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Agro-forest Integration: A Case Study of Mandi Himachal Pradesh for Rural Prosperity, Sustainability and Global Food Security.

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Abstract: *Himalayan ecosystem is a rich storehouse of biodiversity contributing to the wellbeing of humanity by supplying aesthetic, ecological, economic and life sustaining services directly or indirectly. Agro-forest integration in the Himalaya has been the backbone of the economy since ancient times, because commercial cultivation in this region is not as profitable as in plains due to various geographical barriers of the mountain ecosystem. So, a sizable population still remains dependent on agro-forest integration for its well-being. However, from the last few years a shift has been observed from traditional cropping to cultivation of high value cash crops and that is not possible without use of chemical fertilizers and pesticides. As a result, a fraction of these chemicals remain in food items affecting the quality of most agro-horticultural produce, but it seems impossible to entirely stop the use of chemical fertilizers and pesticides to feed the growing human population with shrinking of agricultural land. So, to produce climate smart quality agro-food, we need a green and sustainable model for agro-forest integration and increase carbon sink by enhancing the land cover. After COVID-19 people around the world are also looking for immunity boosting natural produce. To fulfil their need and to achieve sustainable development goals, we need to make agro- forest integration more inclusive, efficient, sustainable and climate smart. For this domestication of some high value multipurpose wild food plants (MWFPs) along with main crops can play a pivotal role. MWFPs are the climate resilient food plants growing in natural habitat, which are source of many other commercially useful commodities besides food. In this study we discussed how the domestication and optimum utilization of MWFPs can help in boosting health income, ecosystem stability and sustainability. MWFPs discussed in present study can be domesticated at field margins, boundaries (as hedge) or at waste land along with main crops, so they can provide natural produce, ensure additional income and eco-restoration. The present study thus aims to analyze the role and scope of 40 MWFPs of Mandi, Himachal Pradesh for domestication and agro-forest integration to overcome food insecurity for zero hunger and malnutrition.*

Key words: *Agro-forest integration; Domestication; MWFPs; Sustainability; Rural prosperity.*

I. Introduction:

Mountain ecosystems covering around 22 per cent of the world's land surface [1] are not only the source of essential life supporting commodities but also the key center of biological and cultural diversity which influences the climate at large. So, it is a locus for contemporary biologist, environmentalist, agriculturist, horticulturist and economist of all over the world. Millions of Himalayan people primarily use agro-forest produce for food and nutritional security. Agriculture in Himalayan ecosystem is mostly integrated with horticulture and sometimes with apiculture. It has traditionally been a 'subsistence based' or 'family farming' system where agricultural production is basically for local consumption [2]. Mandi (31°42' 29.4" N latitudes and 76° 55' 52.92" E longitudes with altitudinal range 500-4034 m.) being the part of Himalayan agro-ecosystem shows many constraints such as fragility, marginal land, inaccessibility and lack of infrastructure viz roads, storage and processing units, testing lab and irrigation facilities.. In spite of such constraints the agro-ecosystem of this region has sustained over years and still continues in fulfilling the basic necessities of life, especially food and nutrients. However, at present it is challenged by several social, economic and environmental stresses such as small landholdings per family, increased rural migration, poor labor availability, disease outbreak, higher cost of production, poor financial resources, environmental pollution, climate change, land fragmentation and soil erosion etc. Reason behind this are modernization, urbanization and westernization. As a result, vulnerable communities (with minimum economic resilience) of this region are suffering in silence. For enhancing yield the use of excessive chemical fertilizers and pesticides is common in modern farming leading to deterioration of human and planet health. As a result, overall, 38 per cent farmer families of the Indian Himalayan region are facing transient/transitory food insecurity [3]. Till now in most developing countries including India sustainable development goals failed to improve the community at large.

Prominent reasons behind this are financial restraint, progressively growing human population and climate change leading to widening the gap between demand and supply. So, we need to look towards a region specific sustainable model for agro-forest integration where people can domesticate some high valued multipurpose wild food plants (MWFPs) to provide both edible and essential life supporting commodities. As MWFPs are excellent in providing food, fodder, fuel, oil, fibre, timber, medicine and material. Their domestication as a hedge or second crop at field margins or boundaries along with main crops can provide additional income, carbon sink and climate smart agro-forest produce. Wild food plants (WFPs) are also climate resilient, so can grow and yield better even in adverse environmental conditions without any use of harmful chemical fertilizers and pesticides [4,5]. Being organic their produce both raw and processed can also be sold at high rate in local, national or international markets. Now food choice and preference of people has changed a lot and after COVID-19 immunity boosting organic produce are one of the major concerns among people. To meet the growing demand of organic produce, domestication and integration of MWFPs with agricultural crops can help a lot. It can ensure eco-restoration, rural prosperity and sustainability of both food and environment [6]. So, present study has been done to analyse the scope and potential of domestication of **MWFPs** towards a sustainable **agro**-forest model for Mandi HP wirh following objectives:

1. To know the present status and need of agro-forest integration in Mandi, HP India.
2. To know the diversity, distribution and potential of MWEPs useful for agro-forest integration
3. To know the potential of MWEPs in eco-restoration and food security.
4. Value addition of harvest for rural prosperity, sustainability and global food security.

II. General Background:

With growing population and shrinking of agricultural land, the demand for food is putting immense pressure on continuity of food supply and ecosystem stability [7]. So, food security and sustainability is a prime focus for the researchers and policy makers, around the globe [4,8]. For this people are working on different aspects of agro -forest interaction to develop sustainable models for enhancing the welfare and quality of life of farmers [9]. Agro-forest integration plays a pivotal role in raising quality food production to meet the economic and dietary requirements of rapidly growing population [10,11]. However, the potential climate change impacts are still unclear more obviously at the regional scales [7] requiring region specific strategies for sustainable agro-forest integration. Planting of interspatial woody perennials, and other land use alternative can act as a resource for poor farmers and add economic value to farms through wood exploitation and natural resources management [12,13]. It can also provide increased values with least negative influences on the agronomic crops in hilly terrain and thus reduce risks in the rural areas [13], In Indian Himalayan Region various geographical constraints challenges the agricultural sustainability and directly affect the agro-potentials of useful crops. [14]. Climate change and uncertainties of weather are also likely to hamper the food security goals in the coming decades, requiring proper research-based strategies at regional level [15]. So, we need a region specific agro-forest model for better results. Present study has been done to develop a sustainable agro-forest modal for Mandi HP by domestication of 40 MWFPs. These plants can be grown between an altitudinal range of 500-4034 m in Mandi and other Himalayan regions with similar altitude and climatic conditions for successful agro-forest integration.

III. Methodology:

3.1Study Area:

Mandi (31°42' 29.4" N latitudes and 76° 55' 52.92" E longitudes) Himachal Pradesh a part of North West Himalaya covers approximately 3,950 km^2 area and comprises 469 panchayats.3374 villages and 2, 19, 145 households The total human populations of study area is 9, 99,777 and livestock population is 67355.Altitudinal range of study area varies from 500-4034 m. It is known for diverse habitats, species, communities and ecosystems. The vegetation is mainly of sub- tropical and temperate types. It is mostly dominated by broad leaved deciduous, evergreen and coniferous types. (District Economic and Statistical Department, Mandi, H.P)

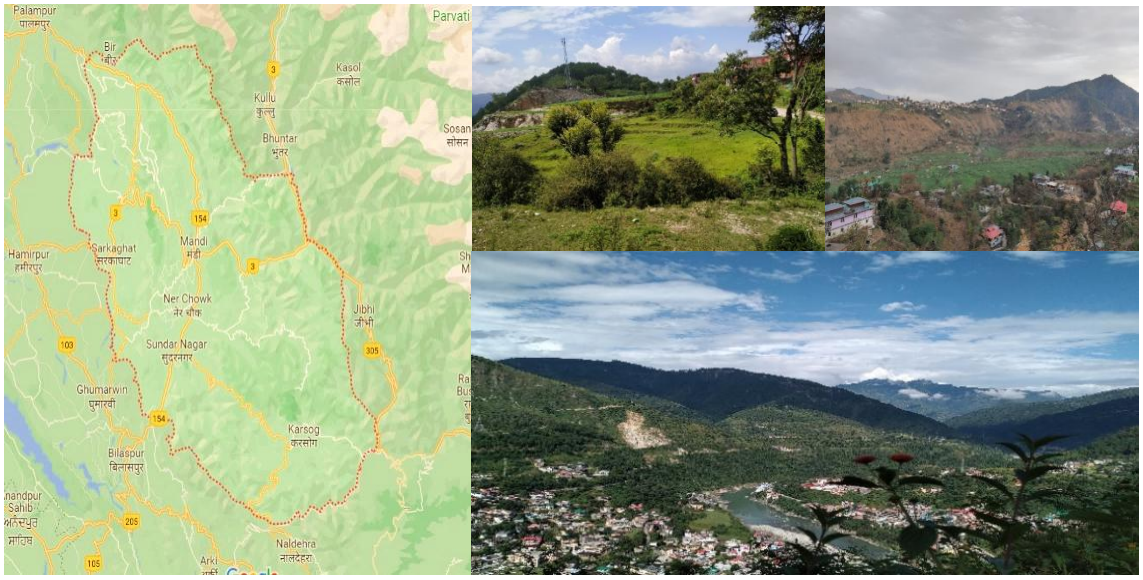


Fig: 1 Showing Goggle map and Study area of Mandi Distt.

3.2 Method:

Present study was based on the survey and sampling (Rapid) of wild food plants between amsl 500-4034 m in Mandi Himachal Pradesh from July 2018 to June 2023. Identification of WFPs was done with the help of local floras [16-18]. Information was gathered through questionnaire. from the knowledgeable persons like traditional hillers, priest and agricultural, horticultural and forest officials of study area. Information was also collected from the People Biodiversity Register (PBR: (managed by PBR managing committee at gram panchayat level) of study area and local seller who are involved in harvesting, preparation, processing and marketing of MWFPs, Knowledgeable persons were interviewed about altitudinal range, habit, habitat (s), method of harvesting, season of availability, market value and utilization pattern of wild food plants, A total no of 230 WFPs were documented in this study. Out of these 40 high valued MWFPs which have 4 or more than 4 uses were selected for domestication and agriculture-forest integration.

IV. Results & Discussion:

4.1 Present status and need for agriculture-forest integration and entrepreneurship development.

The agriculture system in the entire Himalayan region including Mandi has been based on locally available natural resources involving complex linkages among farms, forests and livestock [19]. Traditionally the local community of Mandi mainly practices integrated farming which involves agro-forestry, animal husbandry and forestry. It has been a perfect example of stability and diversity from decades with long term sustenance and overall reflection of the region. So, is the economic backbone of local communities. However, analysis of this agro-pastoral practice has shown that horticulture (apples, walnuts, plums, peaches, cherries, almond, kiwi, etc) dominates in greater and outer region of Mandi, while field crops (rice, maize, wheat, bajara) and vegetables (radish, potato, colocasia, cabbage, cauliflower, pea, beans etc) dominate in lower belt of study area. People in the past used to leave land barren for some time (From 2 to 6 months) to rebuild soil's productivity and resume cultivation cycle called *Jhum*. But with passage of time and with increasing human pressure on land this cycle is becoming shorter day by day (1 to 2 months). As a result, a significant acceleration in soil erosion and nutrient depletion has been noticed leading to deterioration of ecological balance throughout the study area requiring strategies for eco-restoration. Diversification of ongoing farming practice with some MWFPs at field margins can be one of the solutions which can stabilize ecosystems at one end and maintain food and goods supply at another. MWFPs can be treated as a second crop to resume the earlier cultivation cycle. As produce from MWFPs like *Moringa oleifera* (Leaves) and *Opuntia spp (Pads)* can be harvested round the year,so will be useful to earn and meet basic nutrient requirements even during *Jhum*. Crop production alone however cannot suffice the food requirement of the local and global community. Processing and value addition is also required to make produce available round the year. Himalayan economy has remained stagnant for centuries due to lack of entrepreneurship, avenues of investment the lack of knowledge (about huge medicinal, nutritive and economic potential of wild produce) among rural communities and the capital market, due to variable climatic conditions, there are several niche areas in Mandi which are suitable for cultivation of high value cash crops including

medicinal and aromatic plants. As this region is bestowed with opportunities which are unique to these agro-ecosystems, the organic agriculture and several agriculture-based subsidiary occupations can boost the rural economy here. But till now optimum resource utilization has not been achieved due to constraints like tough geography, poor road connectivity, lack of knowledge about vast medicinal and nutritive potential, lack of testing lab, better processing units, store houses and market opportunities. Due to these constraints most of the useful plant produce gets wasted at resource level only, which can be employed in overcoming food crisis as well as in entrepreneurship development. Further due to inaccessibility and poor road connectivity, commercial agriculture in hills is not as profitable and high yielding as in the plains. Thus, we require scientific planning, technical support, better processing units, investment and value addition of agro-forest produce to enhance the shelf life of the produce plus careful management of available natural resources to sustain agro-forest integration. However, a change is now being observed in cropping systems of the entire Himalayan region and farmers are now shifting from paddy and maize cultivation to cash crops like fruits, vegetable and aromatic plants. Agroforestry is the traditional land use system where the two main components i.e. trees and shrubs are artificially managed with the agricultural crop [20]. This is one of the autonomous strategies to adapt to a changing climate by integrating trees in the farming system. However, with the diversification of farming in the IHR towards horticulture, many second generation ecological (marginal areas coming under fruit cultivation) and social (equity, gender and ethnicity etc.) issues of unsustainability, excessive use of chemicals in the form of pesticides and fertilizers are emerging [21]. These are great hurdles for the sustainable development in the mountainous region, requiring agro-forest integration by domestication of MWFPs.

4.2 Diversity, distribution and potential of MWEPs useful in agri-forest integration for ensuring rural prosperity, sustainability and global food security.

4.2 .1 Diversity: 40 (Herb=05; Shrub=10; Tree=25) MWEPs of Mandi belonging to 25 families and 31genera. has been documented in present study Family Rutaceae was found dominant represented by 4 genera followed by family Lythraceae and Moraceae (represented by 2 genera each). Among genera Ficus was found
4.2 .2 Distribution: 31 MWFPs were distributed in lower or lesser Himalayas while 9 MWFPs were restricted to Greater Himalayas**. (**Table.1 & Fig.2, 5)

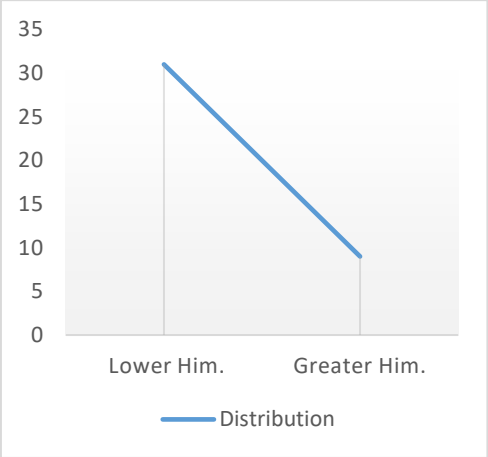


Fig: 2 Showing Distribution of MWEPs

4.2 3. Potential of agro-forest integration:

Agri-forest integration can directly help in easy availability of dietary energy and nutrients along with other essential commodities like fuel, fodder, medicine and materials, which are useful in day to day life [8, 22-24]. As plants discussed in present study are multipurpose type so their produce both raw and processed has tremendous potential of socio-economic upliftment of local communities. All the 40 documented WEFPs are used as food and medicine by the local community. 39 plants show economic value; 31spp used as fodder, 6 used for household items, 6 used as ornamental, 8 plants used for hedge, 14 have religious value, 26 used as fuel, 5 used for oil and 7 used for its timber properties**.** (Table.1 & Fig. 3, 5) For better outcome we need to empower the locality-wise farming communities towards climate resilient and sustainable global food system, Measures to reduce food wastage and loss can greatly help in meeting the food security goals. For this we need region and location specific strategies along with need based facilities to farmers. [4][24][25][26][27].

Fig: 3 Showing Potential of WEPs (Ed= Edible, Md= Medicinal, Ev= Economic value, Fd= Fodder, Fl= Fuel, Rl= Religious, T= Timber, Hh= Household items, Or= Ornamental, He= Hedge, O= Oil)

4.3 Eco-restoration:

Economic securities in India largely rely on environmental sustainability, but environment sector is worst affected in Indian Himalayan Region from recent few decades. This resulted into huge economic insecurities imposing social, environmental and health cost *r*equiring additional efforts to mitigate pollution, increase land cover, carbon sink and allocate additional budget for environment conservation and eco restoration policies. For this domestication of MWFPs like *Opuntia* spp., and *Euphorbia royleana* belonging to family Cactaceae and Euphorbiaceae (Being C4 plants these are more efficient in capturing atmospheric carbon due to presence of Kranz anatomy) at private land along with agricultural crops can help to increase carbon sink and get food, fuel, medicine and materials too. By cultivating these plants (as a side crop or hedge) farmers can earn additional income by selling carbon credit either to the voluntary carbon market or to the developed countries. As most of MWFPs discussed in present study are not only a source of useful commodities to man but also offer food, shelter and shade for wildlife as well. MWFPs like *Ficus spp. Citrus spp., Artocarpus lakoocha, Bauhinia variegata Ziziphus mauritiana, Bombax ceiba, Myrica esculenta*, *Bambusa arundinacea, Syzygium cumini are* keystone species of study area and play significant role (direct or indirect) in soil conservation and habitat stabilization. Sustainable agro-forestry measures by domestication of MWFPs thus can enhance use-efficiency for inputs, increase production, reduce food losses and ensure environmental safety too through reduction in carbon emissions [28,29]. Mitigation and adaptation approaches by domestication of climate resilient food crops like *Opuntia* spp., and *Euphorbia royleana* in association with main crops will also narrow down the gap of GHGs emissions through increased food choices and reducing GHGs emissions to secure food security under sustainable food production systems [30]

4.4. Value addition of produce for rural prosperity, sustainability and global food security.

Edible plant parts of MWFPs are usually harvested and marketed for fresh use or dried and stored for later use to ensure their availability during off season. Value added produce from these plants have tremendous marketing potential and offer livelihood opportunities to local communities in their different processing stages like harvesting, grading, processing, packaging and marketing, harvest need to be processed in several stages for enhancing shelf-life of produce [31]. Details for each stage are different for different plant species. As MWFPs offer raw material for many commercial commodities other than food and medicine, value-added produce from these MWFPs both edible and non-edible can be utilized for boosting the socio-economic status of the local community. Value added edible plant parts of these plants can be sold throughout the year in the form of pickle, *sirra (Starch),* candy, juice, badiyan*, murrabba,* jams, local alcoholic drinks and powder in the local market and at high rate in various national or international fairs and festivals. Thus their produce can be utilized as a source of income in maximum part of the year [32, 33]. For example, *Aesculus indica* seed flour sold at a high rate of 800 to 1200 Rs/kg. Its wood is utilized for construction of toys, deities and decorative items which are sold at a high rate in the local market. Soap prepared from its seeds is employed to wash shawls or other woolen clothes in hills. Likewise, dried seeds and other value added products from *Prunus mira* like local alcoholic drinks, oil, and pickles are sold at a high rate in local and national markets, so they are a good source of earning for locals throughout the year. Similarly, raw and value added products both edible or non-edible (Broom.

leaf plates, mats, basket, sticks, ropes, agricultural tools etc) from MWFPs *like Moringa oleifera, Phoenix sylvestris, Aegle marmelos, Zanthoxylum armatum, Citrus jambhiri Citrus pseudolimon, Aegle marmelos, Bambusa arundinacea, Phyllanthus emblica* are excellent source of earning for local community. Table.1& Fig. 5

V. Conclusion:

The agrarian practices in Mandi HP from decades is self-sustaining and mainly based on locally available natural resources. One can still witness an ecologically sound cultural practices in this region with a perfect harmony between man and nature. But from last few years with increase in population size we have seen a significant enhancement in pace of resource utilization; living standards and developmental works, making it challenging to meet growing needs of quality food production and sustainable crop production. Last few Global Hunger index reports [34-37] also reveals that India including entire Himalayan range is continuously facing the challenges of hunger and nutritional insecurities leading to silent epidemic of malnutrition. So, farmers are eventually forced to overuse chemical fertilizers and pesticides, to yield more for fulfilling growing food requirements. All this has created an imbalance in public health, economy and ecosystem stability. Due to various geographical and climatic constraints of Himalayan region viz poor road connectivity, lack of knowledge about vast medicinal and nutritive potential, lack of testing labs, better processing units, store houses and market opportunities most of valuable produce from forest usually get wasted at resource level, which otherwise can be a potential source of food, medicine, material and income for the local community. So, to protect and preserve the environment and meet local and global needs there is an urgent need of enhancing the capacity of farmers. For this agriculture-forest integration is one of solution by selection and adoption of high yielding multipurpose and climate resilient crops for domestication to judiciously produce more from every unit of land, water, soil, inputs, time and energy. To achieve the UN goal of 'zero hunger world' by 2030 and to mitigate hunger and malnutrition, all the geographical and climatic constraints need to be addressed. So that produce from agro-forest integration can be useful to ensure eco-restoration, sustainability, rural prosperity and global food security.

Recommendations:

1. Mass awareness for domestication of MWFPs as a side crop.
2. Sustainable harvesting and optimum utilization of produce.
3. Maintaining post-harvest losses from biotic and abiotic agents.
2. Value addition of produce,
4. Provision for better marketing opportunities.
5. Upgrading the standards of packing and labelling to meet market demand
6. Strengthening the entire supply chain from production to consumption.
7. Provision for latest processing units and infrastructure of cold chain for perishable produce.
8. Providing scientific storage, knowledge and techniques of food grains for efficient utilization.
4. Accelerating the tec-driven transformation by providing and popularizing the digital agro-ecosystem to uneducated or semi educated small and marginal farmers.
9. Strengthening the bond between collectors and seller.
10 Strengthening the policies and research for domestication & commercialization.

Table: 1 Diversity, distribution and potential of MWEPs useful in agri-forest integration for ensuring rural prosperity, sustainability and global food security.

S. No.	Family/ Botanical Name/common Name/ Local name	Processed/ value added products (Edible/ Inedible)	Useful Parts	Altitudinal Range (m) & Habit	Commercial uses & market value of produce (Rs)	Indigenous Uses
1	**Arecaceae** *Phoenix sylvestris*/ Wild Date Plum/ *Khajara*	Ed=Syrup, Alcoholic Beverage. HH= Broom, mats & decorative items	Wp	2200 m (T)	Fr = 800/kg Mats =200 to 500/ pcs Broom= 70-100/pcs Basket=150-200/pcs	Fr are eaten to cure dysentery, toothache, menstrual complaints and Rt is employed for scouring teeth. Ed, Md, Hh, Fd, Or, He, Rl, Ev, Fl
2	**Asteraceae**	Ed= Powder Oil	Lf & Ts	1000 m (Hb)	Dried Lf Rs-298/kg	Useful in enhancing memory when taken with *Centella asiatica.*Taken as tonic anagist antifertility, eye

	Eclipta postrate/ False daisy/ *Bhringraj*					disorders, conjunctivitis, dandruff, toothache.asthma, bronchitis, liver complaints & malaria. Ed, Md, Fd, Rl, O, Ev
3	**Betulaceae** *Corylus jacquemontii/ The Himalayan Hazel/ Thngi*	Ed= Dry fruits	Fr, Sd, Br	2200-3300m (T)	*Dry Fr*= 1500 to 2500/kg Oil= 2500/Lt.	The Sd oil massage of the species is used for relieving muscular pain. Ed, Md, Ev, Fl, O, T
4	**Boraginaceae** *Cordia oblique*/ Clammy Cherry/ *Lasura*	Pickle,	Fr, Br	Upto 1500m (T)	Raw Fr=100-200/Kg Pickle= 680/kg	Fr are considered effective against chest infection, coughs and chronic fever. They are used as a demulcent and helpful to treat the diseases of the spleen. Ed, Md, Fd,Ev, Fl
5	**Cactaceae** *Opuntia dillenii/ Prickly pear/ Drabhad chhonh*	Fr= Alcoholic drink	Pads Fr	Upto 1500m (Sh)	*Alcoholic drink =450-650/lt*	This plant is considered effective to cure stomach disorders, fever, piles inflammation, anaemia, ulcers, urinary, complaints, tumours, loss of consciousness, and enlargement of the spleen. Ed, Md, He, Or, Ev
6	*Opuntia ficus indica/ Barbary fig/Kabuli chhoonh*	Fr Alcoholic drink	Pads, Fr	1300-2600m (Sh)	Alcoholic drink= 450/lt	Pads of this plant have many vital phytochemicals, fibre, anti-oxidants, vitamins, and minerals which are immunity boosters. Fl are used to cure bleeding, treat problems of the gastro-intestinal tract, and an enlarged prostate gland. Md, Ed, Md, He, Or, Ev
7	**Combretaceae** *Terminalia bellirica*/ Myrobalan/ *Baheda*	Triphala Churan, Pickle	Fr, Br	1000 m (T)	Churan Is Sold 50/100g. Rs-399 (500gm)	Fr are considered effective in curing vitiated conditions of kapha and vata. They are taken in powdered form to overcome general debility and to cure cough. skin diseases, leprosy, fevers, ulcers, diarrhoea and dysentery. Ed, Fd, Md, Fl, Ev
8	*Terminalia chebula/ Black Myrobalan/ Harad*	Triphala churan Pickle	Fr, Br	1500m (T)	Churan Is Sold 50/100g. Rs-499 (500gm)	Fr are taken as tonic to cure stomach and cardic disorder. Being digestive, anthelmintic, carminative, depurative, antiseptic, febrifuge, they are useful in vitiated conditions of tridosa. Ed, Fd, Md, Fl, Ev
9	**Dioscoreaceae** *Dioscorea belophylla* /Ruiding/ *Taradi*	Pickle, Badiyan	Tu	1800 m (V)	Tu raw = 200-350/kg Pickle=300-500/kg Badiyan = 300-400	Tu juice is considered effective against fever, headache, malaria, and dysenteries. Md, Fd, Hh, Ev
10	*Dioscorea pentaphylla*/ Buck Yam/ *Dareghal*	Pickle, Badiyan	Bu, Lf & Tu	1500 m (V)	Tu= 250 to 500/ kg Pickle=300-500/kg Badiyan = 300-400	Tu paste is applied on swelling of joints. Tu are also taken as tonic to improve body immunity. They are used to cure stomach pain and rheumatic swellings. Inflorescence is used as vegetables to improve body weakness. Ed, Md, Fd, Ev, Hh
11	**Ericaceae** *Rhododendron arboretum*/ Tree Rhododendron/ *Buraans*	*Chutney,* Juice/ Servat.Tea	Fl, Br	2300 to 3500 (T)	Fresh Fl= a bunch of 10-20 Fl For 20 to 50. Dried Fl=300-500/kg Chutney=600/kg Sharbat =200-300/kg	Fl are eaten as an effective remedy to cure nose bleeding. Leaf paste is applied on the forehead to cure headache. Ed, Fd, Ev, Md, Fl, Rl, Or.

12	**Euphorbiaceae** *Euphorbia royleana/ Chhoohin, Chu*	Pickle	Br	Upto 2000m (Sh)	-	Milky latex is effective against joint pain. Young shoot eaten for treating piles. Ed, Md, Or, He
13	**Fabaceae** *Bauhinia variegata/* Orchid tree/ *Karyale , kachnar*	Pickle, Dried flower	Fl, Fl Bu, Br	1700m (T)	Fresh Fl= 80-100 g Fl buds =120-450/kg	The dried buds are useful in piles and dysentery. Bk is useful against skin disease and Rt is used as an antidote to snake poisoning.Ed, Fd, Md, Ev, Fl, T
14	*Phanera vahlii/ Maloo creeper/ Taur*	Dunu (Bowl), Pattal (Leaf Plate)	Fl Bd, Pd, Sd,	1500m (V)	Lf Bowl (Dunu)= Lf plate (Patr)=	A pinch of powdered Fl with common salt and white pepper snuffed to relieve headache. Paste of Lf and Fl with some hair oil applied externally to check hair. Known in India as tonic and for antifertility, dysentery. Ed, Ev, Fd, Md, Rl
15	**Juglandaceae** *Juglans regia/* Walnut/ *Khod*	*Chutney*	Sd, Br, Lf	1000 m (T)	Nuts -2000/kg	Lf, Bk and Ft rind are widely used to clean teeth. Fr are sweet, emollient, thermogenic, aphrodisiac, tonic and carminatives. The kernels are said to posses' aphrodisiac properties and are recommended in colic and dysenteries. Ed, Md, Ev, Fl, Rl, O, He
16	**Lauraceae** *Cinnamomum tamala*/ Indian Cassia/ *Meetha patta*	Dried Lf	Lf, Br	2400 m (T)	Lf-300-400/kg	Lf paste is applied on the forehead to treat headache. Tejpata oil obtained from the Lf of this plant is anti-flatulent and diuretic. It is useful to cure cardiac disorders. Ed, Md, Fd, Ev, Fl
17	**Lythraceae** *Punica grantatum/* Pomegranate/ *Daadu*	*Chutney*	Fr, Br	2500 (Sh)	Dried Fr=450/kg	Fr juice is used to treat jaundice and diarrhoea. Fr juice along with Lf juice of *Cynon dactylon* is used for treatment of cold and runny noses. Powdered Bk used to expel worms from the body. Ed, Fd, Md, Ev, Rl, Fl
18	*Woodfordia fruticosa*/ Fire-Flame bush/ *Dhave*	Dried flowers	Fl	1800 m (Sh)	Fl= 50/kg	Fl, Fr, Rt, Lf & buds considered effective in gynecologicaltreatment. Young Br used as toothbrushes. Decoction of Fl is helpful in regulating liver disorder, Lf paste when applied on the forehead can relieve headache. Ed, Md, Fd, Ev
19	**Malvaceae** *Bombax ceiba*/ Silk cotton tree/ *Simbal*	Pickle	Fl Bd, Br	1300 m (T)	Fr= 40 to 60/ kg *Rs-120-450*	Fl and Fr in combination with other drugs are considered good for the treatment of snake-bite and scorpion sting. The spines of this plant are locally used to treat pimples which develop on eyelids. Ed, Md, T, Ev, Fl
20	**Moraceae** *Artocarpus lakoocha, Dheu/ Monkey Jack*	Sauce, Pickle,	Fr, Fl, Br	Upto 1300m (Hb)	Fr raw= 40-80/kg Pickle=200-300/kg	A paste of the Bk found beneficial by local application in boils and small pimples. Sd are purgative. The Bk is used to treat headache.Ed, Fd, Md, Ev, Fl
21	*Ficus palmate*/ Wild fig/ *Fegra*	Pickle,	Fr	1550 m (T)	Raw Fr =100/kg Pickle =200-300	Young Fr are considered blood purifiers and eaten as vegetables or pickles. They are also useful against constipation and in diseases of bladder and lungs. Ed, Fd, Md, Ev, Fl
22	*Ficus hispida /Debre*	Pickle	Fr, Br	Upto 1100m (T)	Pickle Fr= 200/kg	Fr are eaten as a remedy of jaundice, piles, mouth dieases of the blood and haemorrhage of the nose. Acrid milk is used. Lf are used for poulticing boils. Ed, Fd, Md, Ev, Fl.

23	*Ficus racemosa*/Cluster fig tree/ *Umre*	Pickle	Fr, Br	1200 m (T)	Pickle=250/kg	Fr and young Lf of this plant are taken as tonic, pickle and vegetable to enhance strength and vigour. It is supposed to enhance age, so the local name '*umare'* is given to this plant. It is known for its antidiuretic effect. Rt are employed to cure hydrophobia, While Fr, Lf & Bk are effective against piles, diabetes, asthma. dysentery. Ed, Fd, Md, Ev, Rl, Fl
24	*Ficus roxburghii/ Elephant ear fig tree/ Tarayambal*	Pickle, Jam	Fr, Lf, Br	Upto 1700m (T)	Pickle Fr= 180/kg	St latex is applied on cuts and wound. Fr are eaten ripe as a treatment of diarrhoea and dysentery.Ed, Fd, Md, Fl, Ev
25	**Moringaceae** *Moringa oleifera/* Horseradish Tree/ *Soonani*	*Chutney*	Lf, Ten Sh, Sd Pd, Fl Bd, Br	1000 m (T)	Dried Lf= 950/kg Sd= 150 (180no.) Dried Fl= 850/kg Raw Pods = 1000/kg	Lf, Fr and Fl of these plants are eaten to enhance immunity, eye sight, strength and vigour. They are considered good to treat diabetes, jaundice, anemia and recover from nutrient deficiency, Ed, Fd, Md, Fl, Ev
26	**Myricaceae** *Myrica esculenta/* Bayberry/ *Kaphal*	Balm	Fr, Br, Lf	1000- 1800 (Sh)	Fresh Fr= 200 to 400/ kg Balm=200.kg	Powered Sd & Fr are considered effective against stomach disorders; one teaspoon is recommended twice a day for 3-5 days. Ed, Fd, Md, Fl Ev, T
27	**Phyllanthaceae** *Phyllanthus emblica/* Indian Gooseberry/ *Ambla*	Pickle, *Murabba,* Jam, *Bhale, Badiyan* Ambla Candy	Fr, Br	1500 m (T)	Fr =250.kg Candy= 360/250gm Jam= 160/500gm Pickle= 600/kg Murabba= 559/kg	Fr are useful in vitiated conditions of tridosa. Taken both fresh and dry as powdered to treat diabetes, ulcer, cough, bronchitis, asthma, skin and eye diseases. Sd oil is used to check baldness and hair fall. Fr are also effective in preventing growth and spread of different types of cancer. Ed, Md, Fl, Rl, Ev, Fd, O
28	**Poaceae** *Bambusa arundinacea/* Bamboo/ *Bans*	Pickle	Te Sh	1250 m (T)	Pickle= 300-600 per/ kg	St & Lf are useful in curing "Kapha", diseases of blood, biliousness, inflammations, wounds and piles. The Sd are acrid, sweet, and manage urinary discharge. Ed, Fd, Md, Ev, Rl, Fl, Hh
29	**Rhamnaceae** *Ziziphus mauritiana/ Indian jujube/ Baer*	Local Alcoholic drink, Badiyan,	Fr, Rt, Br	Upto 1800m (Sh)	Local alcoholic drink= 180/1lt Badiyan= 150/kg	Rt are bitter, cooling and tonic. Useful in vitiated conditions of *pitta*, fever, wounds and ulcers. Bk & Lf being bitter and cooling are useful for treatment of dysentery, diarrhoea, boils and stomach disorder.Ed, Md, Fd, Ev, He.
30	**Rosaceae** *Prunus mira/ Smoothpit peach, Aroo/ Behmi*	Pickle, Alcohol	Fr, Sd Oil, Br	Upto 4000m (T)	Local alcoholic drink= 120/lt Oil= 340/10ml Dry seeds= 650/500gm	Sd oil massage is helpful in curing disorders of joints. Fr in small quantities helpful in stimulating respiration, improving digestion and gives a sense of wellbeing. Ed, Fd, Md, Ev, Rl, Fl
31	*Prunus cerasoides/ Himalayan wild cherry/ Paja*	Jam, *Chutney,*	Fr, Sd, Br	Upto 30m (T)	Chutney= 100-200/kg Jam= 150/kg	BK used as a toothbrush for cleaning teeth, its decoction is useful to cure fever and relieves stomach ache. Sd are chewed to cure kidney stone, bleeding disorders, burning sensation and skin diseases.Ed, Md, Fd, Ev, Rl, Fl, T
32	**Rutaceae** *Aegle marmelos/ Bill Patri ,*	Jam, *Murabba,* Pickle,	Fr, Lf, Br	Upto 900m (Sh)	Dry Ft -130-1500 Jam Lf dried= 150/ 100gm	Every part of this plant is considered medicinal. Lf is taken as a remedy to cure diabetes. Fr has a cooling and sedative effect on body and mind. They are taken to cure fever, asthma and stomach disorder. Ed, Md, Ev, Rl, Fl.

					Lf fresh= 334/250gm	
33	*Citrus jambhiri* /Rough Lemon/ *Jhamirdi*	*Chutney*, Juice;,KumKum	Fr	1200 m (T)	Fresh Fr =50-80/kg Juice-200-450	Fr juice is considered effective in controlling high cholesterol. Juice is used as a gargle for sore throats and useful in treatment of infections, scurvy & cold Ed, Md, Or, Ev, Rl, He
34	*Citrus pseudolimon*/ Hill lemon/ *Galgal*	Chukh & Pickle	Fr	3000 m (T)	Fresh Fr =50-80/kg Juice-200-450 Pickle= 200/kg Chukh= 250/500gm	Useful against infections & survey. Ed, Md, Rl, Ev, He
35	*.Murraya koenigii*/ Curry Leaf/ *Gandhelu*	*Chutney* & Jam	Te Sh & Lf, Br	1500 m (Sh)	Dry Lf= 1200/kg Lf Powder= 900/kg	Lf, Bk & Rt used as a tonic & a stomachic. Powdered lf are taken as remedy to treat diabetes, blood pressure, and tonic. Ed, Md, Fd, Ev
36	*.Zanthoxylum armatum/ winged prickly ash/ Tirmire*	*Chutney*, Stem as toothbrush	Sd, Ten Sh, St	Upto 2000m (Sh)	Lf powder= 340/kg Sd= 2200/kg St= 2500/kg	Fr, Bk and Sd are taken as tonic to cure stomach disorders, common cold, cough, toothache and fever. Young Br or shoots of plants are used as toothbrushes. Fr & Sd are beneficial in dental troubles, so used to prepare dental pastes.Ed, Fd, Md, Ev, Hh, He
37	**Sapindaceae** *Aesculus indica*/ Indian Horse Chestnut/ *Khanot*	Seed flour, Toys, Statue of Deities,	Sd, Br	1800- 3000 m (T)	Flour- 800-1200/kg	Sd flour is considered good to cure various gynecological disorders. Ed, Md, Fd, Ev, Fl, T, O
38	**Tiliaceae** *Grewia optiva/ Bhimal/ Beul/ Bihul*	*Rope of stem fibre*	Fr, Br	1800-2000m (T)	Rope=350-500(2no.)	Used for treating various diseases like, cough, dysentery, diarrhea, rheumatism and eczema. Its Bk was used to assist child birth. The products made are also Anti- bacterial and Antimalarial. Ed, Md, Fd, Fl, Hh, Ev.
39	*Grewia tilifolia/ Dhaman/ Pharsu*	Dessert, *Hh= Rope of stem fibre*	Fr, Ten Lf	Upto 1800m (T)	*Rope=350-400(2no.)*	It is useful in vitiated conditions of cough and pitta. The Fr are sweet, sour, cooling and edible and are useful in treatment of cough, skin diseases, pruritus, wounds, ulcers, diarrhoea, vitiated conditions of vata,pitta and kapha.Ed, Md, Fd, Fl, Hh, Ev
40	**Taxaceae** *.Taxus contorta/ Yew/ Rakhal*	Jam , Tea	Sd, Br	2000-3500m (T)	-	Lf & Bk is useful in treatment of asthma, bronchitis, cancer, hiccup, indigestion, rheumatism, heart and kidney problems etc. Ed, Md, Fd, Ev, Fl, Rl, O, T

Abbreviation: Hb= Herb, Sh=Shrub, T=Tree, Sd= Seed, Lf= Leaf, Br= Bark, Rt= Root, Fr= Fruit, Sh= Shoot, Pd= Pods, Ten Sh= Tender shoot, Wp= Whole Plant, Fl= Flower, Fl Bd= Flower bud, Tu= Tuber, Bu= Bulb, Ed= Edible, Md= Medicinal, Ev= Economic value, Fd= Fodder, Fl= Fuel, Rl= Religious, T= Timber, Hh= Household items, Or= Ornamental, He= Hedge, O= Oil

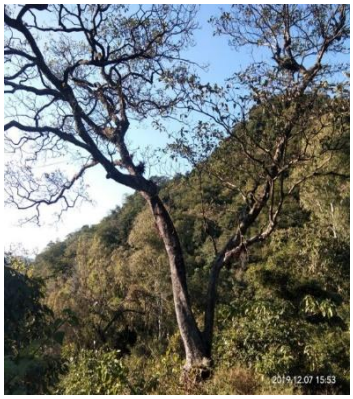
Opuntia dillenii

Eclipta prostrata

Corylus jacquemontii

Cordia obliqua

Phoenix sylvestris



Terminalia bellirica

Dioscorea belophylla

Dioscorea pentaphylla

Rhododendron

Euphorbia roylaena

Bauhinia variegate

Juglans regia

Cinnamomum tamala

Punica granatum

Woodfordia fruticosa

Bombax ceiba

Artocarpus lacucha

Ficus Palmata

Ficus hispida

Ficus racemosa

Ficus roxburghii

Phyllanthus emblica

Moringa oleifera

Myrica esculenta

Bambusa arundinaceae

Ziziphus mauritiana

Prunus mira

Prunus cerasoides

Aegle marmelos

Citrus jambhiri

Murraya koenigii

Zanthoxylum armatum

Aesculus indica

Grewia optiva

Taxus contorta

Fig: 5 Showing morphology and uses of WEPs

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References:

[1]. Xu J, Badola R, Chaudhary RP, Zomer R, Pokhrel B, Hussain SA, Pradhan S and Pradhan R 2019. Sustaining biodiversity and ecosystem services in the Hindu Kush Himalaya. In:Wester P, Mishra A, Mukherji A and Shrestha AB (Eds.). The Hindu Kush .

[2]. Schroeder, R. F. (1985). Himalayan subsistence systems: Indigenous agriculture in rural Nepal. *Mountain Research and Development*, 31-44.

[3]. IMI FAO Report 2019. State of the Himalayan armers and arming. A f f part of the project "Strengthening Institutional Capacities for Sustainable Mountain Development in the Indian Himalayan Region" awarded by FAO under the TCP/IND/3601/C1 to IMI.

[4]. Sen, T. D (2021) Domestication of some nutritionally important wild edible plants of Mandi Himachal Pradesh, North Western Himalayas for boosting health, immunity, rural prosperity and food security" in International Journal Of Tropical Agriculture 2021,39 (1-2), 87-108..

[5]. Sen, T. D., Singh, S., Thakur, T., Devi, B. (2022). Climate Resilient Wild Edible Succulents of Mandi Himachal Pradesh, Their Indigenous Uses and Role in Socio-Economic Development ofthe Region. In Economics and Policy of Energy and Environmental Sustainability (pp. 323-340).Springer, Singapore.

[6]. Sen, T. D.,2021). The Role of Wild Food Plants of Himachal Pradesh in Boosting Immunity to Combat COVID-19. *Journal of Scientific Research in Medical and Biological Sciences*, *2*(2), 23-62. https://doi.org/10.47631/jsrmbs.v2i2.238.

[7]. Farooq, M. S., Uzair, M., Maqbool, Z., Fiaz, S., Yousuf, M., Yang, S. H., et al. (2022). Improving nitrogen use efficiency in aerobic rice based on insights into the Ecophysiology of Archaeal and Bacterial Ammonia Oxidizers. *Front. Plant Sci.* 13:913204. doi: 10.3389/fpls.2022.913204.

[8]. Devi, T (2021). Diversity, Distribution, Nativity and Indigenous Uses of Crop Wild Relative of District Mandi Himachal Pradesh and Their Potential in Crop Improvement Programme. *International Journal of Scientific Research in Biological Sciences*, 8(1)108-121.

[9]. Ribaski J, Varella AC, Flores CA, Mattei VL (2012). Sistemas silvipastoris no bioma pampa. Resumo da palestra submetida e apresentada no VII Congresso Brasileiro de Sistemas Agroflorestais, junho 2012.

[10]. Alexandratos, N., and Bruinsma, J. (2012). "A synoptic visualization framework for the multi-perspective study of biography and prosopography Data," in *Proceedings 2nd IEEE VIS Workshop on Visualization for the Digital Humanities*, Phoenix, AZ.

[11]. Hunter, M. C., Smith, R. G., Schipanski, M. E., Atwood, L. W., and Mortensen, D. A. (2017). Agriculture in 2050: recalibrating targets for sustainable intensification. *Bioscience* 67, 386–391. doi: 10.1093/biosci/bix010

[12]. Yadav RP, Bisht JK. Agroforestry: A way to conserve MPTs in North Western Himalaya. Research Journal of Agriculture and Forestry Sciences. 2013;1:8-13

[13]. Hammarstrom, D. G., & Bianchi, V. (2019). Integration of tree crops and pastures: Literature review. *African Journal of Agricultural Research*, *14*(26), 1091-1096.

[14]. Kumar, P., Sharma, P. K., Kumar, P., Sharma, M., & Butail, N. P. (2021). Agricultural sustainability in Indian Himalayan Region: constraints and potentials. *Indian J Ecol*, *48*(3), 649-662.

[15]. Heal, G. M., and Millner, A. (2014a). Agreeing to disagree on climate policy. *Proc. Natl. Acad. Sci. U.S.A.* 111, 3695–3698. doi: 10.1073/pnas.1315987111

[16]. Chowdhery HJ, Wadhwa BM. "Flora of Himachal Pradesh", Botanical Survey of India,(1984)

[17]. Dhaliwal DS, Sharma M. "Flora of Kullu District, Himachal Pradesh", Bishen Singh and Mahendra Pal Singh, Dehradun.1999

[18]. Singh PB, (1918); "Flora of the Mandi District Himachal Pradesh North West Himalaya".Bishen Singh Mahendra Pal Singh, Dehradun.

[19]. Tiwari PC and Joshi B 2015. Climate change and rural out-migration in Himalaya. Change and Adaptation in Socio-Ecological Systems 2(1):8-25.

[20]. Mosquera-Losada MR, McAdam JH, Romero-Franco R, SantiagoFreijanes JJ and Rigueiro-Rodróguez A 2009. Definitions and components of agroforestry practices in Europe. In: RigueiroRodróguez A, McAdam J, Mosquera-Losada MR (Eds.) Agroforestry in Europe Advances in Agroforestry . , vol 6. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8272- 6_1.

[21]. Partap T 2011. Hill agriculture: Challenges and opportunities. Journal of Agricultural Economics 66: 33 52.

[22]. Cassidy, E. S., West, P. C., Gerber, J. S., and Foley, J. A. (2013). Redefining agricultural yields: from tonnes to people nourished per hectare. *Environ. Res. Lett.* 8:034015. doi: 10.1088/1748-9326/8/3/034015.

[23]. Shepon, A., Eshel, G., Noor, E., and Milo, R. (2016). Energy and protein feed-to-food conversion efficiencies in the US and potential food security gains from dietary changes. *Environ. Res. Lett.* 11:105002. doi: 10.1088/1748-9326/11/10/105002.

[24]. Sen, T. D., Singh, S., Thakur, T., & Devi, B. (2022). Climate Resilient Wild Edible Succulents of Mandi Himachal Pradesh, Their Indigenous Uses and Role in Socio-Economic Development of the Region. *Economics and Policy of Energy and Environmental Sustainability* (pp. 323-340). Singapore: Springer Nature Singapore.

[25]. Asrat, P., and Simane, B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecol. Process* 7:7. doi: 10.1186/S13717-018-0118-8/TABLES/9

[26]. Hansen, J. W., Vaughan, C., Kagabo, D. M., Dinku, T., Carr, E. R., Körner, J., et al. (2019). Climate Services Can Support African farmers' context-specific adaptation needs at scale. *Front. Sustain. Food Syst.* 3:21. doi: 10.3389/FSUFS.2019.00021

[27]. Stringer, L. C., Fraser, E. D. G., Harris, D., Lyon, C., Pereira, L., Ward, C. F. M., et al. (2020). Adaptation and development pathways for different types of farmers. *Environ. Sci. Policy* 104, 174–189. doi: 10.1016/J.ENVSCI.2019.10.007

[28]. Murray, B. C., and Baker, J. S. (2011). An output-based intensity approach for crediting greenhouse gas mitigation in agriculture: explanation and policy implications. *Greenh. Gas Meas. Manage.* 1, 27–36. doi: 10.3763/ghgmm.2010.0004

[29]. Cavigelli, M. A., Del Grosso, S. J., Liebig, M. A., Snyder, C. S., Fixen, P. E., Venterea, R. T., et al. (2012). US agricultural nitrous oxide emissions: context, status, and trends. *Front. Ecol. Environ.* 10:537–546. doi: 10.1890/120054

[30]. Sylvester, O. (2019). "Achieving food security in the face of inequity, climate change, and conflict," in *The Difficult Task of Peace*, ed. F. Rojas Aravena (Cham: Palgrave Macmillan). doi: 10.1007/978-3-030-21974-1_13

[31]. Sen T, Samant S. S, Sharma A, Tewari L M (2013) Diversity, Endemism And Economic Potential of Wild Edible Plants in Rissa khad Watershed of District Mandi, Himachal Pradesh." Non-Timber Forest Products, Vol. 20 (2) : 155-164, 2013.

[32]. Devi, T and Sen, V (2020) "Role of Wild Food Plants in Culinary Tourism Development of District Mandi Himachal Pradesh," International Journal of Scientific Research in Biological Sciences,7 (6)14-38.

[33]. Sen, T. D., & Thakur, T. (2021). Some Ethnomedicinal Plants of Western Himalayas Useful in Making Local Alcoholic Drinks. Journal of Scientific Research in Medical and BiologicalSciences, 2(3), 75-103.

[34]. Von Grebmer, K. J. Bernstein, R. Mukerji, F. Patterson, M. Wiemers, R. Ní Chéilleachair, C. Foley et al. (2019). Global Hunger Index: The Challenge of Hunger and Climate Change. Bonn and Dublin: Welthungerhilfe and Concern Worldwide.

[35]. Von Grebmer, K., J. Bernstein, R. Alders, O. Dar, R. Kock, F. Rampa, M. Wiemers et al. (2020). Global Hunger Index: One Decade to Zero Hunger: Linking Health and Sustainable Food Systems. Bonn: Welthungerhilfe; and Dublin: Concern Worldwide.

[36]. Von. Grebmer, K., J. Bernstein, C. Delgado, D. Smith, M. Wiemers, T. Schiffer, A. Hanano, O. Towey, R. Ní Chéilleachair, C. Foley, S. Gitter, K. Ekstrom, and H. Fritschel. (2021.) Global Hunger Index: Hunger and Food Systems in Conflict Settings. Bonn: Welthungerhilfe; and Dublin: Concern Worldwide.

[37]. Von Grebmer, K., J. Bernstein, D. Resnick, M. Wiemers, L. Reiner, M. Bachmeier, A. Hanano, O. Towey, R. Ní Chéilleachair, C. Foley, S. Gitter, G. Larocque, and H. Fritschel. (2022). Global Hunger Index: Food Systems Transformation and Local Governance. Bonn: Welthungerhilfe; and Dublin: Concern Worldwide.