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The cultivation of wild food and medicinal plants for improving community livelihood: The case of the Buhozi site, DR Congo

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Abstract

This study aims to demonstrate the effect of farming technology on introducing medicinal plants (MP) and wild food plants (WFP) into a traditional agricultural system within peri-urban zones. Field investigations and semi-structured focus group interviews conducted in the Buhozi community showed that 27 health and nutrition problems dominated in the community, and could be treated with 86 domestic plant species. The selected domestic MP and WFP species were collected in the broad neighboring areas of the Buhozi site, and introduced to the experimental field of beans and maize crops in Buhozi. Among the 86 plants introduced, 37 species are confirmed as having both medicinal and nutritional properties, 47 species with medicinal, and 2 species with nutritional properties. The field is arranged in a way that living hedges made from *Tithonia diversifolia* provide bio-fertilizers to the plants growing along the hedges. The harvest of farming crops does not disturb the MP or WFP, and vice-versa. After harvesting the integrated plants, the community could gain about 40 times higher income, than from harvesting farming crops only. This kind of field may be used throughout the year, to provide both natural medicines and foods. It may therefore contribute to increasing small-scale crop producers' livelihood, while promoting biodiversity conservation. This model needs to be deeply documented, for further pharmaceutical and nutritional use.

Key Words: Integrated agriculture, peri-urban zone, medicinal plants, wild food plants, community building

Introduction

During the last decades, agriculture in numerous African countries has been confronted with decreases of production yield, and less competitiveness for market access [1,2]. Subsequently, food and nutritional insecurity has been increasing gradually at household levels, especially in the rural areas that are occupied by more than 70% of the population. The situation is catastrophic within the African Great Lakes Region [3], and especially in DR Congo [4,5] where the Human Development Index is critical [6].

In the eastern part of DR Congo, rural food assets are limited in quality, and lead to several scenarios of malnutrition, affecting children of different ages, and women in post-conflict areas [4-6]. In such conditions, community access to better health care services is lacking, and governmental institutions are not able to support even the common illnesses. Due to this situation, local villagers rely on the traditional knowledge of medicinal plants (MP) and wild food plants (WFP), as a way of self-reliance in health and nutrition. The first preliminary survey showed 277 traditional medicine practitioners, who are active in both urban and peri-urban areas, collect MP material from the wild, using unsustainable methods [7]. Since crop production on poor and eroded soils does not help to ensure food security, cultivating WFP and MP could become an option for improving livelihoods in the households of small-scale farmers.

Buhozi is selected as a study site since Buhozi village is a typical farming zone, directly linked to the City of Bukavu from the Panzi urban district. Buhozi has predominant banana plantations, mixed with bean, maize and cassava farms. The majority of people are small-scale farmers who produce beans, cassava and corns just for household consumption. The peri-urban zones around Bukavu City are not taken into account for support from Humanitarian Development agencies, while people suffer from extreme poverty and hunger, as well as from various chronic

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illnesses.

It is recognized that 80% of poor people rely on local medicinal plants to heal their illness. Plants are collected from bushes and fallows, which are perpetually deteriorated by overpopulation and poor environmental policies [8]. About 60% of Buhozi households are led by women who are poor, jobless and illiterate, and who at the same time, manage about 6 children below 15 years old. Seventy percent of youngsters are less educated, and work in Bukavu and surroundings as domestic servants, heavy carriers, millers or house builders/repairers, with poor monthly salaries. There is only one health center, with poor infrastructure, which serves about 3,750 inhabitants. Malaria, sexually transmitted diseases, water-borne diseases and malnutrition are major health problems in Buhozi.

This study aims to introduce innovative agricultural techniques, to integrate WFP and MP into the existing agricultural system at the Buhozi experimental site. Consequently, after conducting this study, and utilizing the cultivated WFP and MP, people in the community can eventually improve their income, health and nutrition status.

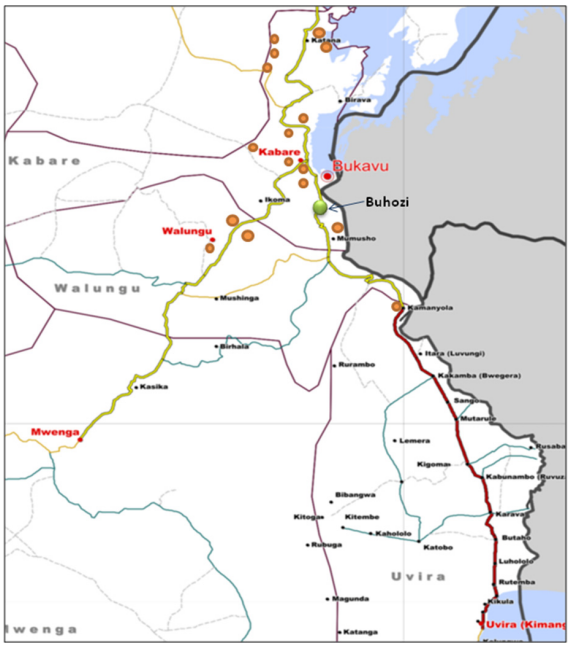

Fig. 1. Plant collecting sites for Buhozi

Subjects and Methods

This study was commenced with a focus group interview, to find out the willingness of Buhozi villagers to cultivate WFP and MP, followed by identifying the health problems of the community. Then, the researchers found traditional WFP or MP that corresponded to the identified problems. Once the listings of the plants were completed, we integrated these plants into the existing farming system for cultivating. After the harvest of some plants, the economic effects and the nutritional values of the selected plants were analyzed.

Subjects

Study subjects were recruited from members of the OBWOLOLOKE organization during June 2011. OBWOLOLOKE, meaning "Woman raise up and take care of yourself", is a community-based development group, organized by women in Bukavu from 2008, which aims to overcome poverty in the post-conflict region, through sound initiatives in agriculture and peace-making. The focus group interview was conducted with 35 participants, to assess community needs concerning health, nutrition and motivation, for bringing WFP and MP into existing agricultural cultivation [9]. We used the baseline study protocol tailored by NGOs, Diobass and PPLM [10], with a direct orientation towards health and sickness aspects, local knowledge, and practices based on botanicals and the environment [10,11]. Additionally, through a semi-structured interview, we tried to identify the major incentives for WFP and MP cultivation, and collection sites of seeds or plant materials. For all questions, the subjects were allowed multiple answers.

Study site and planting

The land for experimentation and technical facilities were provided by the ULPGL (Université Libre des pays des Grands Lacs) administration, through international cooperation. The management scheme (mapping) of the garden has been drawn at community levels, and the collecting agenda of WFP and MP has been defined by OBWOLOLOKE members, by regrouping 42 Buhozi households. Based on the results of needs assessment, 37 WFP & MP, 2 WFP and 47 MP were selected, and then planted on prepared land in Buhozi, according to the mapping. The cultivation started from September, 2011. Germoplasmes of those plants containing cuttings, seedlings, or seeds [12-16], have been collected from the territory of Kabare (Fig. 1). Plant identification has been done from available facilities of the Economic Botany Unit at the CERUKI (Centre de Recherches Universitaire du Kivu, ISP Bukavu, DR Congo), from useful floras [17-22].

The field is arranged in a way that living hedges made from *Tithonia diversifolia* provide bio-fertilizers to WFP and MP growing along the hedges. Cultivation was conducted by 40 OBWOLOLOKE members, along with their existing agricultural plants.

Monitoring and analyses of nutritional values of WFP and MP

The follow-up to cultivation was done by weekly field visit, based on the growth status of plants. Photographs were taken at different growth stages. The frequencies of use of the cultivated plants (WFP or MP) were counted, at a regularly scheduled meeting with 40 people of the OBWOLOLOKE team.

The harvest was done all year around, whenever the plants were ready, after one year of seeding. The prices of the harvested plants were surveyed at the local markets in Bukavu City, and the additional income from the integrated plants was estimated with the market price.

Nutrients analyses of selected plants were conducted. At this preliminary stage, five plants of *Amaranth cruentus, Harunagana madagascariensis, Harunagana montana, Moringa stenopetala* and *Tremma orientalis* were selected for nutritional analyses. The Harungana family was selected, due to its abundance in the area, and the rest were selected, due to their well-known traditional usages. Thiamin, ascorbic acid, niacin and pyridoxine were analyzed simultaneously using HPLC. Vitamin E was analyzed using GC-FID. Mineral contents of the Harungana family were also analyzed using ICP-MS.

Results

Results of needs assessment

Investigation, driven by 35 members of OBWOLOLOKE of Buhozi, interviewed separately, showed seven motivations for bringing wild food and medicinal plants into cultivation (Table 1). Twenty-seven types of existing illnesses or malnutrition, which affect household members in Buhozi, were found through focus group interview (Table 2). Illnesses that are predominant in children of less than 15 years also exist. Out of 27 illnesses, eight types of illnesses were chronic tendency (+++), including malaria, alcoholism, dermatitis, verminosis, food poisoning, sexually transmitted disease and acute gastritis, which affect all household members (men, women and children). Periodic illnesses (++) were recorded as flu and cough. Illnesses, observable in only isolated cases (+), were HIV/AIDS, uterine prolapse and sexual asthenia.

Selection of plants and integration into the existing agriculture

According to the results of the survey, a total of 86 plants were selected, in order to ameliorate the major health problems of Buhozi (Table 3). The plant species were collected from varied agro-eco systems, such as bushes, managed medicinal gardens, fallows, riparian zones of Kahuzi Biega National Park, and the Ruzizi valley. The table shows 37 plants with both food and medicinal effects, which are already cultivated in Buhozi. Among them, 16 can be used as vegetables (source of minerals and vitamins), 3 species can be eaten as fruit (source of minerals and vitamins), 2 different species can be eaten as tubers (sources

Table 1. Motivation scheme for wild food and medicinal plants cultivation in Buhozi site

Motivation	N (%)
For self healthcare at home	35 (100)
To develop capabilites for local process of wild food and medicinal plants	28 (80)
To keep the local tradition on usages of wild food and medicinal plants	27 (78)
For sale at markets	9 (26)
For sale to traditional medicine practitioners	25 (72)
To minimize expenses for health cares	28 (80)
To build community center to share knowledge on usages of wild food and medicinal plants	20 (58)

Table 2. List of common illnesses and major health problems in Buhozi

Common illness and health problems	Women	Men	Children
Alcoholism	+++	+++	
Amibiasis	+++	+++	+
Anaemia			+
Dental caries	+	+	
Dermatitis	+++	+	+++
Diabetes	+	+	
Epilepsy	+	+	+
Sexual asthenia		+	
Typhoid fever	+	+	+
Frigidity		+	
Acute gastritis	+++	+++	+
Flu	++	+	++
Hepatitis	+	+	
High blood pressure	+	+	
Sexually transmitted disease	+++	+++	
Hypolactation	+		
Food intoxication	+++	+++	+++
Kwashiorkor			+
Malaria	+ ++	+++	+++
Uterine prolapsus	+		
Prolapsus anal	+		
Painful menstruation	++		
Rheumatism	+	+	
Cough	++	++	++
Vision insufficiency	+	+	+
Verminosis	+++	+++	+++
HIV/AIDS	+	+	

+++ Chronic tendency diseases, ++ Periodic diseases, + Disease recorded from isolated cases

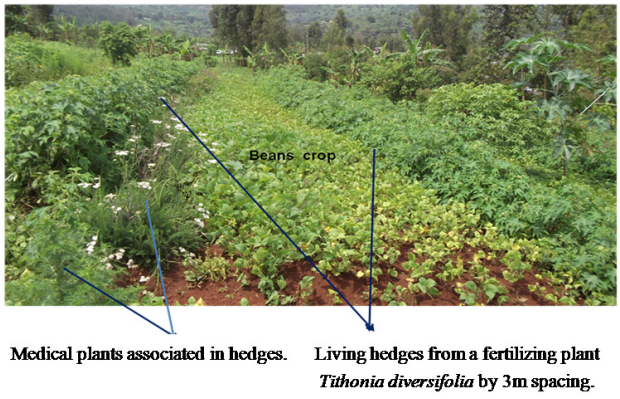

Fig. 2. Integrating wild food and medicinal plants within bush bean cultivating plot

Table 3. List of wild food and medicinal plant species and the usages

N°	Scientific names	Vernacular name	Usage		Remedies and mode of usages
1	*Abrus precatorius*	Abrus		MP[1)]	Aphrodisiac, myorelaxant, antidiabetic
2	*Achillea millefolium*	Achillée		MP	Antibacterial, parasiticide, insecticide anti-cancer, myo-relaxant, expectorant, strengthening the immune system
3	*Ageratum conyzoides*	Kahyole		MP	Cough, antibacterial, wound dressing, insecticide,
4	*Agrocharis incognita*	Celeri ya pori		MP	Antimalarial, intestinal worms
5	*Alchemilla kivuensis*	Alchemilla		MP	Antibacterial, fungicide, parasiticide,
6	*Allium sativum*	Garlic	WFP[2)]	MP	Food poisoning, intestinal worms,
7	*Aloe barbadensis*	Cigaka		MP	Parasiticide, fungicide, antibacterial, wound dressings, strengthening the immune system
8	*Amaranthus cruentus*	Amarante inca	WFP	MP	Vegetable
9	*Amaranthus viridis*	Local Amarante	WFP	MP	Vegetable
10	*Annona squamosa*	Mustafère	WFP	MP	Vegetable
11	*Artemisia annua*	Armoise chinoise	WFP	MP	Antimalarial, menstruation disorders, strengthening the immune system, gastric tonic
12	*Blumea alata*	Chirhabirhabi		MP	Cough, snake bite
13	*Bombacopsis glabra*	Kalanga ya wazungu	WFP	MP	Cough, aphrodisiac, furuncle
14	*Borago officinalis*	Bourrache	WFP	MP	Cough, antibacterial, wound dressing,
15	*Brillantaisia cicatricosa*	Namadwi		MP	Antidote, parasiticide, wound dressing, kwashiorkor
16	*Calendula officinale*	Souci		MP	Dysmenorrhea, vaginal candidosis, wound dressing
17	*Canavalia gladiata*	Cikubwekubwe		MP	Parasiticide, antibacterial, wound dressing, antidote
18	*Cannabis sativa*	Ibangi		MP	Abdominal disorders, anxiolytic
19	*Celosia trigyna*	Kabalala nkwale		MP	Intestinal worms, snake bites, strengthening the immune system,
20	*Chenopodium ambrosioides*	Kivunjahoma		MP	Parasiticide, fungicide, antibacterial, wound dressings, fungicide
21	*Chenopodium procerum*	Mugunduzimu		MP	Antibacterial, parasiticide, insecticide, antiviral, bronchite
22	*Clerodendrum myricoides*	Mukuza nyena		MP	Intestinal worms, snake bites
23	*Crassocephalum bumbense*	Mufulubwindi	WFP	MP	Wound dressing, hemorrhagia, placenta expellent
24	*Crassocephalum vitellinum*	Nshungululu		MP	Hepato-protecter, wound dressing, parasiticide, antioxidant
25	*Cucurbita maxima*	Pumpkin	WFP	MP	Vegetable
26	*Cucurbita pepo*	Pumpkin	WFP	MP	Vegetable
27	*Cymbopogon citratus*	Lemon grass	WFP	MP	Hypoglycemic effect, febrifuge, diuretic, insecticide, aphrodisiac, tea
28	*Datura metel*	Chamukwale		MP	Myo-relaxant, neuro-stimulant, wound dressing
29	*Datura stramonium*	Nyamugunga		MP	
30	*Dicliptera colorata*	Mpindula		MP	Strengthening the immune system, parasiticide, antiviral, antibacterial, anti-anemic
31	*Dioscorea bulbifera*	Yam	WFP	MP	Tubers
32	*Dioscorea dumetorum*	Yam	WFP	MP	Tubers
33	*Embelia schimperi*	Kashalula	WFP	MP	Vegetable
34	*Equisetum ramosissimum*	Prèle de champs		MP	Osteoporosis, parasiticide, fungicide
35	*Erythrina abyssinica*	Cigohwa		MP	Hepatitis, sexual asthenia, furuncles
36	*Eucalyptus maideni*	Eucalyptus		MP	Insecticides, flu, female frigidity
37	*Gladiolus psittacinus*	Glaïeul		MP	Antibacterial, parasiticide, insecticide, antiviral, intestinal worms, food poisonings
38	*Guizotia scabra*	Cimbehe		MP	Skin and mental disorders
39	*Gynandropsis gynandra*	Muhole	WFP	MP	Parasiticide, fungicide, antibacterial, wound dressings, insecticides
40	*Harungana madagascariensis*	Ndwamuko		MP	Food poisoning, intestinal worms, hepatitis, snake bites
41	*Hibiscus noldae*	Mukera nshungu		MP	Myomes, dermatosis, abdominal disorders
42	*Hygrophila auriculata*	Buganga bukali		MP	Uterine prolapse, antimalarial, dermatosis
43	*Hypoxis subspicata var. esculenta*	Wild tomato	WFP	MP	Hormonal stimulant, wound dressing, parasiticide
44	*Lantana camara*	Maviyakiku		MP	Myo-relaxant, neuro-sedative, expectorant, snake bite
45	*Laportea alatipes*	Ortie	WFP	MP	Strengthening the immune system, parasiticide, antiviral, antibacterial, fractures, hepatitis
46	*Lavandula offinalis*	Lavande	WFP	MP	Antibacterial, parasiticide, insecticide, myo-relaxant, neuro-tonic, strengthening the immune system
47	*Leucas martinicensis*	Kanyamafundwe		MP	
48	*Matricaria camomilla*	Camomille		MP	Internal inflammation, parasiticide, antioxydants
49	*Melia azedarach*	Lilas de Perses		MP	Parasiticide, fungicide, antibacterial, wound dressings, insecticides, strengthening the immune system, insecticide, antimalarial
50	*Melissa officinale*	Melisse	WFP	MP	Aantibacterial, parasiticide, insecticide myorelaxant, expectorant, somniferous, gastritis

Table 3. continued

N°	Scientific names	Vernacular name	Usage		Remedies and mode of usages
51	*Mentha piperita*	Peppermint	WFP	MP	
52	*Moringa oleifera*	Moringa	WFP	MP	Parasiticide, antiviral, antibacterial, antioxidant, wound dressing, gastric tonic, insecticide
53	*Morus nigra*	Mulberry	WFP	MP	Antibacterial, wound dressing, strengthening the immune system
54	*Ocimum basilicum*	Basilic	WFP	MP	Myo-relaxant, parasiticide, strengthening the immune system
55	*Pelargonium graveolens*	Géranium rosat		MP	Insecticide, cough, allergies cutanées
56	*Physalis peruviana*	Mbuma	WFP	MP	Parasiticide, strengthening the immune system
57	*Piper capense*	Forest pepper	WFP	MP	Parasiticide, fungicide, antibacterial, wound dressing, strengthening the immune system, insecticide, antimalarial
58	*Plantago palmata*	Chibarhama		MP	Myorelaxant, wound dressings
59	*Plectranthus barbatus*	Mutuzo gw'ebubembe		MP	Antibacterial, wound dressings, parasiticide, anal prolapsed
60	*Portulaca oleracea*	Matako ya bibi	WFP	MP	Wound dressing, intoxication of gatrsics
61	*Rosmarinus officinalis*	Rosmarius	WFP	MP	Antibacterial, parasiticide, insecticide, myorelaxant, expectorant
62	*Rubus apetalus*	Mangaka	WFP	MP	Mental disorders, infertility
63	*Rumex bequaertil*	Nango		MP	Parasiticide, wound dressings, antibacterial, fungicides
64	*Rumex usambarensis*	Munyugunyugu	WFP	MP	Colitis, gastric ulcers, tonsilitis
65	*Rumex abyssinicus*	Rumex	WFP	MP	Fungicide, uterine pain, myorelaxant
66	*Salvia nilotica*	Chumya		MP	Skin and mental disorders
67	*Salvia officinale*	Sauge	WFP	MP	Antibacterial, parasiticide, insecticide, myorelaxant, expectorant
68	*Senecio cidoniifolius*	Kalalire		MP	Snake bites, verminosis, fractures
69	*Senna didimobotrya*	Sena		MP	Parasiticide, antiviral, antibacterial, wound dressings, insecticides, hepatitis
70	*Senna septemtrionalis*	Mukanganjoka		MP	Epilepsy, snakebites, fungicide
71	*Solanum nigrum*	Mulunda	WFP	MP	Food poisoning, intestinal worms, hepatitis, snake bites
72	*Solanum nigrum var nigrum*	Mulunda	WFP	MP	Vegetable
73	*Spathodea campanulata*	Chifulafula		MP	Ulcers, aphrodisiac, urinary track problems, furuncles
74	*Spilanthes mauritiana*	Cenda		MP	Dental caries, osteoporosis, snake bite
75	*Symphitum officinale*	Consoude	WFP	MP	Wound dressing, fractures, gastric tonic
76	*Synadenium grantii*	Nyamalimbwa		MP	
77	*Tagetes minuta*	Chikanga mbasi		MP	Insecticide
78	*Taraxacum officinale*	Dandelion	WFP	MP	Salades
79	*Tetradenia riparia*	Mutuzo gw'ebushi		MP	Antibacterial, antiviral, fungicide, parasiticides, rheumatism
80	*Thymus vulgaris*	Thym	WFP	MP	Cough, nervous fatigue, verminosis, myorelaxant, tea
81	*Tithonia diversifolia*	Cilula		MP	Intestinal worms, cholera, strengthening the immune system, insecticides
82	*Trema orientalis*	Mushakushaku		MP	Parasiticide, antiviral, antibacterial, antioxidant, anti-aging, wound dressings, insecticides, fracture
83	*Tropaeolum majus*	Capucine	WFP	MP	Antibacterial, parasiticide, antioxidant, myo-relaxant, expectorant, strengthening the immune system
84	*Vernonia amygdalina*	Mubirizi		MP	Antimalarial, anti-diabetes, strengthening the immune system
85	*Vigna unguiculata*	Niébé	WFP		Vegetable, grains
86	*Zingiber officinale*	Gingembre	WFP	MP	Myo-relaxant, wound dressings, aphrodisiac, hepatoprotector, poisonings

[1] MP, Medicinal plants
[2] WFP, Wild food plants

of polysaccharides), and 7 types of herbs can be grown and served as spices and refreshing teas. Additionally, 2 species can be used as food sources only. Table 3 also shows utilization profiles of the 47 MP cultivated in Buhozi. Out of 84 species recorded as MP, 70% are indigenous (afrotropical), whilst 30% are described as exotic.

A basic knowledge of MP usages was derived from workshops undertaken at community level. It was completed and validated through literature reviews [13,23-27].

Fig. 2 shows the disposition of the experimental field (0.25 ha = 2,500 m^2), with mixed crops alternating between living hedges of *Tithonia diversifolia,* spaced from 3 m. WFP and MP are mixed in with crops (bush beans, maize and sweet potato).

Economic opportunities from cultivated plants

Table 4 shows the differences of generated incomes between traditional income crops (beans and maize) of the Buhozi community, and selected MP cultivated together on the same plots, but harvested at different periods. The comparison is enforced by the price found on the Bukavu market. The estimated gain of the community by cultivating the special MP during

Table 4. Income through cultivating medicinal and wild food plants from local market

Products	Market price per 1 kg (US dollar)	Harvested quantity and area	Estimated gain (US dollar)
Traditional crops			
Beans	2	35 kg[1)] from 2,500 m^2	70
Maize	0.8	10 kg[1)] from 2,500 m^2	8
Integrated plants			
Artemisia annua	125	20 kg from 200 m^2	2,500
Calendula officinale	200	0.5 kg from 100 m^2	100
Laportea alatipes	50	1 kg from 100 m^2	50
Mentha piperita	20	0.5 kg from 100 m^2	10
Thymus vulgaris	100	1 kg from 100 m^2	100
Vernonia amygdalina	100	3 kg from 100 m^2	300

[1)] Available amount for sale after domestic consumptions

Table 5. Individual frequencies for the uses of growing medicinal plants on the site

Plants	Main reason for plant collection	Number of collectors from January to June 2013
Artemisia annua	Malaria	20
Guizotia scabra	Intestinal worms	5
Guizotia scabra	Abdominal pains	5
Plantago palmata	Wounds	7
Plantago palmata	Tonsilitis	10
Aloe barbadensis	Diarrhoea	8
Aloe barbadensis	Burr	7
Tithonia diversifolia	Intestinal worms in goat	25
Tetradenia riparia	Cough	10
Cymbopogon citratus	Fever	15
Brillantaisia cicatricosa	Gastroenteritis in infants	5
Laportea alatipes	Rats traps	9
Trema orientalis	Fracture	2
Vernonia amygdalina	Malaria	9
Rosmarinus officinale	Exhaustion	8
Rosmarinus officinale	Food spice	4
Physalis peruviana	Abdominal pain in infants	10
Dicliptera colorata	Anaemia	7
Achillea millefolium	Dysmenorhea	15
Symphitum officinale	Vegetable	12
Symphitum officinale	Gastritis	4
Harungana madagscariensis	Food poisoning	3
Harungana madagscariensis	Hepatitis	2

2012-2013 is 3,060 US dollars, which is about 40 times higher than the income from traditional cash crops only (78 US dollars). Table 5 shows the frequencies of collecting and sporadic uses of medicinal plants from Buhozi garden according to individual circumstances. These results demonstrate that 16 species of the plants are often exploited as phyto-medicine. Among them, two are used as food.

Table 6 shows the results of the micro nutrients analyses of the selected plants. Amaranth, moringa and trema were rich in vitamin E and vitamin B_6. Amaranth also showed high vitamin B_1 content. Harungana showed high mineral values, although it did not show any vitamin contents.

Discussion

Oxfam Novib [28] reported that during the last two decades, millions of people have succeeded in escaping poverty. At the same time, one out of five still lives in poverty, while one out of seven suffers from chronic hunger. According to the 2008 World Bank report, one billion in the world live on less than one dollar per day, and 2.7 billion live on less than 2 dollars per day. The majority of them are women. Promoting food security with community-based adaptation for alleviating poverty should be tried. Action research provides broader initiatives and

Table 6. Micro-nutrient compositions of the selected plants (mg/100 g)

Micro-nutrient/Sample	*Amaranthus cruentus*	*Harungana madagascariensis*	*Harungana montana*	*Moringa stenopetala*	*Trema orientalis*
Vitamin E	22.17	Nd[1)]	Nd	34.2	29.90
Vitamin C	Nd	Nd	Nd	6.19	2.49
Vitamin B_1	39.00	Nd	Nd	Nd	Nd
Niacin	Nd	Nd	Nd	Nd	Nd
Vitamin B_6	8.00	Nd	Nd	475.06	73.20

	Harungana madagascariensis		*Harungana montana*
	Leaf	Bark	
Calcium	16.0 ± 0.7	16.0 ± 0.9	15.5 ± 0.9
Copper	5,390.0 ± 0.3	5,250.0 ± 0.1	1,150.0 ± 0.3
Iron	3,010.0 ± 2.1	18,000.0 ± 51.6	2,740.0 ± 0.1
Potassium	6,120.0 ± 3.5	29,970.0 ± 24.7	11,200.0 ± 5.8
Magnesium	125.0 ± 0.8	8.0 ± 0.2	7.5 ± 0.0
Sodium	58.0 ± 0.0	11.0 ± 4.2	12.2 ± 2.3
Phosphorus	8,440.0 ± 9.8	9,220.0 ± 9.4	7,870.0 ± 8.9
Selenium	82.0 ± 2.57	152.0 ± 0.3	1,280.0 ± 0.0
Zinc	628.0 ± 63.5	675.0 ± 0.1	1,250.0 ± 0.0

[1)] Nd: not detected

experiences, which can lead to changes of community, where efforts of Humanitarian agencies are lacking, as in the peri-urban zones of Bukavu city. Katwanyi et al. [8] reported that these zones appear as passage-ways of human movements toward rural areas, in the territories of Walungu and Kabare. The results of the action research of our study improved the economic status of the community, as well as the nutrition and health status.

The health problems found in the study area (Table 2) seem to be related to environmental damage, or to extreme poverty [6]. In general, among 27 illnesses recorded, 24 are related to female, 19 to male and 13 to children. Since HIV/AIDS is found in Buhozi, one can imagine that the combined effects of alcoholism, poverty and general illiteracy propagate this pandemic at large scale, in the peri-urban and urban areas. Peri-urban zones have complex social features that must be monitored, in the movement towards sustainable development. People in these areas work as home workers, bikers, sentries, or home servants in the city. On the other hand, because of poverty, these villages often become potential refuges for informal armed groups or rebels. However, at the same time, the same villages provide vegetables, bananas, hens and rabbits, as well as honey for the city. By introducing an integrated agriculture, these villages can provide medicines and vegetables, which can reinforce the farming savings. The seven different expectations from Buhozi people towards developing WFP and MP (Table 1) are summarized as 1) developing self-reliance in health care at the community level, 2) producing and processing home medicines, 3) providing raw materials to traditional medicine clinics available in the city of Bukavu, and 4) conserving and protecting local knowledge on medicinal plants uses.

The incentives evoked by these farmers meet the aims of ANAMED International [29], and those of Neema [30], which are to promote natural medicine, and at the same time, to integrate environmental management and cultural diversity. Although small-scale farming activities show little profitability to ensure the food security of the producers, previous studies reported that intercropping aromatic and medicinal plants on farmland provided economic and social opportunities that support biodiversity conservation [31-35]. In the present study, we attempted to introduce MP and WFP that meet the needs of the Buhozi community. All the plant species we listed for WFP (Table 3) are well documented for their nutritional and medicinal properties [13,27,29,36-40], and provide food sources for Buhozi, where people suffer from severe food insecurity [8,41]. The nutritional values of the selected plants were also confirmed by this study. The traditionally renowned edible plants of amaranth, moringa and trema showed high vitamin E and B_6. Harungana did not show any vitamins, but does have high copper, iron, potassium phosphorous and zinc contents. Even if harungana is not considered to be an edible food plant, its mineral contents are high, offering a remedy to certain malnutrition syndromes, such as anemia.

However, the majority of these plants are listed as under-utilized plants species [14,42-43]. Their domestication at the Buhozi sites is a way of combining conventional and non-conventional food, for food security and market access for poor communities. Medicinal properties for responding to the illnesses, particularly predominating in Buhozi (Table 2), have already been described in several scientific literatures [13,23-26,40]. The present results corroborate the publication [23] on widespread medicinal plants within the Bukavu region since 1950. Out of 84 plants already showing medicinal properties, 37 plants can be used as food with high nutritional values [14,24,37-38], although they are listed as under-utilized species in Africa [8,43]. Since small-scale farmers contribute to the conservation of natural resources, with broad agricultural mixtures, the environment status can be improved with a larger biodiversity, in a post-conflicts phase [44]. This is a broader initiative to enhance better foods in a poor community of the peri-urban and urban zones of Eastern DR Congo [2,6,8]. This approach is confirmed by others, as well [31,33]. They demonstrated how the cultivation of medicinal and aromatic plants can improve livelihoods in small scale producers. Furthermore, 47 species are exclusively medicinal, and can be processed for pharmaceutical purposes.

The disposition of the experimental field (size 0.25 ha = 2,500 m^2) with alternating mixed crops between living hedges of *Tithonia diversifolia* is an innovative farming method that we introduced to the area of Buhozi. WFP and MP were mixed with crops (bush beans, maize and sweet potato) of the existing agricultural system. The selection of *Tithonia diversifolia* is due to its triple advantages: 1) bio-fertilizing properties and ferralitic soil improving properties [45], 2) fodder and veterinary medicine provider for goats [23], and 3) anti-erosive properties [29]. The field profile facilitates the growth of any kind of plant species, and makes weeding and harvesting easier. Farmers can collect what they need from medicinal or food plants, during certain periods, with more sustainability. This innovative farming method provides multi-purposes for a farming plot, with various harvests all the year round. This may positively impact household economies, through its concept of multistage cropping. Medicinal plants grow themselves in fallows, and therefore, farmers benefit from several harvest options of health, nutrition and environmental management. This is a part of the technical recommendations from Shabidullah and Haque [45], as well as from Hirt *et al.* [29]. Therefore, the Buhozi garden offers enormous opportunities to small-scale producers, to raise their economies, and improve livelihoods at village levels.

The market prices of the cultivated plants (Table 5) clearly demonstrate that conventional crops (e.g. beans or maize) grown in a 0.25 ha (2,500 m^2) plot size are less profitable than medicinal plants, in the Buhozi context. It is clear that cultivating crops under a complex agricultural system leads to more attractive market access. Planting certain medicinal plants, of *Artemisia annua, Calendula officinale, Thymus vulgaris* and *Vernonia amygdalina,* is more profitable than planting beans. Literature

from India shows similar results [31-32,45]. By successfully introducing WFP and MP into the existing farming system, the community can improve its health and ameliorate nutrition insecurity, as well as its economic status.

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