Czech University of Life Sciences Prague

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Bachelor thesis

Economic potential of neglected and underutilised plant species: A review

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Declaration

I hereby declare that this thesis entitled "Economic potential of neglected and underutilised plant species: A review" is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague-Suchdol, 20th of April 2017

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Kateřina Šrámková

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Abstract

World crop production depends on a few major crops. The minor species so-called neglected and underutilized crop species (NUS) have been overlooked by the world economy, despite the fact they have great potential for improving food security, balanced diets, income of rural households and preserving agro-ecosystems in changing climate conditions. Aim of this review was to analyse available scientific literature dealing with NUS species with specific focus on socio-economic aspects of studies to recommend sources and goals for further research. Thompson Reuters ISI Web of Science database and its tools were exclusively used for the purpose of the research. Studies were assessed according to number of quotations, scope of the data collection methodology and evaluations of journals. Based on analysis of abstracts, keywords and titles of the articles were found nine studies dealing with economic potential out of the total of 360 considered articles. Their closer analysis highlighted with coincided the articles, what they recommend in conclusions and what methodology they used. This review took a picture of the interest of the scientific community on NUS and underlined the need for further research, however, economic studies remained rather limited and always were part of interdisciplinary papers. Based on these aspects were recommended journals such as Economic Botany, Mountain Research and Development, and Genetic Resources and Crop Evolution as suitable for publication economically oriented studies on NUS and/or for getting recent valuable findings on focused topic.

Key words: value chain, minor crops, underexploited herbs, market niche, food security

Abstrakt

Světová rostlinná produkce závisí na několika málo hlavních plodinách. Minoritní druhy takzvané podužívané druhy rostlin (NUS) byly světovou ekonomikou přehlédnuty, přestože mají velký potenciál pro zlepšení potravinové bezpečnosti, vyváženosti stravy, příjmů venkovských domácností a pro zachování agro-ekosystémů při měnících se klimatických podmínkách. Cílem této práce bylo analyzovat dostupnou vědeckou literaturu zabývající se NUS se speciálním zaměřením na socio-ekonomické aspekty studií pro doporučení zdrojů a cílů pro budoucí výzkum. Pro účely výzkumu byla použita databáze Thompson Reuters ISI Web of Science a její nástroje. Studie byly řazeny podle počtu citování, tématu a hodnocení periodik. Na základě analýzy abstraktů, klíčových slov a názvů článků bylo nalezeno devět studií zabývajících se ekonomickým potenciálem NUS z celkového počtu 360 posuzovaných článků. Jejich bližší analýza zvýraznila, na čem se články shodují, co doporučují v závěrech a jejich použitou metodiku. Toto shrnutí zachytilo zájem vědecké obce o NUS a zdůraznilo potřebu dalšího výzkumu, nicméně ekonomické studie zůstaly spíše omezené a vždy byly součástí interdisciplinárních článků. Na základě těchto aspektů byly doporučeny časopisy jako jsou Economic Botany, Mountain Research and Development a Genetic Resources and Crop Evolution, jako vhodné pro publikování ekonomicky orientovaných studií na NUS a/nebo pro získání nedávných cenných poznatků na dané téma.

Klíčová slova: hodnotový řetězec, minoritní plodiny, nepoužívané byliny, mezera na trhu, potravinová bezpečnost

Content of the thesis

1. Introduction 1
2. Aim of the thesis 5
3. Methodology 6
4. Results 7
   - 4.1 Scientometric approach 7
   - 4.2 Analysis of the Economic Studies 12
     - 4.2.1 Exploring the economic value of underutilized plant species in Ayubia National Park (Sheikh and Sumaira, 2007) 12
     - 4.2.2 The role of collective action in the marketing of underutilized plant species: Lessons from a case study on minor millets in South India (Gruère et al., 2009) 13
     - 4.2.3 Emmer (Triticum dicoccon) Production and Market Potential in Marginal Mountainous Areas of Turkey (Giuliani et al., 2009) 14
     - 4.2.4 Women's Traditional Knowledge, Use Value, and the Contribution of Tamarind (Tamarindus indica L.) to Rural Households' Cash Income in Benin (Fandohan et al., 2010) 16
     - 4.2.5 The Situation for Quinoa and Its Production in Southern Bolivia: From Economic Success to Environmental Disaster (Jacobsen, 2011) 17
     - 4.2.6 Value chains of cherimoya (Annona cherimola Mill.) in a centre of diversity and its on-farm conservation implications (Vanhove and Van Damme, 2013) 20
     - 4.2.7 Monkey jack: underutilized edible medicinal plant, nutritional attributes and traditional foods of Western Ghats, Karnataka, India (Sarala and Krishnamurthy, 2014) 21
     - 4.2.8 Conservation of Brosimum alicastrum, an underutilized crop and keystone forest tree species; a potential win–win for conservation and development in Latin America (Lander and Monro, 2015) 22
     - 4.2.9 Spiny coriander (Eryngium foetidum L.) cultivation in the Chittagong Hill Tracts of Bangladesh: Sustainable agricultural innovation by indigenous communities (Hossain et al., 2017) 24
   - 4.3 Compared methodologies in identified studies 28
5. Discussion 30
6. Conclusion 33

   References 34

1. Introduction

Only 30 plant species are being globally used to meet 95% of the world's food requirements while there is more than 50,000 known edible plant species known and/or used in the world (Cheng et al., 2017; Oh et al., 2015; Barbieri et al., 2014; Jaenicke and Pasiecznik, 2009). At the same time, there is huge diversity of plants that have a great potential to supply the needs of households and industries for different products and at the same contribute to biodiversity conservation. One decade ago, Jaenicke and Höschle-Zeledon (2006) summarized this idea as follows: *"The world is presently over-dependent on a few plant species. Diversification of production and consumption habits to include a broader range of plant species, in particular those currently identified as 'underutilized', can contribute significantly to improved health and nutrition, livelihoods, household food security and ecological sustainability. In particular, these plant species offer enormous potential for contributing to the achievement of the MDGs, particularly in combating hidden hunger and offering medicinal and income generation options. They are also closely tied to cultural traditions, and therefore have an important role in supporting social diversity"*.

Until now, numerous terms have been employed in literature to characterize these species, including "minor crops", "underutilized species", "neglected species", "orphan crops", "underexploited species" and "underdeveloped species". The most used term is neglected and underutilised plant species, commonly known under the abbreviation NUS. Correspondingly, numerous definitions are used without the one settled in the scientific community, such as following two:

Species with under-exploited potential for contributing to food security, health (nutritional/medicinal), income generation and environmental services (Jaenicke and Höschle-Zeledon, 2006).

Those non-commodity crops, which are part of a larger biodiversity portfolio, once more popular and today neglected by users' groups for a variety of agronomic, genetic, economic, social and cultural factors (Padulosi and Höschle-Zeledon, 2004).

NUS are found in numerous agricultural ecosystems and often survive mainly in marginal areas. It is time to review their status because, in last decades, a number of scientific and economic interests have emerged which focus on underutilised species (Padulosi et al., 1999). Despite this, research and development (R&D), in general, is still lacking on underutilised crops due to government policies barely funding the research and its applications (Williams and Haq, 2002). Economic aspects of use and potential commercialization of these species came under attention of international organizations and institutions, such as Food and Agricultural Organization, Bioversity International, United Nations Development Programme etc. United Nations pointed on the importance of exploring the NUS of economic development (inter alia) already in 1992 (United Nations, 1992), however with the new millennium, studies on underutilised species emerged. They were particularly focused on value chains, markets and livelihood (Will, 2008; Gruère et al., 2006). At the beginning, scientists and policy-makers connected NUS particularly with the developing world, and this perception became even a part of the definitions, e.g. Gruère et al. (2006) mentioned that *"...some of these species, called underutilized plant species, are characterized by the fact that they are locally in developing countries but globally rare, that scientific information and knowledge about them is scant, and that their current use is limited relative to their economic potential"*.

Regarding the economic characteristics of NUS, both private and public values must be considered. Private includes nutrition, medicine, supply balance and income at personal or household level, while public values deal with biodiversity, future asset, culture or tradition. Especially, traditional knowledge is typically associated with the use of these species, while scientific knowledge is emerging, but limited (Biodiversity international, 2017; Hughes, 2009; Gruère et al., 2006).

Increased public awareness about underutilized species was further prompted by world well-known organizations and their actions such as already mentioned Convention on Biological Diversity (United Nations, 1992), Global Plan of Action for the Conservation Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (FAO,

1996) or Consultative Group on International Agricultural Research (CGIAR) expanded its research agenda to include underutilized species (World Bank, 2005).

From the economic perspective, underutilisation means under-valuation of particular resource. In temporal dimension are three cases of market observed and potential value of NUS. In first case market value was equal to potential, but it declined. For example, in the past, mallow (*Malva sylvestris*) was used in Syrian rural households to prepare a traditional stew. The stew is in this time considered as food of the poor (Gruère et al., 2006). In second past value is low, but potential market price increases recently as we have more knowledge about the plant, for example quinoa in the Andes. And third case has always been undervalued like the multipurpose baobab (*Adansona digitata*) tree (De Smedt et al., 2011; De Caluwé et al., 2009; Gruère et al., 2006).

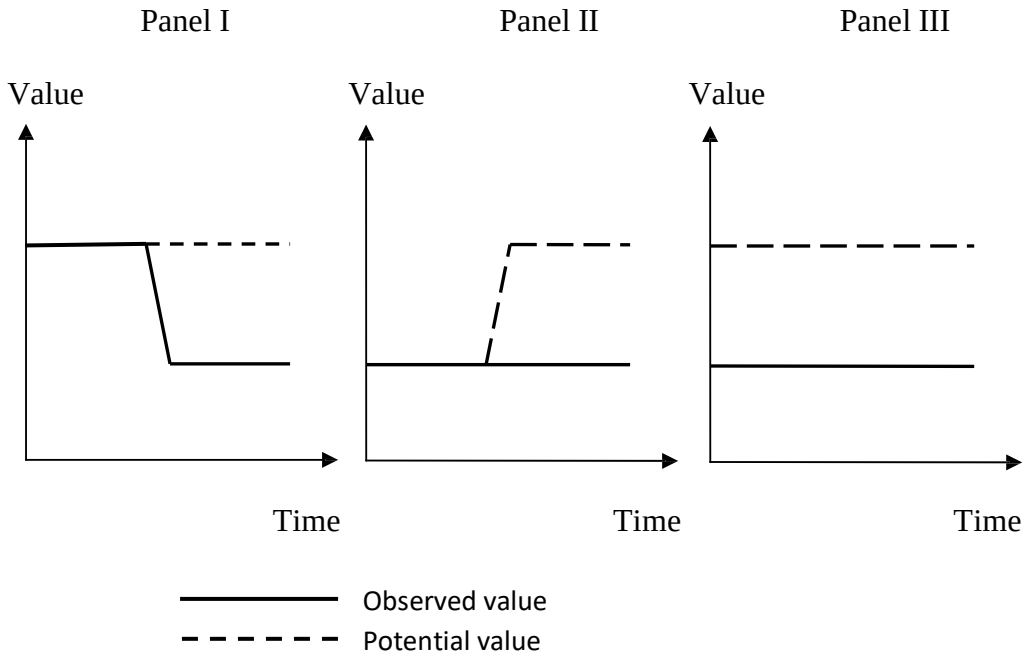

Figure 1
Temporal characterization of underutilized plant species
(Gruére, 2006)

It is important to mention that NUS cannot exist in perfectly competitive market. There are several imperfections the markets have for which the economic potential of NUS remains unutilised that are showed in Figure 1. First, is missing output market for NUS

that is result of several characteristics such as a lower yield or shorter freshness that reduces the possibility of transportation or storage. Second is a suboptimal market equilibrium when the market price does not reveal the full value of the product or the consumer willingness-to-pay and the quantity produced does not represent the optimal scale of production or production capacity. The obstacles for NUS in this way are weak market demand, inefficient supply and/or combination of the two. Last is represented by the market failures. Due to less knowledge of the producers and the consumers about those plants NUS perceive underrated public value resulting in a lower demand or the government supports the production of other primary crops (Baldermann et al., 2016; Gruère et al., 2006).

Generally, the narrowing base for global food security reduces or limits livelihood options for the rural poor, particularly in marginal areas. The great importance have a ‘major crops’ that were perceived to be superior to those of NUS a ‘minor species’, in terms of characteristics of crops, production, handling and processing, marketing, environmental properties, R&D capacities and globalization effects (Kotni, 2012; Azam-Ali, 2010; Will, 2008; Youngs and Hammett, 2001). Nevertheless, any policy strategy, development projects, curriculum development at educational institutions could not be launched without support in scientific studies. Thus, this bachelor study summarizes and analyses the current amount of scientific studies publish on the topic of NUS.

2. Aim of the thesis

Considering increasing institutional support and promising positive impact of neglected and underutilised plant species on human well-being, there is a need for review of so-far published scientific literature dealing with NUS in order to better target future research goals. Thus, the aim of the thesis was to analyse available scientific literature dealing with neglected and underutilised plant species with specific focus on economic aspects of collecting, planting, processing and marketing.

3. Methodology

Thesis is compiled as a literature review. A Thompson Reuters ISI Web of Science® (WoS), the most recognized proprietary database for peer reviewed journal content, was used as the only source of information. Other material such as books, proceedings form conferences, web pages or technical reports of international organizations as well as other scientific databases, such as SciVerse Scopus, PubMed etc. remained omitted. Keywords entered into the database were "underutilized" AND "plants".

Generated results were limited via WoS analytical tools to articles according to 'Source Type' and only those published after 1990 according to 'Publication Years'. The next step was classification of results according to scientometric approach according to highest number of citations, most frequent journals, most frequent authors and institutions. Time perspective was also considered to document publication history on chosen topic. Identification of economically-oriented articles was done on a subjective decision of the thesis author, supported by identification of economic terms in key words, title, abstract or major chapters of the text. Scientific papers with dealing with economic issues were further analysed with special focus on geographical location, theoretical approaches, species, techniques of data collection and analysis, and main recommendations for further research.

4. Results

4.1 Scientometric approach

Total number of 360 articles was identified. According to the consistent classification of topics by abstracts relates to clearly to NUS topic, 161 articles were further analysed, which is 45% of the overall total. Any ongoing analyses will be based on those 161 articles.

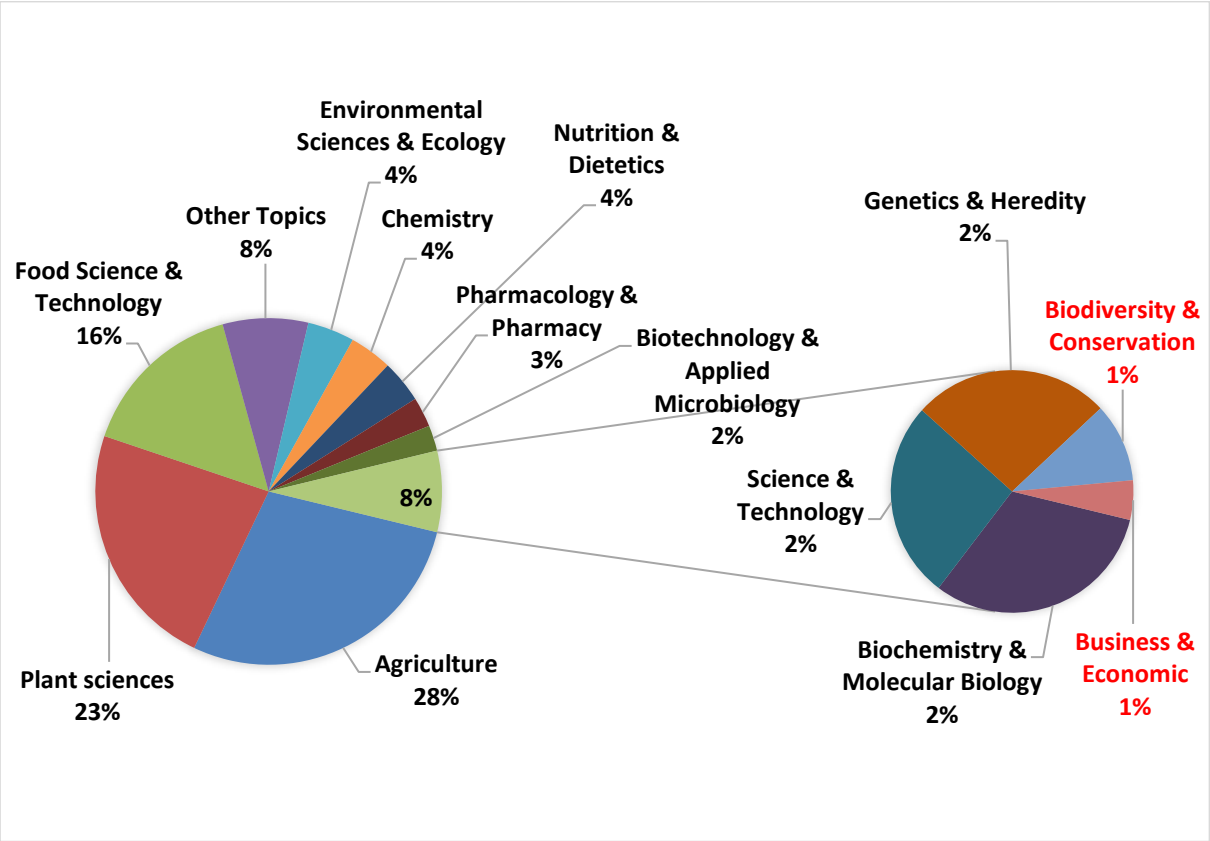

Figure 2
Distribution of articles into subject categories
(based on data WoS)

The most common categories were agriculture, plant sciences, and food science and technology with the 28, 23 and 16 percentages of studies respectively. Subsequent categorization showed that only three articles (2%) were listed directly in the category of economics and one in the biodiversity conservation. More specifically is the

distribution among particular categories is shown in Figure 2. However, such classification provides us with certain overview of the main focus of the studies, but for deep analysis of the generated articles, abstracts, key words and titles of the articles must be analysed as well. The abstracts analysis further identified economic background in another six articles. Hence, total number of the articles dealing with economics was nine, which is less than 6% of the found articles relating to NUS. Those articles will be analysed in the chapter 4.2.

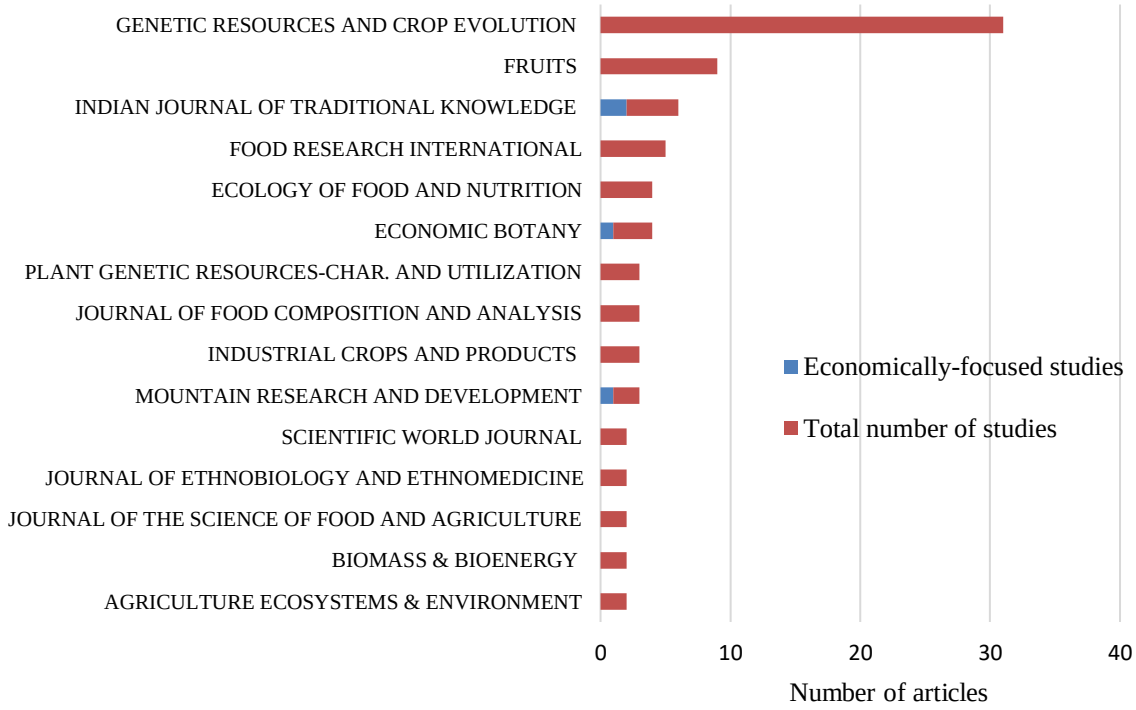

Figure 3.
Scientific journals with the most frequent publications on NUS
(based on data WoS)

From the articles, I chose the ten most quoted and analysed their characteristics as a geographical location, species, year of publishing, journal, category and subjective category (after analysis abstract etc.) in the Table 2. There is recorded a number of the citations, an article title, year of publication, research area by WoS, identified theme of the abstract, species, a place that is mentioned in the abstract, where the study was conducted, or where the species comes from and magazine in which the article was published. These articles are published in the years 1999-2012. They deal mainly with the analysis of plants, but also food security, renewable energy and one of them with

environmental impact on the already exploited economic potential of quinoa. This case study from the southern Bolivia will be discussed more detail in the chapter 4.2.5. By far the greatest scientific interest is about a study aimed at producing biodiesel from the underutilized plant Karanja (*Pongamia pinnata*) from 2008.

Another summary of data was performed by the journals that frequently publish articles related to NUS. In the Figure 3 are first 15 of those journals and there are also shown the articles related to economic topic. We can see that is obvious that by far the most common periodical that deals with the NUS is the "Genetic Resources and Crop Evolution". As the name suggests, it deals not with their economic potential, but their extension, description, analysis and genetics. This is the first step in order to be subsequently produced the economic studies on the described species. According to this chart, it is possible to recommend three periodicals for further research into the economic potential of NUS. Namely these are the "Indian Journal of Traditional Knowledge", "Economic Botany" and "Mountain Research and Development".

Table 1. Evaluation of journals with highest number of journals (based on data WoS)

Journal	IF 2015	IF last 5 years	Quartile
AGRICULTURE ECOSYSTEMS & ENVIRONMENT	3.564	4.233	Q1
INDUSTRIAL CROPS AND PRODUCTS	3.449	3.554	Q1
BIOMASS & BIOENERGY	3.249	4.146	Q1, Q2
FOOD RESEARCH INTERNATIONAL	3.182	3.871	Q1
J OF FOOD COMPOSITION AND ANALYSIS	2.780	3.302	Q1
J OF ETHNOBIOLOGY AND ETHNOMEDICINE	2.414	2.599	Q2
J OF THE SCIENCE OF FOOD AND AGRICULTURE	2.076	2.212	Q1, Q2
GENETIC RESOURCES AND CROP EVOLUTION	1.258	1.477	Q2, Q3
SCIENTIFIC WORLD JOURNAL	1.219	1.300	Q2
ECONOMIC BOTANY	1.109	1.581	Q3
FRUITS	1.013	1.047	Q2
MOUNTAIN RESEARCH AND DEVELOPMENT	0.911	1.471	Q4
ECOLOGY OF FOOD AND NUTRITION	0.894	1.047	Q4
PLANT GENETIC RESOURCES-CHARACTERIZATION AND UTILIZATION	0.442	0.763	Q4
INDIAN JOURNAL OF TRADITIONAL KNOWLEDGE	0.371	0.530	Q4

For more relevant recommendation used to evaluation of the journals by WoS. Table 1 shows these 15 journals ranked according to the actual value of impact factor, impact factor in last five years and quartiles according to the research area which the journal is indexed. Of the three magazines that deal with the economic potential of NUS is best evaluated a journal Economic Botany. It appears as the best candidate for the further exploration of the topic. Compared to the others these three magazines are on the low rungs. And for that I can read small scientific interest in the economic potential of NUS.

Last but not least important factor is the time. This study focuses on the articles since 1990, when the NUS came into the world consciousness. But have the new scientific studies emerged since that year? The time perspective is shown in the Figure 4. There we can see that a scientific interest began to increase in 2007 and reached a peak of 2011. However, in the scientific database WoS is a general trend that the study every year gain frequency. We cannot therefore say whether the scientific interest of NUS increases over time compared to the other disciplines.

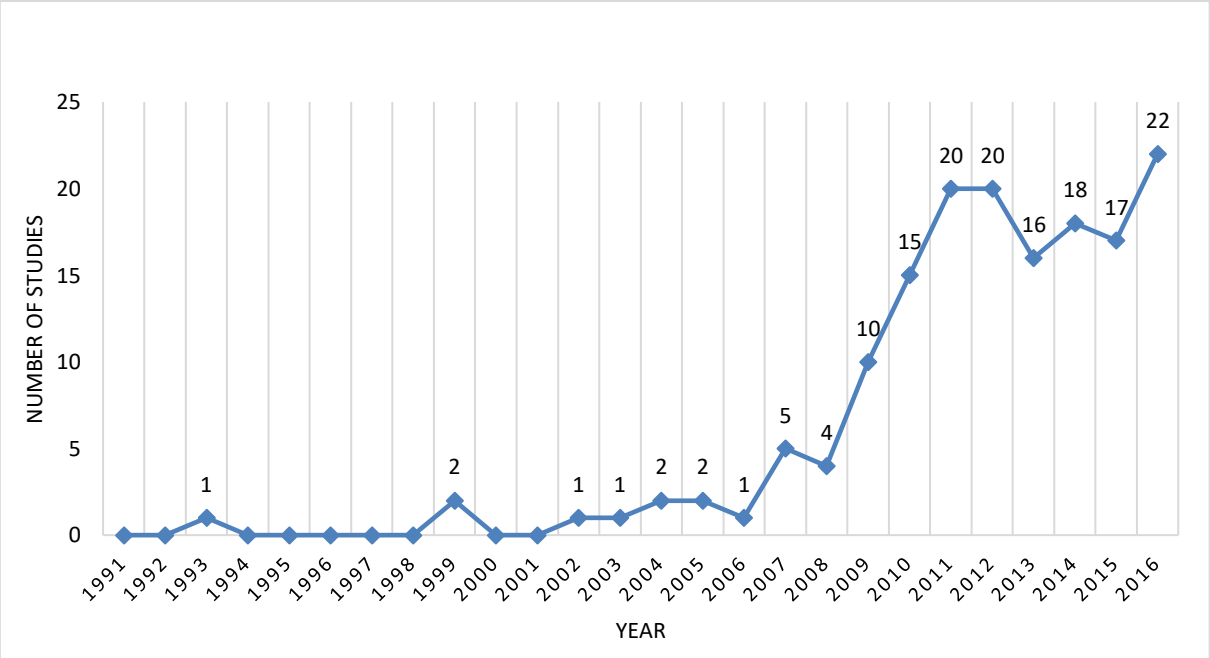

Figure 4.
Number of studies published annually on NUS issues
(based on data WoS)

Table 2. Ten the most frequently cited articles dealing with NUS (based on data WoS)

Citations	Title	Year	WoS Research Area	Identified Theme of the Abstract	Focused species	Region	Journal
143	Production of biodiesel from high free fatty acid Karanja (Pongamia pinnata) oil	2008	Agriculture; Biotechnology & Applied Microbiology; Energy & Fuels	NUS, Renewable energy	Karanja (*Pongamia pinnata*)	not specified	BIOMASS & BIOENERGY
67	Characterization of two novel type I ribosome-inactivating proteins from the storage roots of the Andean crop *Mirabilis expansa*	1999	Plant Sciences	NUS, Biochemistry	Mauka (*Mirabilis expansa*)	Andes	PLANT PHYSIOLOGY
41	Crop Wild Relatives-Undervalued, Underutilized and under Threat?	2011	Life Sciences & Biomedicine - Other Topics	NUS, Food security	not specified	not specified	BIOSCIENCE
38	Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds	2012	Agriculture; Plant Sciences	NUS, Analysis, Nutritional values	not specified	Mediterranean	GENETIC RESOURCES AND CROP EVOLUTION
35	Valorisation of wild strawberry-tree fruits (*Arbutus unedo* L.) through nutritional assessment and natural production data	2011	Food Science & Technology	NUS, Analysis	Wild strawberry-tree fruits (*Arbutus unedo L.*)	Mediterranean	FOOD RESEARCH INTERNATIONAL
32	The Situation for Quinoa and Its Production in Southern Bolivia: From Economic Success to Environmental Disaster	2011	Agriculture	NUS, Economics, Ecology	Quinoa (*Chenopodium quinoa*)	South Bolivia	JOURNAL OF AGRONOMY AND CROP SCIENCE
28	Content and distribution of flavonoids among 91 edible plant species	2008	Nutrition & Dietetics	NUS, Analysis, Summary	91 of species	Taiwan	ASIA PACIFIC JOURNAL OF CLINICAL NUTRITION
27	Polyphenols, carotenoids, and ascorbic acid in underutilized medicinal vegetables	2012	Food Science & Technology	NUS, analysis, Biochemistry	24 of species	Indonesia	JOURNAL OF FUNCTIONAL FOODS
27	Distribution of 127 edible plant species for antioxidant activities by two assays	2006	Agriculture; Chemistry; Food Science & Technology	NUS, Analysis	127 of species	not specified	JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE
26	Towards a 'red list' for crop plant species	2005	Agriculture; Plant Sciences	NUS, Systematization	not specified	not specified	GENETIC RESOURCES AND CROP EVOLUTION

4.2 Analysis of the Economic Studies

Studies of NUS economic potential, which will be analysed can be viewed in the Annexes in Table 3. I will focus on the methodology of data collection, conclusions, geographical location, focused species and the study issue. From the comparing of these components I will draw the conclusions about available studies in discussion. The order is ascending studies from the oldest to the newest.

4.2.1 Exploring the economic value of underutilized plant species in Ayubia National Park (Sheikh and Sumaira, 2007)

A study of Ayubia National Park (Pakistan) focuses on the economic potential of unused six plants, selected based on six criteria in order to fall under the NUS. 30 local plant collectors and merchants were interviewed by questionnaire method. The six plants were monitored at three popular markets near the park to determine their value chains and by method questionnaires were studying medicinal, ecological and nutritional aspect of the plants and with the help of available literature as well. In this markets shopkeepers, elders and plant traders were interviewed.

In discussion authors realized that three of the examined species show consistently high crude protein, variable but relatively low fat and relatively high carbohydrates and are significantly higher in total protein than are local agricultural plants like sorghum, millet and manioc.

"The study explicitly explains that these selected species have great medicinal and nutritional importance and can become a source of poverty alleviation of poor local community of study area, but proper harvesting and management is the need of time. These 6 underutilized species (Adhatoda vasica, Artemisia scoparia, Galium aparine, Amaranthus viridis, Hedera nepalensis and Urtica dioica) need to be conserved in their natural habitats. Better communication with local communities can raise and improve the awareness, importance and preservation of the diversity of these underutilized species and build capacity among stakeholders."

4.2.2 The role of collective action in the marketing of underutilized plant species: Lessons from a case study on minor millets in South India (Gruère et al., 2009)

This study is dealing with Minor millets in South India. Until recently, minor millets were extensively grown and widely consumed in Kolli Hills (South India) mostly as a subsistence crop. However, their cultivation has declined due to changing consumption and production preferences in favour of other crops such as cassava, rice and pineapple, which are grown exclusively for sale.

In response to this development, the M.S. Swaminathan Research Foundation (MSSRF), a leading non-governmental organization based in Chennai, India, has led 'conservation-cum-commercialization' intervention programmes over the last 10 years in Kolli Hills which aim to raise the market potential of minor millets through value addition and help the farming communities maintain their agro-biodiversity by providing economic incentives for its conservation. This study analysed the market development initiative for minor millets in Kolli Hills with a specific focus on the role of collective action and group initiatives organized by MSSRF that take place in the minor millet value chain and compare it to the cases of two competing cash crops in the same region: cassava and organic pineapples. It is based on a series (unfortunately unspecified number) of focus group discussions with stakeholders (12 groups were established by MSSRF) held during the summer of 2006 and 2007.

The outcome of the initiative was successful in many aspects: it provided a new incentive for the production and consumption of minor millets, thereby generating an extra source of income for local rural users. According to this document a groups a collective action are necessary for the success of market development and most likely are needed for a sustained, effective marketing strategy. Pooling resources, realizing scale economies, sharing information, and developing a community-based incentive structure are essential contributions of collective action. Unlike pineapples and cassava, minor millets are not locally, regionally and internationally known by consumers or they are not driven by robust industrial demand. As a result, developing a market for NUS is a question of expanding demand and creating wider consumer acceptability.

Cassava is more profitable in the short-time income, but especially rice and cassava cultivation is expected to reduce soil fertility, resulting in progressively declining yields and reduced income. The diversification towards cassava might also be affecting the food security and dietary diversity of the local communities in the long run.

Another constraint of Minor millets is because rice is heavily subsidized, undermining demand for millets. Even without the price difference, traditional cooking knowledge about minor millets has been lost over time and tastes have changed, so that replacing rice with minor millets could be challenging. This study recommends constantly efforts and need to target a specific, stable segment of consumers. As well indirect public support, such as the use of minor millets in school meal programmes, hospital meals and military rations, which could help provide a robust demand and a continued incentive to produce. Public policies designed to redress production externalities could also facilitate the change in the incentive structure to the benefits of minor millets. Collective action by local users could contribute to reaching policy support, via information campaigns, collective purchases or consumption subsidies. Collective action remains a necessary but not sufficient condition for successful commercialization.

4.2.3 Emmer (*Triticum dicoccon*) Production and Market Potential in Marginal Mountainous Areas of Turkey (Giuliani et al., 2009)

The present study analyses the production, consumption, and marketing of emmer (NUS), with the objective of understanding the constraints, opportunities for emmer production, marketing and the impact on the livelihoods of the mountain communities and understanding why it became a NUS. This trend in Turkey is compared with the reverse tendency in Italy, where like in other countries in Western Europe is increasing demand for emmer. Once fallen into NUS, emmer has experienced a come-back in Italy as a high value product demanded on the market thanks to a combination of interventions put in place by various actors to promote emmer, support smallholder producers, and improve the conservation of genetic resources.

In Turkey, emmer is still cultivated for its high adaptability to poor soils by farmers who live in marginal mountain areas where cultivation of high-yielding crop varieties requires high inputs. In the emmer market chain are no producers' or traders' organizations. A new attitude toward healthy food, particularly among urban residents translates into a potential niche market for emmer due to the taste and nutritional properties which make emmer potential resource for securing the livelihoods of poor rural communities in marginal areas.

Methodology: Kastamonu and Sinop provinces in the Black Sea region still producing emmer by preliminary research on emmer cultivation in Turkey at the Central Research Institute for Field Crops (CRIFC) in Ankara. A household survey was conducted in 28 villages, using semi structured questionnaires and focus group discussions with farmers. Using purpose-sampling methods, they conducted 50 in-depth household interviews. The production and marketing information was gathered through interviews with key market chain actors, government officials from the Provincial and Country Agricultural Directorates of Kastamonu, Sinop, Boyabat, and Arac¸, the Turkish Export Union, the Food Engineering Department of Hacettepe University in Ankara, and a big wheat flour and pasta factory in Ankara. The results were then compared. The information about the Italian case was collected through a literature review and brief visits to emmer-producing areas in the Marche, in Italy.

In conclusion, authors stated that the national research community, policymakers, and local municipalities should foster the development of production and marketing for emmer, as in the Italy. Research targeted to agronomic improvement, characterization, and value addition, as well as marketing and promotion events, would help improve these poor producers' livelihoods and conserve the genetic pool. Research activities on the nutritional properties, also based on genetic diversity, should be continued in order to adapt the right processing methods and improve the quality of the final product. Diversification in emmer products in the flour industry can be encouraged through examples coming from countries that successfully produce emmer products. An active public awareness campaign targeted at consumers should be put in place by local governments, with the involvement of nongovernmental organizations and farmers'

organizations. As for most NUS, a combination of public–private interventions was the key to promoting these valuable resources for sustainable use and conservation.

Research has shown that NUS play a fundamental role in the livelihoods of poor communities living in harsh environments, as a source of income, nutrition, and medicinal remedies based on traditional knowledge.

4.2.4 Women's Traditional Knowledge, Use Value, and the Contribution of Tamarind (*Tamarindus indica L.*) to Rural Households' Cash Income in Benin (Fandohan et al., 2010)

Tamarind is a multipurpose tree typical of savanna ecosystems, mainly in riparian habitats. Its pulp is much appreciated in condiments, is used to make juice, and is a good source of proteins, fats, and carbohydrates. Tamarind seeds are 2 to 15 times richer in protein than local maize and cassava. The leaves are used medicinally, and the seeds are used to manage diabetes.

Until recently, scientific research on tamarind (and according my results this concerns many other NUS) in Africa has been limited to biochemical analysis, genetic diversity, breeding systems, and pollination-related issues. Ethnobotanical studies on tamarind are scarce which could help determine the true value of the species. The objectives of this study were (1) to characterize differences in knowledge and utilization of tamarind among ethnic groups in Benin, (2) to assess the impact of tamarind product sales on rural women's cash income, and (3) to analyse the conservation and utilization aspects of tamarind as a model for enhancing rural women's purchasing power. The research involved seven rural communities of northern Benin.

Methodology of this document says that data were collected from the districts of Karimama (KD) and Banikoara (BD) in the uppermost north of Benin, and Matéri (MD) in the northwest from total of seven tribes. Semi-structured individual interviews with 25 women in each of the seven tribes, translating to a total of 175 women were realized. Interviews focused on female knowledge on the species' products and uses, variability in the species, and its contribution to cash income during the dry season. During

interviews, women were asked to describe the use of each tamarind plant part. Thereafter, each participant was asked to attribute a rank to each specific use, depending on the frequency of utilization.

Tamarind fruits were found to be the only commercially valuable part of the tree but it is used by local people in different ways, including edible fruit, timber, fodder, medicine, magic, and others. The study found significant ethnic variation in knowledge and use value of tamarind. This diversity of traditional uses and knowledge should be considered when designing regional management strategies. For example, because women of one tribe assigned a high ethnobotanical use value to medicine, social, cultural, and material categories, but low values to commerce and firewood, they should be involved in strategies aimed at improving genetic selection. At the same time, because commercial and food use values were high for second tribe women, they should be involved in identifying potential market niches for the species development in Benin. The average contribution of tamarind fruit sales to overall income during the dry season is 35%, suggesting that tamarind plays a key role in targeted tribes livelihood. However, there was wide differences among the tribes which suggest that these results should not be generalized across too great an area. Further research on tamarind and other plant extractive products should be carried out in order to further promote sustainable resource use and improved welfare for rural women. Strategies to enhance its utilization should focus on (i) cross-collaboration and knowledge exchange with other countries where the species is better valued (e.g., India, Thailand), (ii) adding value through transformations, (iii) conforming product quality to international standards, and (iv) organizing local and international market channels. These strategies may also help to improve incomes and empower the purchasing power of local women.

4.2.5 The Situation for Quinoa and Its Production in Southern Bolivia: From Economic Success to Environmental Disaster (Jacobsen, 2011)

This study is like reverse case due to NUS. Now the problem is no small demand, ignorance crops or biodiversity conservation, but too big boom of demand in the market one previously unused crop. A proverb says enough is enough and it also shows the case. Document discuss how the development of an export market can have a negative

effect on the environment and on home consumption of the same product. The aim of the study is to present the consequences of this situation and to discuss possible solutions to it.

Methodology of this study is based on project work and regular visits to the region, when the author was employed at the International Potato Center (CIP), Lima, Peru, from 1996 to 2002, and as then in a private sector project BIO QUINUA, funded by the Danish government agency DANIDA, with the processing plant Andean Valley of La Paz, and the Danish bakery Aurion. Another project on minor Andean crops has been initiated (2010–2013), together with various institutions in Bolivia, with quinoa including the project. But Jacobsen says that "*This study is not to be regarded as an original scientific publication, as it rather is a reflection and presentation of the author's personal impression on the changes, which have occurred in the quinoa-producing area of southern Bolivia."*

Conclusions say that he farmers in the southern altiplano region are no longer consuming their own quinoa (*Chenopodium quinoa*). They rather sell the quinoa on the market and consume cheaper products such as pasta or rice now, because of the high market value comes quinoa to export. The price of quinoa has increased rapidly during the last decade. This suggests perhaps quinoa is now becoming an underutilized food among quinoa producers. Quinoa is a very good case study of an NUS that has been promoted for the market in a way that has not considered important social, environmental and health aspects. Rapid degradation of natural resources owing to unsustainable land use in the southern altiplano of Bolivia is likely to be worsened from the negative impacts of the expected climate changes. The soils are degraded because of intensive management with no planning of adequate use. The situation is alarming as the altiplano is already in a process of desertification which can be seen in Figure 5.

In discussion voiced recommendations that it is necessary to formulate a conservation strategy to prevent further erosion of natural resources, including the agro-biodiversity in the Andes. Variability of the crops between regions, their status, uses and cultivation methods by local farmers, must be studied. The sustainability of the traditional management is under threat because of growing export markets that is increased

mechanisation, leading to soil erosion; increased pest problems; diminishing use of animal manures and a more intensive cultivation. Andean biodiversity and local traditional experience is need to rescue because of local breeders of all crops depend on trait variation in primitive and wild species to produce cultivars adapted to new environments and with higher and more secure yield. Unfortunately, the options for diversification of the farming system and biomass production are limited owing to the harsh environmental conditions. Development should be turned in the right direction, securing both a high value food like quinoa for the Bolivian population, and a resource for income to the Andean farmers, when satisfying global market demands in a sustainable way.

Figure 5. Quinoa field at the southern Bolivian altiplano (Alter Eco, 2017)

4.2.6 Value chains of cherimoya (*Annona cherimola* Mill.) in a centre of diversity and its on-farm conservation implications (Vanhove and Van Damme, 2013)

Cherimoya (*Annona cherimola* Mill.) is one of the many edible fruit species in the Annona genus and it is considered among the finest fruits on earth. Spain is the world's largest cherimoya producer but it is a minor crop compared to other fruit species. In the Andes, cherimoya occurs in natural stands or as semi-domesticated plants in home gardens in the valleys of Ecuador, Peru and Bolivia.

Methodology: They distinguished four strongly interlinked key dimensions of value chains for perishable tropical food products: market channels, governance regime, quality performance and added value distribution. The channels dimension describes how cherimoya fruits currently reach the final customer and which alternative channels could be developed in the future. Analysis of the governance regime covers transactions, interactions, and cooperation among chain actors. Quality performance deals with how consumer quality expectations are met. Article describes the distribution of the added value along the value chain. Data for the value chain analysis were obtained from informal talks with relevant sector stakeholders (NGOs, government institutes, researchers) and from structured interviews with 152 cherimoya producers in 9 departments, a total of 434 traders (107 wholesalers and 337 retailers, including 38 supermarkets), 36 ice cream parlors (only cherimoya processors in the Andean) and 501 surveys from consumers in Ecuador, Peru and Bolivia.

The result of this paper are two clear, distinct channel types which prevail in the Andean cherimoya value chains: Cumbe cherimoyas that are produced in the Lima region in Peru and marketed in the whole Andean region; and local cherimoyas that are elsewhere produced, marketed and consumed. The Cumbe cherimoya value chain is the more competitive of the two and this variety and typically longer than those of local cherimoyas. Although organoleptic on-farm quality is not distinctively better for Cumbe cherimoyas compared to local cherimoyas, trust of traders and consumers in the Cumbe chain is higher and the prices as well. Added value is quite evenly distributed over all

chain actors and for the Cumbe chain, highest share in added value is taken by producers.

There are two Andean areas of interest for in situ cherimoya conservation: i) the putative centre of origin in southern Ecuador and northern Peru, where diversity is high; and ii) Bolivia, where rare genotypes occur. Both locations are faced with obstacles in value chain development. Support for improvement of the cherimoya value chain in these areas may lead to in situ conservation of cherimoya germplasm.

The study suggests enhancing value chain of local cherimoyas by i) the formation of farmer organizations; ii) extension of scientific knowledge about adequate cultivation practices to farmers; iii) introduction of elite germplasm material; iv) introduction of more adequate packaging material; v) market information systems, communicating both quality standards as well as pricing according to different quality classes; and vi) construction of (centralized) warehouses for cherimoya fruit.

To prevent genetic erosion can be expansion of cherimoya production areas. Should be then stressed the relation between the qualities of cherimoya fruit and the production area rather than a certain cultivar. Also, governments could reward farmers for cultivating local cherimoyas through payment for agrobiodiversity conservation services (PACS). The latter is a sub-category of payment for ecosystem services (PES) to compensate farmers' opportunity costs of maintaining traditional crops and varieties instead of adopting more profitable crops.

4.2.7 Monkey jack: underutilized edible medicinal plant, nutritional attributes and traditional foods of Western Ghats, Karnataka, India (Sarala and Krishnamurthy, 2014)

The present paper deals with occurrence, harvesting, processing and preservation, utility and marketing of monkey jack (*Artocarpus gomezianus* Wall. ex Trecul) at various regions of Western Ghats of Karnataka.

Regarding methodology, the fruit samples were sampled at different regions of the Western Ghats of Karnataka in 2009 and 2010. The protocol of morphological of fruits, fruit juice and powder yield, was made during the number of field visits. The utility and market value of fruits were gathered from the local people based on the questionnaire and personal discussions. Unfortunately, the authors did not specify the number of people questioned. The fruits were subjected for determination of proximities, nutritive value, elemental components and the harvesting, processing, preservation and utility were documented. The morphology and fruit yield were studied.

The monkey jack (raw and processed) is also used in the preparation of local traditional dishes that are in detail describes. This study reveals that the monkey jack is one of the important underutilized fruits which not only generate income but also provide employment opportunities. The total jack processing making the notable added value. The raw fruits earn Rs 500 - 600/100 kg and processed products Rs 7000-8000/100 Kg which may initiate establishment of cottage industries. Monkey jacks are collecting, labelling, transportation and storage through the cooperative societies and voluntary organization which decreases the cost of transportation and storage. The data reveal that fruits are edible and potential sources for food supplements and it also replaces uses of tamarind (*Tamarindus indica L.*) one of the important ingredients in the preparation of dishes in the mountain region of Western Ghats. Program for conservation this crop helps in conservation of biodiversity and of social, traditional and cultural heritage. The entire tree is used not only for food and fodder but also other uses, therefore the monkey jack needs study and conservation.

4.2.8 Conservation of *Brosimum alicastrum*, an underutilized crop and keystone forest tree species; a potential win–win for conservation and development in Latin America (Lander and Monro, 2015)

Brosimum alicastrum Swartz (Moraceae) is a mid- to late-successional, canopy-emergent, keystone tree species in Latin America and NUS of high nutritional value. This study dealing with win-win program when is possible genetic conservation and human development as well.

Methodology says that herbarium samples were used from 213 individuals in 34 populations across the geographic range of *B. alicastrum* (South America, the Caribbean, Central America (including Mexico), North Pacific, Atlantic regions, South Pacific). The samples were microbiologically and genetically analysing.

Analyses found high genetic diversity within the species and suggested that there are distinct varieties of *B. alicastrum* north and south of the Panamanian isthmus. *B. alicastrum* is arguably a keystone species - define forest structure, influence microclimates, and contribute substantially to ecosystem processes and it is promising species for reforestation. Community species diversity is one method for identifying areas of high conservation priority. Initiatives run by the Maya Nut Institute promote conservation and sustainable harvesting of *B. alicastrum* to relieve rural hunger and poverty, support reforestation programmes, and provide fodder for cattle and pig production. 'The Healthy Kids Healthy Forest' programme connects women's cooperatives that harvest and process *B. alicastrum* seeds with local schools in Nicaragua and Guatemala and funds the provision of food and drinks made with *B. alicastrum*. MNI also supported the planting of around two million seedlings of *B. alicastrum* in Haiti, Colombia, Guatemala, Peru, Honduras, Nicaragua and Mexico between 2010 and 2014.

In the literature are persistent suggestions that *B. alicastrum* was an important food crop for the Maya, but none of the archaeological or ecological data supports this claim. The study suggests that there is no need to justify the current use of *B. alicastrum* through claims of Mayan use. Study has identified potential priority areas for conservation in five entire countries, and based only on the genetic diversity identified in this keystone species, so this prioritisation represents a first approximation. Developing *B. alicastrum* as a food and fodder crop could improve human well-being in some of the most deprived communities in Latin America, the study suggests that conservation of this crop represents an opportunity to achieve the fabled win–win of conservation and development.

4.2.9 Spiny coriander (*Eryngium foetidum L.*) cultivation in the Chittagong Hill Tracts of Bangladesh: Sustainable agricultural innovation by indigenous communities (Hossain et al., 2017)

Spiny coriander (*Eryngium foetidum L.*) is a culinary, spice and medicinal leafy herb mostly grown in tropical Africa, South Asia and warmer southern parts of Europe, which is intrinsically linked to the culture and traditions of indigenous local communities. It is a traditional component crop of jhum. This study examined cultivation techniques, productivity, contribution to household income and its role in supporting resilience to climate change. Due to a large increase of the population in the Chittagong Hill Tracts CHT, there is straining of soil by intense farming and growing market hybrids crops, which have adverse effects to soil and ecosystem. This leads to accompanying adverse long term economic consequences and fast disappearing of NUS under the pressure of hybrids. Moreover, the indigenous techniques employed in cultivating local crops are more sustainable production in environmentally sensitive and economically marginal areas, but they are diminishing due to modernization and overall development trends.

Methodology: The study was carried out in two villages; Choto Pagli and Shapchari. The methods of data collection had two phases, a short Focus Group Discussion (FGD) followed by semi-structured household interviews in each village (14 farmers at Chotopagli, 16 farmers at Shapchari). Cultivation techniques practiced by the smallholders for different crops including spiny coriander, as well as market demand, income, and the challenges smallholders faced were discussed in the FGD. The farmers were divided into three farm size categories (small, medium and large) to correlate production with varying farm size. Following the FGD's 40 randomly selected households were then interviewed, 20 in each village using a semi-structured survey questionnaire consisting of both closed and open questions for collect data on crop composition, farmers' crop preference, cultivation techniques, seed sources and associated networks, market potentialities, productivity, and contribution to household income.

Historically farmers rarely sold it in the market, but now 86 % of respondents cultivate this crop for cash income. Larger farms enjoy better returns per unit land. This may be due to more effective commercialization of the whole cultivation system by larger farm holders. Spiny coriander has great market demand over the region and wholesalers and businessmen are buying harvested spiny coriander from farmers. In the retail market, its price is about BDT 5 per bundle of 2-3 plants or BDT 80-120 per bundle of 1 kg of plants depending on size and market condition. Generally, the farmers receive higher returns from spiny coriander when compared to other crops. Other studies suggest that the spiny coriander also has huge potential as the source of an essential oil. Currently access to foreign export markets for indigenous communities in the CHT is limited to raw fruits, vegetables and certain spices. There may be opportunities to generate more revenue by exporting spiny coriander to the foreign markets in both raw and processed form as essential oil (coriander oil) extracted from spiny coriander leaf.

Changing climatic conditions impose higher production costs as well as greater crop damage, and insect infestation. The promotion and improvement of spiny coriander cultivation techniques in the study areas has the potential to provide a substantial monetary return while also building the resilience of local farming systems to climate change and other environmental changes shocks.

The study shows the capacity of small holders to engage in self driven development strategies employing a traditionally cultivated crop in the face of changing agro-ecological and socioeconomic conditions. While this is an exploratory study it does at the least suggest that further research and the engagement of policy makers concerning the future development and expansion of this herb is merited and has the potential to enhance the financial and environmental wellbeing of marginal farmers in the CHT.

Figure 6. Spiny coriander leaf bundles (price BDT 10 each) for sale in the local market (Hossain et al.,2017)

Table 3. Studies focused on the economics potential of NUS (based on data WoS)

Title	Year	Citations	WoS Research Area	Focused species	Region	Journal
Exploring the economic value of underutilized plant species in Ayubia National Park	2007	19	Plant Sciences	*Adhatoda vasica, Artemisia scoparia, Galium aparine, Amaranthus viridis, Hedera nepalensis, Urtica dioica*	Ayubia National Park, Pakistan	Pakistan Journal of Botany
The role of collective action in the marketing of underutilized plant species: Lessons from a case study on minor millets in South India	2009	20	Agriculture; Business & Economics; Food Science & Technology; Nutrition & Dietetics	Minor millets	Kolli Hills, south India	Food Policy
Emmer (*Triticum dicoccon*) Production and Market Potential in Marginal Mountainous Areas of Turkey	2009	9	Environmental Sciences & Ecology; Physical Geography	*Triticum dicoccon* (Emmer)	Kastamonu and Sinop provinces in the Black Sea region, Turkey	Mountain Research and Development
Women's Traditional Knowledge, Use Value, and the Contribution of Tamarind (*Tamarindus indica* L.) to Rural Households' Cash Income in Benin	2010	14	Plant Sciences	*Tamarindus indica L.* (Tamarind)	Benin	Economic Botany
The Situation for Quinoa and Its Production in Southern Bolivia: From Economic Success to Environmental Disaster	2011	32	Agriculture	*Chenopodium quinoa* (Quinoa)	South Bolivia	Journal of Agronomy and Crop Science
Value chains of cherimoya (*Annona cherimola* Mill.) in a centre of diversity and its on-farm conservation implications	2013	1	Biodiversity & Conservation	*Annona cherimola* Mill. (Cherimoya)	southern Ecuador and northern Peru	Tropical Conservation Science
Monkey jack: underutilized edible medicinal plant, nutritional attributes and traditional foods of Western Ghats, Karnataka, India	2014	0	Plant Sciences	*Artocarpus gomenzianus Wall.ex Trecul* (Monkey jack)	Western Ghats, Karnataka, India	Indian Journal of Traditional Knowledge
Conservation of *Brosimum alicastrum*, an underutilized crop and keystone forest tree species; a potential win-win for conservation and development in Latin America	2015	1	Biodiversity & Conservation; Environmental Sciences & Ecology	*Brosimum alicastrum*, Moraceae (Maya nut)	Latin America	Biodiversity and Conservation
Spiny coriander (*Eryngium foetidum* L.) cultivation in the Chittagong Hill Tracts of Bangladesh: Sustainable agricultural innovation by indigenous communities	2017	0	Plant Sciences	*Eryngium foetidum L.* (Spiny coriander)	Chittagong Hill Tracts of Bangladesh	Indian Journal of Traditional Knowledge

4.3 Compared methodologies in identified studies

Table 4 summarizes the methodology of the articles. The most common method of data collection was a questionnaire method, which was used in five cases of nine. Then was often used focus group discussions (FGD) with farmers and households 3/9 and individual interviews 3/9. Combined methods have been used in five cases. Two documents differing methodology. One is based on author's experience and long-term observations. This study has also unknown number of respondents, but the author argues that *"it rather is a reflection and presentation of the author's personal impression"* (Jacobsen, 2011) than the original scientific publication and still has the highest number of citations - 32 in these socio-economic studies. Second is based on collecting of plant samples and analysing of them and due to focus of the study there was no need have respondents.

Regarding the number of respondents and geographic spread, the greatest research has been made by Wouter Vanhove and Patrick Van Damme in 2013. Their methodology in the study is additionally described in detail and the research lasted for one year. As the second document is written by Giuliani et al. in 2009. They have fewer respondents and smaller location than Vanhove and Van Damme, but they used all three methods of data collecting – the questionnaire, FGD and individual interviews.

Table 4. Compared methodologies in identified studies

	Focus of study	Method used	Locality	Number of respondents	Reference
1.	Market survey	Questionnaires, monitoring market, interviews	Pakistan	30 local collectors and merchants; Unknown of traders	Sheikh and Sumaira, 2007
2.	Analysis of the market development initiative	Focus Group Discussions	India	12 groups of stake holders (established by MSSRF)	Gruère et al., 2009
3.	Value chain survey	Questionnaires, Focus Group Discussions, interviews	Turkey	28 FGDs households, 50 households, 7 key market actors	Giuliani et al., 2009
4.	Market survey	Semi-structured interviews	Benin	175 women	Fandohan et al., 2010
5.	Risks intensification of cultivation	Long-term observation	Bolivia	Unknown	Jacobsen, 2011
6.	Value chain survey	Questionnaires	Ecuador, Peru and Bolivia	152 producers, 434 traders, 36 processors, 501 consumers	Vanhove and Van Damme, 2013
7.	Value chain survey	Questionnaires, personal discussions	India	Unknown	Sarala and Krishnamurthy, 2014
8.	Genetic conservation and human development	Microbiological and genetic analysis	Latin America	None	Lander and Monro, 2015
9.	Value chain survey	Focus Group Discussions, semi-structured questionnaires	Bangladesh	30 farmers, 40 households	Hossain et al., 2017

5. Discussion

This thesis provided an overview of the available scientific literature dealing with the NUS from the economic perspective. Generally, scientific community is increasingly concerned with NUS with a great interest of the studies is dedicated to genetic variations, nutritional and biochemical composition and last but not least renewable energy. Although the economic potential NUS is already presented in those studies, there is still a lack of studies published on economic issues. This means that the scientific community does not attach importance to this issue yet, despite the many facts that support the need to address this issue (De Smedt et al., 2011; De Caluwé et al., 2009; Gruère et al., 2006; Williams and Haq, 2002; United Nations, 1992). On the other hand, socio-economic perspective is usually connected to multidisciplinarity of so-far published studies.

The analysed studies agree on the reasons why it is necessary to conduct research in this direction. NUS were often forced out of its original area and its markets by commercially advantageous crops. Resulting in a reduction of agro-biodiversity, therefore, diet diversity of local communities, as well as new fields of industrialization and intensive monoculture agricultural land and damaging the ecosystem, thus in future economic income from the new prevailing crops will reduce. It was mentioned several times the need for new options in maintaining food security in the context of global climate change. This created a need to address alternatives to further cultivate and generate income in a sustainable system.

There was a lot of similarity in the conclusions of the studies. For example, they showed a potential to enhance the financial and environmental well-being of farmers with including NUS to cultivation. Group efforts have a greater impact and a chance to get NUS into the minds of larger merchants. Government engagement and, above all, catering in the public sector, such as hospitals and schools, would have a huge impact on the potential use of NUS.

This study is not without limitations. First, as mentioned earlier, socio-economic perspective is already contributing to identified studies, which are of interdisciplinary character. Secondly, using Web of Science as the only reference source, bring us the advantage to work with reviewed papers published in high-ranked scientific journals. On the other hand, many other sources were omitted. Thirdly, only combination of two key words was applied to identify suitable articles. Last, but not least, despite of the fact that this survey present quite nice picture of available scientific literature on NUS, more detailed research should be done in that field. Considering the level of knowledge on biodiversity in different geographical locations, next review should be strictly geographically oriented and only well documented species, such as nutritional value, chemical composition or traditional use, could be further considered for socio-economic analyses.

There is a project 'Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa' with aims to build capacities and to foster an enabling policy environment in Africa for the development of enhanced value chains for NUS. It was running from 2014 to 2016, and was supported by the ACP Science & Technology Programme, ACP Secretariat, European Union, the CGIAR Research Programmes on Policies Institutions and Markets (PIM) and Climate Change, Agriculture and Food Security (CCAFS). It was focused on Bambara groundnut (*Vigna subterranea*) and amaranth (*Amaranthus spp*.) in Benin, Kenya and Zimbabwe (Biodiversity international, 2014). Similar projects are a great example of the impact of previous studies (e.g. Azam-Ali SN, 2007; Basu S et al., 2007; Johns and Eyzaguirre, 2007) that with their information have helped the world organizations to plan and target support precisely.

My results could serve to local decision-makers to improve the food and nutrition security of the communities living in the geographical location of focused studies. My results could serve to visualize and highlight the market niches as well to other scientist to continue in our research. Further research could be oriented on deep analysis of published articles in identified journals, e.g. Economic Botany (EB), Mountain Research and Development (MRD), and Genetic Resources and Crop Evolution

(GRCE). Although the magazine GRCE did not find in terms of this research study focused on the economic potential of NUS, it had far more researches on NUS than the other journals. It seems like a good resource for further socio-economic studies of plants whose characterization has been described in earlier research. I would like to recommend as well Indian Journal of Traditional Knowledge (IJTK) thanks to its numerous studies on the topic of NUS and more socio-economically targeted, but its classification is worse than previous periodicals (see Table 1). However, it is still source maintained in the recognized database Web of Science. Finally, based on my research, I can recommend two groups of authors of scientific studies as a model for future research - Wouter Vanhove with Patrick Van Damme and Alessandra Giuliani et al.

6. Conclusion

Majority of identified studies deals with agriculture, plant sciences and food sciences and technology scientific categories. Basically, engaged in species identification, nutritional values estimation, mapping local species occurrence. Economic and social studies remain rather limited. However, this study clearly illustrates the direction of NUS studies in general and the socio-economic studies in particular. With the changing climate, the importance of using alternatives such as NUS is increasing. Many studies have agreed that the involvement of group efforts, NGOs, but also governments, and in particular the public sector, has a major impact on the economic potential of NUS. Next review should be strictly geographically oriented to only well documented species to support the future effort to bring NUS to the world markets. The three journals and two groups of authors have been recommended for future deeply research regarding the number of citations, journal evaluation and methodology of studies. There is still a need to explore NUS to find new ways to ensure food security, improve the nutritional balance of rural communities' food and fill the world markets niches for their economic income.

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