to ensure the conservation of traditional landscapes and ecosystems.

A successful example of integrating the agricultural use of oligotrophic mountainous grassland with the harvesting of medicinal plants, in particular *Arnica montana*, with resource management and value-adding can be found in the Apuseni Mountains, Romania (Vaida et al. 2016).

3.1 Arnica System: From concept to practice

Arnica montana is an important plant species from a nature conservation and an economic point of view. In the Apuseni Mountains, it has been harvested from the wild for more than 50 years (Pop and Florescu 2008). Additional income for the local people can be generated by harvesting and processing medicinal plants, and specifically *Arnica montana*. This helps to counteract the emigration mainly of young people towards urban areas and foreign countries and increases the local people´s interest in maintaining their environment, which is traditionally managed oligotrophic grassland. These efforts are supported in the Apuseni Mountains by the company, *Arnica System*.

Arnica System is organised in the form of a company and goes back to the German-Romanian interdisciplinary research *Proiect Apuseni*, funded by the German Federal Ministry for Education and Research (BMBF) and located in the village of Gheţari, which belongs to the community of Gârda de Sus, Alba County. Between 2000 and 2004, the rural landscape, the land uses and perspectives for regional development were investigated. These studies provided the base for several trans-disciplinary implementation projects, including ecotourism, rural architecture, improved farming practices and sustainable use of medicinal plants for the benefit of biodiversity conservation

and welfare of the people (Ruşdea et al. 2005). From 2004 up to 2007, the collection of medicinal plants was professionalised and developed in the follow-up *Arnica Project*, funded by WWF-UK and the Darwin Foundation. It developed a management plan for the sustainable use and conservation of *Arnica montana* and initiated the co-operation of the Swiss-German company, Weleda (Michler et al. 2006). Until then, *Arnica montana* was collected in an unsystematical and unsustainable way, low quality was produced and a low purchase price was obtained for the harvesters (Kathe 2006, Michler 2005, Michler et al. 2004).

In 2007, a small local company named *Ecoherba* was founded in Gârda. From 2010 onwards, the activity of *Ecoherba* was extended also to the neighbouring communities from the northern and central parts of the Apuseni Mountains. In order to face these new challenges, a new company called *Bioflora Apuseni* was founded in 2010, which expanded the collection of *Arnica montana* to the northern Apuseni Mountains. These two companies have merged and are now working together as *Arnica System*, which implements the developed ideas and grown experiences. The vision of *Arnica System* is to preserve oligotrophic grasslands, often hay meadows, for the cultural landscape, for continued habitat tradition and biodiversity by providing additional income to the local people through the sustainable use and trade of medicinal plants. *Arnica System* has a close co-operation with the main beneficiary of the arnica plant material, the Weleda Company in Schwäbisch Gmünd, Germany – as well as with other beneficiaries; with universities (the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania and the Albert-Ludwigs University of Freiburg, Germany); with institutions for the preservation of natural resources (Apuseni Natural Park, Institute for Biological Research Cluj, Romania; National Agency for Environmental Protection, Romania; Commission for Natural Monuments, Romania); and with local administrations (13 communities from the Apuseni Mountains).

The study and activity area has increased since 2000, starting from a small area of 287 ha of grasslands with arnica in the transect area from Gârda de Sus up to the Plateau Gheţari-Poiana Călineasa (Michler 2005); it was then extended to the whole area of the Gârda de Sus community (87 km^2), where an area of 550 ha of oligotrophic grasslands with *Arnica montana* was identified (Michler 2007). And finally, the *Arnica System* extends the activity to an area of 13 communities in the central and northern part of the Apuseni Mountains (Gârda de Sus, Arieşeni, Scărişoara, Albac, Horea, Beliş, Călăţele, Mărgău, Săcuieu, Mărişel, Măguri-Răcătău, Băişoara, Râşca), covering 1,470 km^2, where the region of oligotrophic grasslands with *Arnica montana* ranges between 4,000 and 5,000 ha. Much of this area is located in the protected area of the Apuseni Natural Park.

From the socio-economic point of view, *Arnica System* today employs four people in permanent positions and 15–20 local people seasonally – for between one and two months during the arnica season – ensuring the stages of processing (checking, sorting, drying and packaging). In addition, the harvesters and collectors are paid according to the amount of arnica flowers collected. In 2015 and 2016, for example, about 550 people were involved in harvesting, most of them women, but recently the number of men has increased, mainly because the timber resources in the region have been plundered.

Another major direction in which *Arnica System* is constantly involved is the management of grassland spaces on its own property or on the property of others (locals, other companies), who want to implement a management system. Through these activities, *Arnica System* contributes to the restoration and reuse of abandoned meadows and provides the resources for the cultivation of the arnica species and at the same time, its maintenance in oligotrophic natural meadows.

The cultivation of *Arnica montana* species can – on the one hand – contribute to reducing the pressure on populations from spontaneous flora and – on the other hand – can be an important means of supplementing the income of the locals (Melero et al. 2012). It would reduce the harvesting pressure of the spontaneous flora because it would stabilise the purchase price and will encourage the locals to harvest from the culture rather than collecting from spontaneous flora.

3.2 Sustainable use of *Arnica montana*: Development and implementation

Arnica System has developed a model for the conservation of oligotrophic grasslands through the sustainable use of *Arnica montana*. The basic idea of this model is "protection through use" (Neitzke 2015). Given the current general conditions in the Apuseni Mountains, adding economic value to oligotrophic grasslands is essential for their conservation. This is all the more important considering that the use of wood, the main monetary resource of the area, has decreased significantly. The principle of *Arnica System* consists of a series of subsequent activities, including habitat characterisation and mapping, the collecting of arnica and other medicinal plants, as well as processing and selling without intermediaries (Fig. 2). The individual activities of this model are presented in more detail below.

3.2.1. Oligotrophic grasslands with *Arnica montana* and their management

In the Apuseni Mountains, the oligotrophic grasslands below the climatic treeline are the result of historical deforestation (Sângeorzan et al. 2018, Goia 2005, Goia and Borlan 2005, Reif et al. 2005). *Arnica montana* occurs in grassland types within a floristic and edaphic gradient from the nutrient-poor, oligotrophic Nardo-Callunetea (Violo declinatae-Nardetum) to the oligo-mesotrophic Molinio-Arrhenatheretea (*Festuca rubra-Agrostis capillaris*-community) (Gârda 2010, Brinkmann et al. 2009, Michler et al. 2005). *Arnica montana* can be considered a "flagship" species, which is associated with other species like *Polygala vulgaris*, *Gentianella lutescens*, *Scorzonera rosea*, *Hieracium aurantiacum*, *Viola declinata*, *Crocus heuffelianus*, *Gymnadenia conopsea* and *Traunsteinera globosa* (Stoie 2011).

The long-term traditional management of grasslands has created a great diversity of species and habitats (Brinkmann et al. 2009). The small-scale farmers live under difficult working conditions with a high proportion of subsistence production. They traditionally use hay meadows with autumnal after-grazing and permanent pasture near the villages. This system is linked to the grazing on the communal high mountain pasture during summer. Some of the hay meadows are fertilised with manure to increase production. In addition, the *Arnica montana* oligotrophic grasslands are used in this way through a combination of mowing and grazing (hay meadows), or only through grazing (permanent pastures).

Particularly rich in *Arnica montana* and associated species are the oligotrophic and extensively used hay meadows in the neighbourhood of farmsteads. On these grasslands the following maintenance measures are traditionally carried out: the removal of stones, the levelling of anthills, the removal of woody vegetation, weed control and fertilisation. All maintenance works are done manually, with different tools, and for the application of fertilisers, horse carts are used.

Mowing was traditionally carried out with a scythe, nowadays it is conducted with mowing machines; the start of mowing depends on the weather, but generally takes place between the end of June and the beginning of August (i.e., after the seed formation of *Arnica montana* and many other grassland species is completed). This traditional management requires the cooperation of many people and their horses. Afterwards, in late autumn, grazing with cattle and horses takes place.

Maintaining traditional management is crucial for the existence and conservation of oligotrophic grasslands, since already minor changes can shift the species composition. Only manure from cows and horses with a six-months deposition is used for fertilisation in small quantities. Fertilisation with an amount of 10 t/ha manure per year causes *Arnica montana* and other oligotrophic species to disappear (Bogdan 2012). Heavy permanent overgrazing also leads to species depletion (Reif et al. 2005).

3.2.2. Approvals for harvesting

Arnica montana is a European threatened species (Coldea et al. 2003), listed in Annex 5 of the EU-FFH-directive (Council directive 92/43/EEC), and is additionally protected by national laws (Sugier

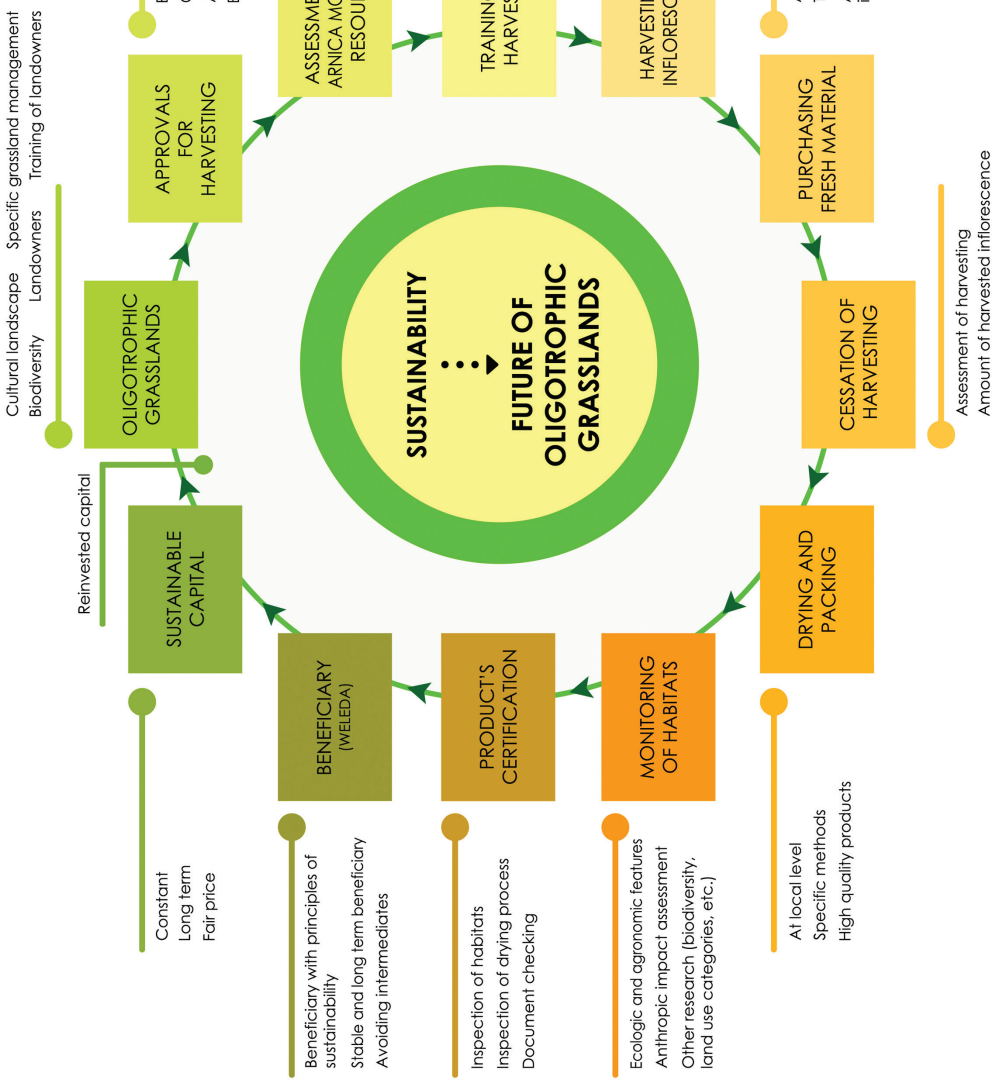

FIGURE 2 Model for sustainable use of *Arnica montana* in the Apuseni Mountains.

et al. 2018). Its harvesting is prohibited except in certain regions in Spain (Obon et al. 2012) and Romania, where arnica was assessed as vulnerable (Oltean et al. 1994). In Romania, the harvesting of arnica flowers is legal but requires an official authorisation from the state institutions according to the Governmental Decree no. 647 from 26.07.2001. The harvestable quantity of arnica flower heads is assessed by the Institute of Biological Research in Cluj-Napoca, and the evaluating study must be approved by the Commission for Natural Monuments of the Romanian Academy, the Agency for Environmental Protection and the Administration of protected areas, in this case the Apuseni Natural Park.

3.2.3. Assessment of the resource

In order to establish the potential and sustainable yield, various biological features and parameters of *Arnica montana* are recorded (see also section 3.2.7. Monitoring and research). This is also important for the development of models for forecasting the harvest quantity. Based on indicators recorded in early spring (April to May), the possible arnica quantity of the coming season can be estimated, which represents an essential basis for the negotiations with customers on the potential quantity of arnica to be supplied.

The monitoring carried out annually reveals information about the resource of flower heads and harvesting methods and management can therefore be optimised.

3.2.4. Participatory approach: training of harvesters

Before harvesting, the harvesters have to be trained in sustainable harvesting methods (Williams and Kepe 2008). *Arnica System* works with harvesters, landowners, collectors (purchasers), seasonal workers and permanent employees. Specific training is carried out for each group depending on the job activity required. Training for the harvesters and landowners is conducted annually before the start of the harvesting season. The materials used in the training are the "Harvesting Guidelines Manual" (Michler 2007) and the Guidelines for management of *Arnica montana* habitats (Michler 2007), as well as posters, flyers, leaflets and presentations concerning the biology and ecology of arnica.

Landowners are informed of and encouraged to apply a traditional management regime on arnica grasslands (Păcurar et al. 2008). Of importance are the control and removal of woody vegetation and fertilisation with small manure quantities (6–10 t/ha), which should be applied every 2–3 years. The grasslands must be mown, beginning at the end of June when arnica has mature seeds. The grass should be spread on the ground for drying, which promotes the dispersal of seeds from the herbaceous plants. In autumn, after-grazing is recommended, beginning when the sward is 8–10 cm high, and ending three weeks before the first frost is expected (Păcurar et al. 2009).

The manuals and posters used for training harvesters and collectors (Fig. 3) demand the following measures: "*Distinction between flowers of arnica and similar species*, *harvesting flower heads only under dry weather conditions, using the textile bags they get from the sourcing team, picking only the full blooming flower heads, picking flower heads without stem, leaving buds, leaving flower heads for seed production, delivering the flower heads in textile bags immediately after picking to the collection points where quality is checked"* (Michler 2007).

3.2.5. Harvesting and purchasing of arnica

Harvesting and collecting *Arnica montana* flower heads involves several stages (Fig. 4), playing a decisive role in obtaining a good-quality final product. The locals collect arnica partly from their own land, partly from other landowners' grasslands. To obtain raw material of good quality, the harvesting is done in sunny and dry weather conditions, in the morning after the dew has evaporated. Only fully developed flowers without peduncles are collected and visually checked for quality (e.g., bloomed flowers or buds are not accepted). It is recommended to leave at least one flower head per plant to ensure seed production and further propagation.

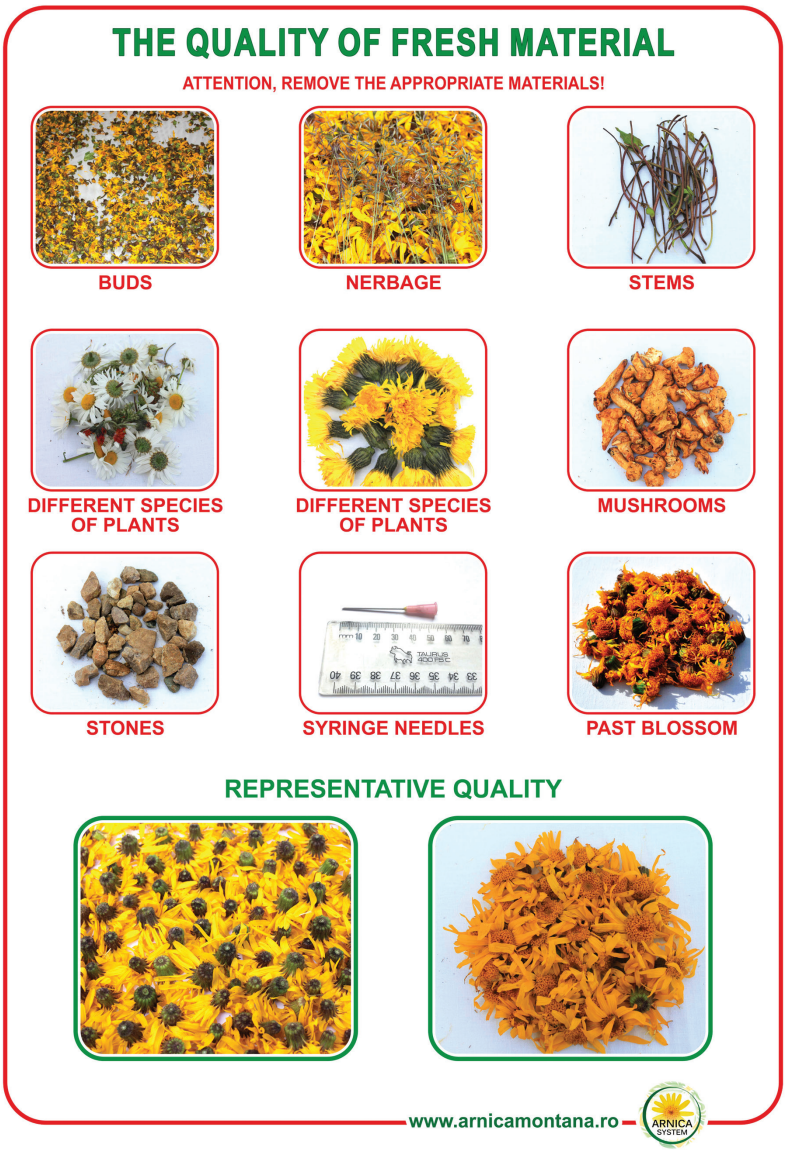

FIGURE 3 Poster regarding the quality of *Arnica montana* fresh material used in the trainings.

The fresh material is stored in textile bags that allow air ventilation and keep the bulk of the flower heads cool. The full bags are delivered to nearby collecting points, where the flower heads are once more visually inspected for quality, sorted and weighed. *Arnica System* has 17 acquisition points in the 13 communities mentioned. The fresh material is transported on the same day to the drying facility located in the village of Ghețari. From remote regions, the transport is done by cooling cars, where a constant temperature of 4°C is maintained. Harvesting and collecting under hygienic conditions is the premise for obtaining a dried product of highest quality (Dugalić 2003).

The entire harvesting process lasts between 5 and 18 days (on average, 10.9 days) and starts regionally at different times, depending on altitude and weather conditions. The harvesting activity takes between 4 and 7 hours per day (on average, 5.7 hours/day). In an average family, about two people are engaged in collecting arnica flower heads. From interviews, we know that a harvester

FIGURE 4 *Arnica montana* processing activities.

can collect on average 1.1 kg of fresh flower heads per hour, and between 40 and 200 kg of fresh material in a whole season (Fig. 5). The income generated by harvesting lies between 5 and 10% (7% average) of the total annual family income. The income contribution varies from year to year depending on the arnica purchase price (see also chapter 3.2.8. Marketing).

Harvesting also generates additional income for other people besides the harvesters (e.g., collectors, who ensure the acquisition of flower heads at the collecting points). The processing of fresh material in the drying facility also generates an income for the seasonal workers (15–20 people hired for 1–2 months per year), accounting for between 15–20% of the total family annual income. The four permanent employees of the company earn between 50% and 100% of their total family income per year.

Further observations will reveal more information regarding the impact of harvesting and collecting of arnica in the socio-economic context.

3.2.6. Development of processing and drying

The processing of the fresh arnica material guarantees the preservation of volatile oils and lactones without affecting the specific smell of the flower. A specifically designed drying and storage facility

FIGURE 5 Harvesting of *Arnica montana* flower heads at Hănăşeşti in the Apuseni Mountains – Photo © Arnica System.

planned by Architecture for Humanity, UK was constructed in 2006 during the *Arnica Project* (Michler 2007). This wooden building was relatively small and designed with the aim of providing simple and practical solutions for a local catchment area, which suffers from poor access to paved roads and a water supply. It included a built-in dryer with shelves for the drying process and a heating system based on firewood. The development of this on-site drying facility with local value-adding was a requirement for establishing business relationships.

With the improvement of transport conditions, the harvesting area and the quantity of harvested flower heads increased and, consequently, a higher drying capacity was needed. To face the new challenges, the existing drying facility was modified in 2011, the building was enlarged and the capacity improved considerably (Table 1). The quality control was enhanced on different levels and the quality of the product has increased significantly (Fig. 6). Under the framework of *Arnica System*, a detailed documentation of the drying process parameters was implemented.

3.2.7. Monitoring and research

Monitoring of the arnica population and its habitats is essential for assessing the long-term effects of harvesting on the arnica flower heads as a resource. The presence of *Arnica montana* and the resource of flower heads on a specific site is the result of a dynamic process of: (1) growing conditions (e.g., soil, micro-climate, water availability); (2) management activities (including absence of management and abandonment); and (3) harvesting activities.

Our goal is to study certain biological features of *Arnica montana* species and to assess the flower heads resource in order to establish the potential and sustainable yield and, respectively, to optimise the harvesting method.

The monitoring focuses on documenting the status of the arnica populations, and of the habitat (species composition and grassland management) and must be repeated annually.

FIGURE 6 Quality control of fresh arnica flowers heads in the drying facility at Gheţari in the Apuseni Mountains – Photo © Arnica System.

TABLE 1
Development of the drying system in Gheţari – Apuseni Mountains.

Drying process *Arnica project* (2006)	Drying process *Arnica System* (from 2011)
Construction of the drying facility in 2006, consisting of three rooms: reception, drying room and storage; Total usable area of 156 m^2.	Enlargement of the existing drying facility in 2011, consisting now of five rooms: reception, drying, sorting-packing, storage and heating room; Total usable area of 254 m^2
Reception room of 18 m^2 for receiving the fresh plant material and weighing.	Enlarged reception room to 35 m^2, additionally space for sorting and careful quality control on special tables.
Drying room with a single drying tunnel (10 m long, 6 m wide, 3 m high) provided with fixed shelves, where the drying racks with frames were placed, the distance between frames being 12–15 cm; a corridor of 2 m width in the middle was left for handling the drying frames; the heating generators were inside the drying room; Total drying surface on the frames is 240 m^2.	Drying room has been divided into three drying tunnels (each 10 m long, 2 m wide, 2 m high); every tunnel contains nine mobile trolleys with 27 drying frames each, the distance between frames being 3 cm; one-way workflow: the trolleys enter the drying room from the reception side and leave on the opposite side towards the sorting and packing room; the heating generators are in a separate room; Total drying surface on the frames is 1,458 m^2.
During the drying process the workers are in contact too frequently with arnica flower heads (shaking material on the frames and manual packaging).	The arnica material is placed on the mobile trolleys and no further manual handling is required and therefore proper hygiene is guaranteed.

TABLE 1 (Continued)
Development of the drying system in Gheţari – Apuseni Mountains.

Drying process *Arnica project* (2006)	Drying process *Arnica System* (from 2011)
Weak ventilation inside the drying room: the four ventilators have a performance of up to 256 m^3/hour each, resulting in a drying capacity of 1,024 m^3/hour related to 180 m^3 dryer volum (but in connection to a small drying surface of 240 m^2 on the frames).	Ventilation has been increased using ventilators with high performance of 8,000 m^3/hour per tunnel, resulting in a drying capacity of 24,000 m^3/hour related to 120 m^3 dryer volum (but in connection to a bigger drying surface of 1,458 m^2 on the frames).
Lack of moisture release due to the poor performance of the dryer.	Humidity is better removed with additional 9 fans of 2,500 m^3/hour each.
Absence of a quality control point after drying.	With the new quality check after drying (in the sorting-packing room), the product's quality has increased significantly.
Absence of a dry material sorting-packaging room.	Packing directly in large paper bags in the sorting-packing room by using a large funnel.
The dried and packed material is manually transported through the reception room (on a narrow staircase) to the storage room upstairs.	The dried and packed material is transported by means of an elevator directly from the sorting-packing room to the storage room upstairs.
Heating system with two small heat generators (with a heating power of 16 kWh each) could provide a temperature of 20–35 ℃.	Two new more powerful heat generators were introduced (with a heating power of 93 kWh each) enable the necessary temperature of 40–44 ℃ and 45% air humidity.
High consumption of firewood for heating; e.g. in 2008 12 m^3 of beech wood were used for drying 3,100 kg fresh arnica flower heads, meaning 4 m^3 wood needed for 1,000 kg of dried arnica.	Reduced firewood consumption; e.g. in 2017 30 m^3 of beech wood were consumed for drying 33,600 kg of fresh material, meaning 0,89 m^3 wood for 1,000 kg dried arnica.
Controlling of temperature and air humidity was done manually and was time-consuming.	Temperature and air humidity are measured automatically every 15 minutes; the drying system is regulated according to these data.
Drying duration of a batch took between 4-6 days (Morea and Michler 2008).	Drying duration of a batch is considerably reduced, ranging from 16 to 20 hours.
Drying capacity was limited: in 2008 the maximum drying capacity was 3,100 kg fresh arnica although more fresh flower heads could be available.	Drying capacity has increased considerably; e.g. in 2017, 33,600 kg fresh arnica flower heads were dried.

Currently, the monitoring activities are only carried out in the perimeter of the Gârda de Sus community. The entire area where monitoring is performed covers 183.5 ha, representing 33.3% out of the total area of arnica habitats (550 ha) in the Gârda community. In the future, this activity will be extended to the areas of the other communities, but this will require new and more efficient monitoring methods.

Biological parameters like number of rosettes, number of flowering stems per rosette, number of flower heads per stem, as well as agronomic parameters are recorded (i.e., the number of stems harvested totally, or harvested partially, or remaining unharvested). The methodology was initiated during the *Apuseni Project* (Michler 2005) and the *Arnica Project* (Michler 2007). *Arnica System* adapted the methodology after 2007; the parameters used for monitoring being the relation between harvest potential and harvest rate. This provides basic information on the density of arnica flower heads and the population size in the study area.

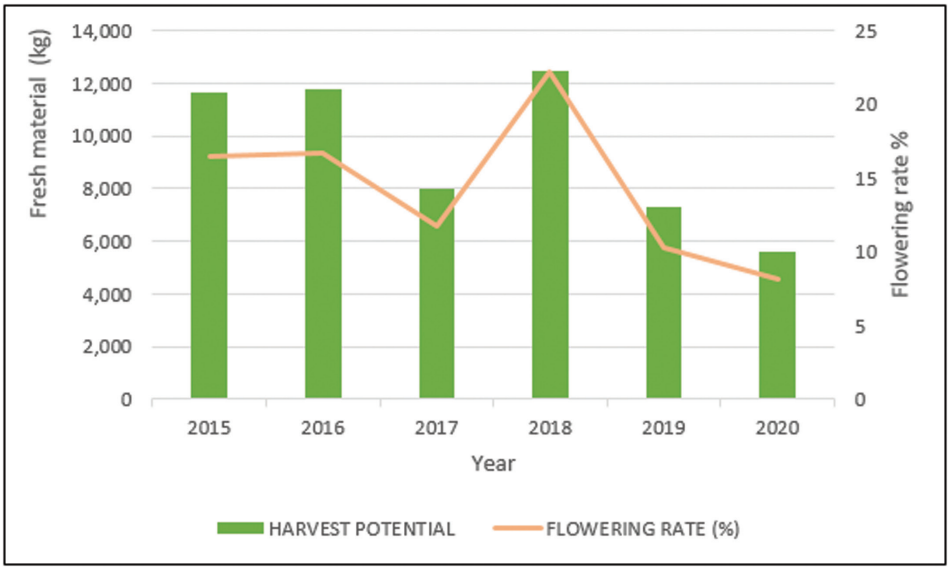

FIGURE 7 Flowering rate and harvest potential of *Arnica montana* for Gârda de Sus community

Annual monitoring reports are prepared providing important information for future harvesting planning, including the development of harvested arnica populations.

The flowering rate is one of the most important characteristics, having a decisive role in planning the harvest. Therefore, the number of flowering and the number of non-flowering rosettes is counted in transects on selected sites. The flowering rate is determined as the number of flowering rosettes divided by the total number of rosettes (sum of flowering and non-flowering rosettes) (Michler 2007).

However, the flowering intensity of arnica is subject to large fluctuations between different years (Fig. 7). For example, the flowering rate in the area of the Gârda de Sus community varied greatly in the period between 2015 and 2020, registering the lowest flowering rate in 2020 (8.12%), and the highest in 2018 (22.24%), depending on weather conditions. From our experience, flowering appears to be most intensive after a snow-rich winter period and under wet weather conditions during the vegetation period.

The total harvest potential, meaning the maximum amount of flower heads that could be harvested (calculated on the basis of our monitoring data), varied accordingly, with a minimum value of 5,578 kg (in 2020) and a maximum of 12,457 kg (in 2018) of calculated green mass flower heads (Fig. 7).

Harvesting does not mean picking all flower heads of a population; on the contrary, it is recommended to harvest a maximum of half of the flower heads on the stem and to leave the rest for seed production (Michler 2007). The harvest rate is represented by the difference between the number of harvested flower heads and the total number of flower heads expressed as a percentage (Fig. 8). Within the area of the Gârda de Sus community, the highest harvest rate was recorded in 2019 (64%), and the lowest values were registered in 2015 and 2020 (47%). The results show that a large part of flower heads remain unharvested, contributing to species conservation, being an effect of the annually applied training for harvesters, collectors and landowners as part of the participatory approach.

In several studies, it is claimed that harvesting is a threat to the arnica populations (Korneck et al. 1998). Therefore, about 50% of the arnica flower heads remain unharvested to keep the population in good condition. This is debatable because these claims are based on observations, and not on

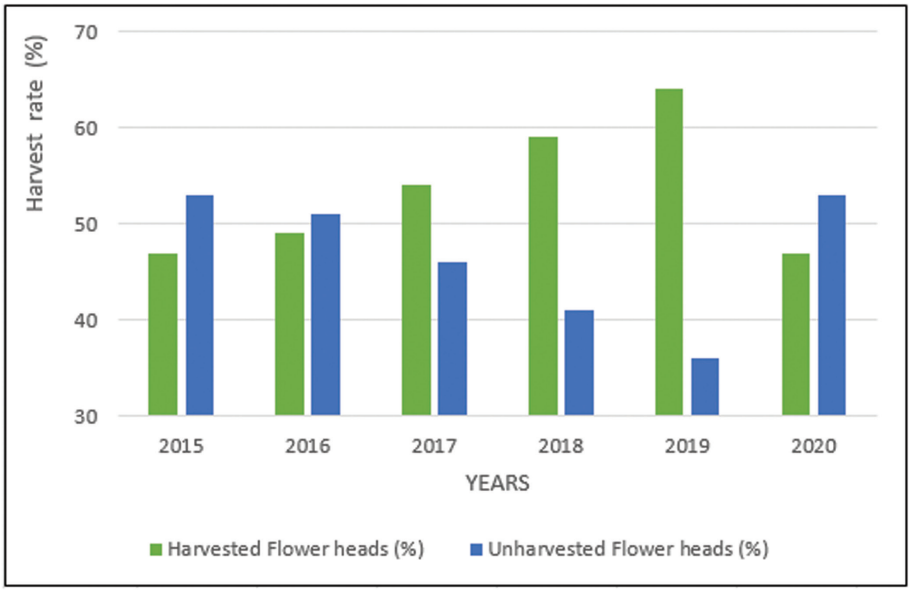

FIGURE 8 Harvest rates of *Arnica montana* species for the community of Gârda de Sus.

experiments. In mountainous regions, *Arnica montana* reproduces more vegetatively and less by sexual reproduction (Maurice et al. 2012).

From our experience, it is not overharvesting but habitat loss that is a much more pressing issue. Populations can be threatened very quickly due to several influences, such as nitrogen enrichment from the atmosphere (Dupré et al. 2010), which promotes the vitality of grasses as a superior competitor to *Arnica montana* (Sugier et al. 2018, Maurice et al. 2012). Other threats are permanent overgrazing or abandonment and successional spreading of *Vaccinium myrtillus* (Mardari et al. 2015).

3.2.8 Marketing

The final product, the dried *Arnica montana* flower heads, are packed in paper bags and prepared with all valid export permits to be sold on the international market. The product offered is certified organic and of the highest quality, which guarantees continuity in business relations with customers. Large quantities of the dried arnica flower heads are sold to the Weleda company from Schwäbisch Gmünd, Germany. Weleda, the main beneficiary, is open to supporting *Arnica System*'s vision and the sustainable use of *Arnica montana* grasslands.

Before establishing the cooperation with Weleda, the harvesters of the region received a price of 0.50 €/kg, for example for fresh material from different buyers in 2002 (Michler 2005). In the meantime prices have risen. The fair and favourable price offered by Weleda allowed a continuous increase in the purchase price of fresh arnica flower heads (Fig. 9). In 2015, the purchase price for fresh material was 2.28 €/kg and reached the amount of 6.61 €/kg in 2020. In 2021, we faced an unexpected situation: the price for fresh arnica flower heads had doubled because of a particularly high demand on the market and, consequently, high competition between many buyers and commercial traders. The contribution of arnica harvesting to the annual family income of harvesters was accordingly higher.

The *Arnica montana* supply chain is buyer-driven; the main and constant beneficiary is the company, Weleda. In the meantime, *Arnica System* also established cooperations with other trading partners and in addition the range of products has been diversified. The products are sold directly to the beneficiary companies without any intermediate purchaser.

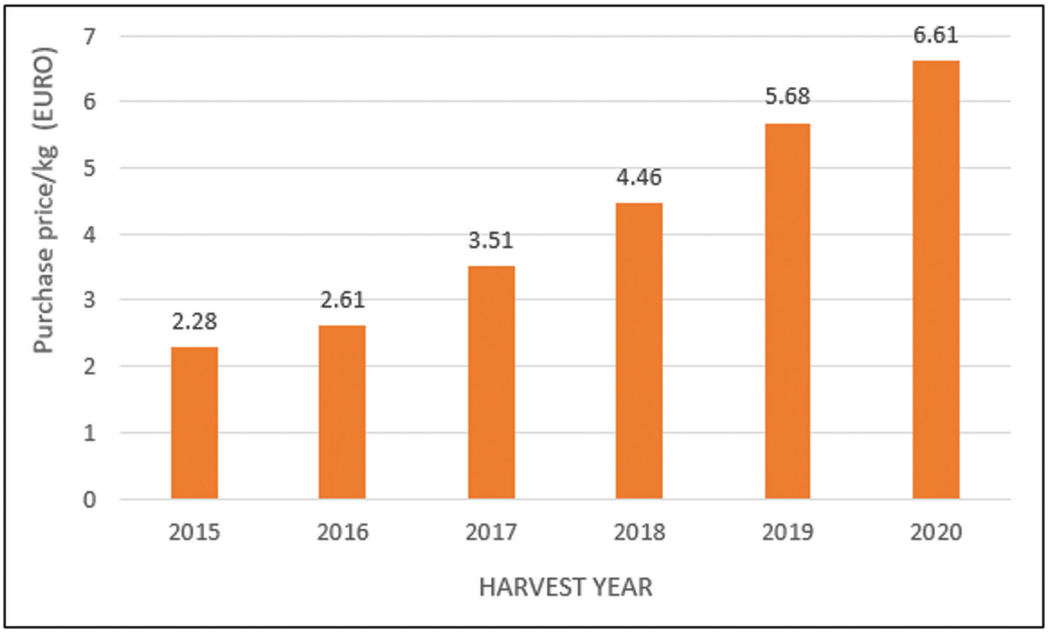

FIGURE 9 Evolution of purchase price for fresh *Arnica montana* flower heads.

In order to encourage sustainable use and create an incentive to continue the management of oligotrophic grasslands, it is important to pay a higher and fair price for fresh arnica flower heads. This higher market price entails the promise of high quality, organic certification and sustainable harvesting and could be a stable contribution to annual family incomes.

3.2.9. Product certification

Certificates support the certified product economically and contribute to a social and environmental balance (Bhattacharyya et al. 2009). Certification of medicinal and aromatic plants (MAP) supports the enterprise by reducing the risk of recalls and rejections, by enhancing the confidence of buyers and by assuring compliance with all legal requriements (Kala 2015). Such certification of plant resources collected from the wild entails an independent assessment to guarantee sustainable management. If a company imports natural products as raw materials, they should be sure to refer to a reliable supply chain in terms of harvesting, cultivation and importation for the seamless supply of authorised medicines (Ahn 2017). Nowadays, certification of medicinal and aromatic plants is becoming more important, because both traders and consumers demand certified goods of high quality.

The quality of the dried material from the Apuseni Mountains is checked by the beneficiary Weleda. The quality is corresponding to the International Specification Raw Material (Dried Drug) *Arnica montana*, Flos sicc., organic (NOC), conform with the European Pharmacopoeia, monograph 1391 on *Arnicae flos*, the International Specification on Herbal Drugs and the National Testing Instruction (current versions).

For the organic certification of its products, *Arnica System* co-operates with the control and certification organisation, ECOINSPECT SRL, from Cluj-Napoca (identification code RO-ECO-008 according to RENAR), which is accredited and acknowledged by the Ministry for Agriculture and Rural Development (www.ecoinspect.ro). The certification includes the control of all processing documentation in the office and a field visit to verify the status of habitats and other economic or

social processes. Certification of the final organic product – dried arnica flower heads – consists of the following steps: certification of suitability of the arnica habitat and the harvesting yield; and certification of the harvesting method, of collecting, transport, sorting, drying, packing and storage of arnica flower heads, including marketing. For each of these activities, *Arnica System* provides the ECOINSPECT Certification Company with all necessary documentation. As a result of the certification process, a control report is issued and the "Certificate of Conformity" with annexes is released.

3.2.10. Reinvested capital

A special characteristic of *Arnica System* is the reinvestment of capital for ecological, social and economic issues. The profit from the system varied between 11.1% and 28.1% of the turnover, with a decreasing trend (Fig. 10). The reason for this decrease is that the purchase price offered to local harvesters and collectors is constantly increasing due to business competition between different traders on the arnica market. Every year, nearly the entire profit, sometimes even more than that, is reinvested in the region – and not skimmed off by shareholders as in typical corporate business models – to promote the sustainable use of the species *Arnica montana*.

From an ecological point of view, the capital is invested in research activities (monitoring and evaluation of the resource and the habitat); in scientific experiments (impact of harvesting on arnica populations); in activities for the maintenance of grassland management, in restoration and the use of abandoned grasslands; in the cultivation of arnica and/or in training the landowners in the sustainable management of their grasslands. Most recently, *Arnica System* co-financed the acquisition of two drones for monitoring the arnica habitats and the sustainable harvesting of flower heads. The corresponding methodology is being developed in an ongoing implementation project funded by the DBU (Deutsche Bundesstiftung Umwelt) from Germany.

From a social perspective, the capital was invested in the creation of seasonal (15–20 people) and permanent (four people) job positions. Employment of local people counteracts emigration and offers employment opportunities for the locals, including young adults.

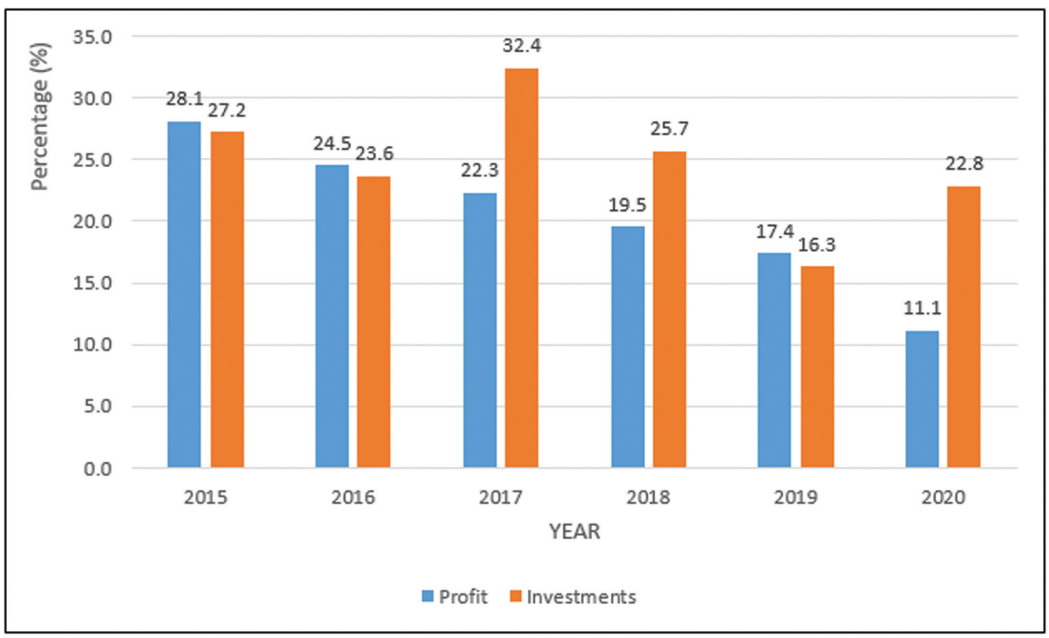

FIGURE 10 'Arnica System' annual level of profit and investments (expressed in % of the turnover).

From an economic point of view, *Arnica System* has invested in facilities and infrastructure; in the establishment of 17 seasonal collecting points distributed in the region; in the purchase of refrigerated transport vehicles; in off-road vehicles for transport in remote areas; in the aquisition of a warehouse with controlled temperature including a cooling chamber; in the modernisation of the drying and packaging system; and in equipment for grassland management (professional mulcher and mowing machine). Another issue concerns providing resources for the cultivation of additional arnica, which will reduce the harvesting pressure on collecting from the wild.

3.3. Perspectives

Sustainable production must be based on resource assessment, habitat monitoring, habitat management monitoring, monitoring of harvesting guidelines and quotas and quality control at different levels ensuring high quality and thus a fair price. Harvesters of arnica flower heads and landowners of oligotrophic grasslands with arnica are integrated into the process through the participatory approach, with annual training on sustainable harvesting and sustainable management of the grassland. The business is clearly linked to the revenue and profit generated. If the revenues of the arnica business do not cover the costs and no profit is generated with sustainable use of the arnica, the locals would be inclined to concentrate solely on collecting arnica and give up the management of habitats. If the resource declines due to habitat loss, abandonment or reforestation, the remaining resource will be overexploited (Michler 2007).

Increasing the purchase price of fresh *Arnica montana* flower heads is not a promising solution for the reason that many local people would not follow the principles of sustainable harvest. Instead, emphasis should be given on supporting the management of the still-existing arnica habitats. Some authors recommend the cultivation of *Arnica montana* to reduce the over-use of flower heads resources (Sand 2015, Pljevljakušić et al. 2014, Sugier et al. 2013). The risk of this strategy is that local farmers would try to cultivate arnica and stop harvesting from the wild and consequently, the interest in the management of HNV grassland would decrease. Instead, a combined system (conservation of oligotrophic grasslands and crop compensation) regulated through contractual conditions could be a sustainable solution for the future.

Management of oligotrophic grasslands is essential for the conservation of cultural landscapes and their biodiversity. However, this is under severe pressure, as payments provided by CAP compensation are not sufficient to preserve the oligotrophic grasslands. Additional income for rural households must be generated by the harvesting and selling of arnica flower heads, whilst the added economic value of processing them into a local product contributes to the maintenance of the HNV grassland.

Increasing the intrinsic interest of local people in maintaining oligotrophic grasslands is the key factor for the conservation of these mountainous landscapes in the future (Fig. 11). This has also been described for other regions with endangered grassland communities (e.g., from British grasslands where local people are acknowledged and play an important role in traditional management) (Blakesley & Buckley 2016). In Romania, successful models for the sustainable use of natural resources are rare (Drăgulănescu and Drăgulănescu 2013). The business model developed by *Arnica System* over almost 20 years is based on transparency, sustainability and fairness and takes into account environmental, economic and social concerns.

4. CONCLUSIONS

The presence of oligotrophic grasslands and the harvesting of *Arnica montana* from the wild is, and will continue to be, important for the Apuseni Mountains region. The creation of local revenue and value adding is an important premise for the stability and balance of the area. The sustainable use of oligotrophic grasslands in the Apuseni Mountains contributes to the living standard of the people and to the preservation of the grasslands and their traditional management techniques.

FIGURE 11 Traditional cultural landscape with oligotrophic grassland (Ocoale Plateau in the Apuseni Mountains) – Photo © Arnica System.

Arnica System has developed a model for the maintainance of HNV oligotrophic grasslands and conservation of traditional cultural landscapes in the Apuseni Mountains through the sustainable production and trade of the flagship species *Arnica montana*. The model shows how incentives and capacities can be created for the conservation of species-rich, traditionally managed habitats and landscapes containing medicinal plants.

Principles and lessons learnt from this case study can be transferred to other regions (e.g., to arnica habitats on other sites in Romania or in other European countries), or to other medicinal plant species in Europe and the rest of the world.

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