Trend analysis of medicinal plants in Kinnaur district, Himachal Pradesh, India

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Trend analysis helps predict future events based on past time-series behaviour. Therefore, trend analysis of five medicinal plants having high economic value (chilgoza, kala jeera, dhoop, karro and kuth) was done during the period 2011–12 to 2020–21. According to the study, growth rate in real terms was seen only in Dhoop species, while the other species were dribbling due to overexploitation as these were easily accessible to the local population. Growth rate was recorded highest for dhoop (18.37%/annum) and lowest for kala jeera (4.75%/annum). Nominal price elasticity for chilgoza, karro and kuth was greater than one, indicating that their quantity is changing faster than price, whereas nominal price elasticity for kala jeera and dhoop was less than one, demonstrating that these species possess inelastic properties, with their quantity changing slower than prices. In the case of real price elasticity, only kala jeera was elastic in nature in real value terms, while the remaining species were inelastic. Scarcity ratio was found to be positive only for kuth, which indicates that the availability of this species is dwindling in the forests daily. Therefore, it is necessary to educate the local population on how to grow key medicinal plants, and every household that depends on the forests for these plants should be provided with in-depth guidelines on how to continue using them.

Keywords: Medicinal plants, nominal and real prices, price elasticity, trend analysis, scarcity ratio.

THE development and survival of communities living in and around forests depend heavily on medicinal plants. The contribution of medicinal plants derived from forests to economy is unknown and could be higher than that of timber products, still retaining the non-significant in the lives of people. In India, there are about 15,000 different plant species, and nearly 3000 of them (20%) produce medicinal plants, of which only 126 species (or 0.8%) are marketable[1].

Himachal Pradesh is a state in India's Northwestern Himalaya, with a total forest area of 37,948 km^2 or 68.16% of its total area, and a forest cover of about 27.73% (ref. 2). The state is well known for its temperate fruit farming. In addition to using cultivated fruits, it is also standard practice among the locals to gather and consume seasonal wild medicinal plants. There are around 1532 edible wild food species present in India, of which 675 are located in the Himalayan region. These medicinal plants play a significant role in providing nutritional food supplements[3,4]. Medicinal plants provide food and other life supporting commodities that are very important for survival of human beings and other organism besides this they protect our environment and maintain nature[5].

A north-eastern frontier region in the Himachal Pradesh state, valleys along the Sutlej River and its tributaries (Baspa and Spiti rivers) make up the majority of Kinnaur. The landscape is rugged, with deep valleys and abrupt steep hills. The extensive range of altitudinal as well as climatic and geographic gradients contributes to the diversity of the terrain in the temperate zone, where conifers predominate. Meadows, sub-alpine woods, dry and moist alpine scrub, and moist and dry temperate forests are among the vegetation types in the area[6]. In Kinnaur, a significant portion of the dry zone up to the treeline is covered by a *Pinus gerardiana* (chilgoza or neoza pine)-dominated forest and *Cedrus deodara*, which predominates in dense coniferous forests below the tree line[7]. The present study was carried out on some important medicinal plants in the Kinnaur district of Himachal Pradesh.

Materials and methods

The study area is in the Kinnaur district of the Himachal Pradesh, a part of the Great Himalayas, which are located between long. 77°45′–79°00′50″E and lat. 31°05′55″–32°05′20″N. In the study, simple arithmetic techniques like percentages and averages were primarily used. The linear growth in the consumption function was estimated

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through SPSS and the results were derived through computer programme.

Data type and source

Both primary and secondary data were collected for the study. Primary data were collected through a personal interview approach, which largely consisted of reaching out to marketing managers, market functionaries, purchasing managers, and other employees. Secondary data were gathered from the records of the Forest Department from Kinnaur division for the period of ten years (2011–12 to 2020–21).

Data analysis

Nominal and real prices of selected species

Real prices refer to adjusted money of a commodity's value in various years, whereas nominal prices refer to a commodity's current money value in various years. The real price was calculated as

$$\text{Real price} = \frac{P_n}{\text{CPI}},$$

where P_n is the nominal price paid by individuals for each selected species and CPI is the consumer price index for 2021, with 2011 as the base year.

Coefficient of variation for nominal and real prices

Coefficient of variation (CV) is a statistical measure of the dispersion of data that can be computed as

$$\text{CV}(\%) = \frac{\text{SD}}{\bar{Y}} \times 100,$$

where SD is the standard deviation and $\bar{Y}$ is the mean value.

Cuddy-Della Valle index

The Cuddy-Della Valle index (CDVI) was used to quantify the relative instability in the extraction/production and the prices of medicinal plants. Coefficient of variation (CV) has been widely used as measure of instability index, however, CV is suitable when data has no trend as it does not account for the time trend. In time series data, there is always some trend; therefore, instability index is estimated by following formula called CDVI

$$\text{CD} = \text{CV} \times \sqrt{1 - r^2},$$

where CV is the coefficient of variation (%) and r^2 is the time-trend regression coefficient of determination.

Linear rate of growth

Linear growth rate (LGR) was calculated to assess the trends in nominal and actual prices of medicinal plants. The growth rate was calculated using the equation

$$Y = a + b_t,$$

where Y is the quantity extracted price of medicinal plants, t the yearly variation in time (1, 2, …, 10), a constant and b is the rate of change or the slope of line when equation is graphed

$$\text{LGR} = \frac{b}{\bar{Y}} \times 100,$$

where b is the coefficient of regression and $\bar{Y}$ is the mean value of the quantity extracted/prices for the medicinal plants.

$$\text{SE (linear rate of growth)} = \frac{100}{\bar{Y}} \times \text{SE}(b),$$

where $\bar{Y}$ is the mean value of quantity extracted/prices for the medicinal plants and SE(b) is the standard error of b.

Supply price elasticity at nominal and real prices

$$\text{Supply price elasticity} = \frac{Q_2 - Q_1 / Q_2 + Q_1}{P_2 - P_1 / P_2 + P_1},$$

where Q_2 is the average supply quantity at P_2 pricing (nominal/real prices) and Q_1 is the average supply quantity at P_1 pricing (nominal/real prices).

Scarcity ratio of medicinal plants

The increase in the real price of the resources over time indicates the economic scarcity, if the scarcity ratio is positive, it can be concluded that there is economic scarcity of medicinal plants[9].

$$\text{Scarcity ratio} = \left[\frac{\frac{\text{SP}_t}{\text{CPI}} - \text{SP}_0}{\text{SP}_0} \right] \times 100,$$

where SP_0 is the average cost of medicinal plants in 2011–14, SP_t the average cost of medicinal plants during 2018–21 and CPI is the 2021 consumer price index using 2011 as the base year.

Results and discussion

Species-wise description of medicinal plants

Pinus gerardiana (Pinaceae)

Vernacular name: Chilgoza

Chilgoza is primarily found in Kinnaur district, while there are also a few isolated cases in Chamba's Pangi and Bharmour districts of Himachal Pradesh. It is one of the most significant cash crops for forest dwellers and is currently traded at very high prices of ₹ 150,000–200,000/quintal. The carminative, stimulative and anodyne properties of the chilgoza seeds improve general debility. In natural forests, seeds typically begin to germinate in March or April, after the snow has melted and the weather has turned favourable.

Bunium persicum (Umbellifereae)

Vernacular name: Kala jeera

Kala jeera is one of the most economically significant medicinal plants that can be found between 1850 and 3100 m amsl. Due to their anti-inflammatory, analgesic, antispasmodic, carminative and lactation-stimulating properties, kala jeera seeds are sold at high prices of ₹ 100,000/quintal in the market. The geographical indication (GI) tag was given to this wild and delicious spice in 2017. Forest dwellers collect kala jeera during the last week of June or the first week of July each year.

Jurenia macrocephala (Asteraceae)

Vernacular name: Dhoop

Dhoop typically blooms from July to September. The root of this plant, which is valued at ₹ 30,000/quintal due to the abundance of active ingredients utilized in the pharmaceutical and numerous perfume and fragrance industries, is its most significant part from a commercial standpoint[10]. According to phytochemical analyses, the alcoholic essence of dhoop possesses anti-malarial[11] and antibacterial properties[12,13] that make it susceptible to overutilization. Thus, it has been categorized as a 'vulnerable' species for Himachal Pradesh[14].

Picrorhiza kurroa (Scrophulariaceae)

Vernacular name: Karro

Karro is a small herb that blooms from July to September and grows on rocky and alpine slopes between 4000 and 4500 m amsl (refs 15–19). Rhizome, which is the most valuable commercial component of the plant, is sold at ₹ 120,000/quintal for its expectorant, anthelmintic, anti-inflammatory, hepatoprotective, antiperiodic, anti-amoebic, cholagouge, antioxidant, cardio-tonic, laxative, carminative and stomachic characteristics[16,20–26].

Saussurea costus (Asteraceae)

Vernacular name: Kuth

Kuth is a small herbaceous plant harvested from July to September and distributed between 2500 and 3500 m amsl in the Himalayan region[17,27,28]. It is often sold at Rs 20,000/quintal and is used to treat a variety of conditions, including dyspepsia, asthma, bronchitis and chronic.

Price trends for selected medicinal plants

Trend analysis of the chosen medicinal plants was done over ten years (2011–12 to 2020–21). The chain of the people involved in the trade of medicinal plants generally follows the course as dispensed in Figure 1. Medicinal plants were collected by the forest dwellers for self-consumption in the initial stage. Thereafter, they started extracting more medicinal plants for commercial purposes to meet their vital needs.

Growth and variability in prices

The instability indices for nominal and real prices as shown in Table 1 exhibit highest deviation of prices in dhoop followed by chilgoza, karoo, kala jeera and kuth. According to Table 1, the linear growth rate of nominal prices of all the specified medicinal plants showed positive and significant growth. The specie dhoop experienced the highest growth rate (18.37%/year), followed by chilgoza (7.25%/year) and karoo (6%/year), however kala jeera demonstrated the lowest growth (4.75%/annum) followed by kuth (5.03%/annum). Furthermore, the linear growth rate of real prices showed that only dhoop price demonstrated positive (3.84%/annum) and significant growth indicating that prices have increased in real terms, whereas chilgoza (–0.88%/annum), kala jeera (–0.38%/annum) and karoo (–1.03%/annum) have displayed negative and non-significant growth. The results are shown in Figure 2, which also includes an estimate of the trend in the growth rate of nominal and real prices.

Nominal price elasticity

We analysed the result or elasticity of quantity demanded to price change (Table 2). The arc elasticity was used to enumerate the price elasticity of selected species. The results revealed that only kala jeera (0.46) showed a positive price-supply elasticity relationship, and was elastic in nature, i.e. proportionate change in the price brought about a notable change in the quantity supplied. The kala jeera plant grows

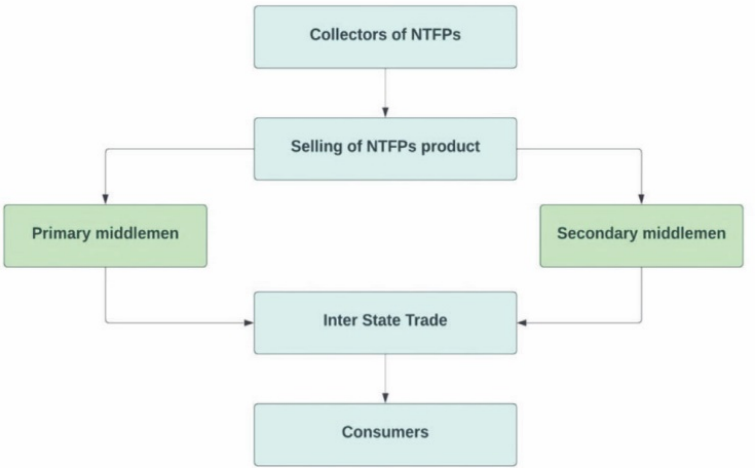

Figure 1. Chain of people involved in the trade of medicinal plants.

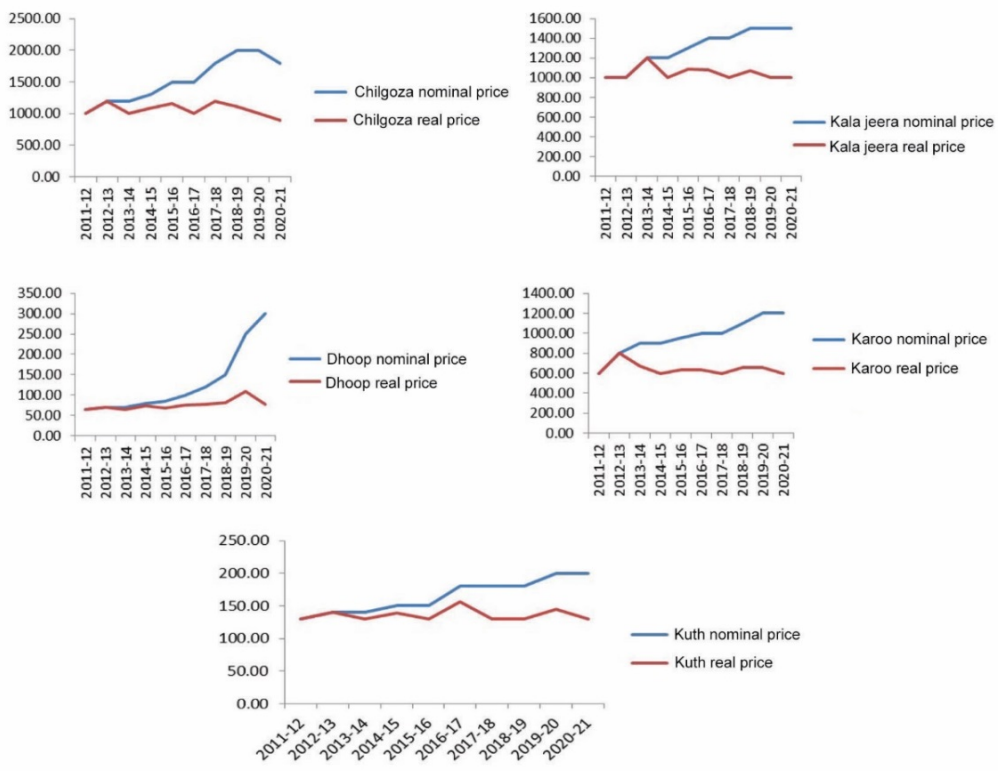

Figure 2. Trends in nominal and real prices of selected medicinal plants.

Table 1. Growth and variability in nominal and real prices of medicinal plants

	Nominal price			Real price			
Selected medicinal plants	Mean (₹)	Nominal price growth rate (%)	Instability index	Mean (₹)	Percentage decrease over nominal price	Real price growth rate (%)	Instability index
Chilgoza	1530	7.25* (0.90)	7.75	1064.83	30.40	–0.88 (1.06)	9.05
Kala jeera	1300	4.75* (0.47)	4.04	1043.17	19.76	–0.38 (0.73)	6.83
Dhoop	129	18.37* (3.61)	30.91	76.54	40.67	3.84* (1.34)	11.47
Karoo	965	6.00* (0.62)	5.35	645.45	33.11	–1.03 (1.04)	8.95
Kuth	165	5.03* (0.45)	3.85	135.97	17.59	0.13 (0.76)	6.54

Figures in parenthesis are the standard errors of linear growth rates.
*Significant at 5% level of significance.

Table 2. Nominal price elasticity of supply of chosen medicinal plants

Medicinal plants	Average quantity in the terminal years in quintals (Q_2)	Average quantity in the base years in quintals (Q_1)	Average price in the terminal years (P_2)	Average price in the base years (P_1)	Elasticity of supply
Chilgoza	47.28	112.67	1933.33	1133.33	–1.57
Kala jeera	140.00	120.00	1500.00	1066.67	0.46
Dhoop	94.00	125.67	266.67	73.33	–0.26
Karoo	73.49	270.90	1166.67	766.67	–2.77
Kuth	9.33	20.07	193.33	136.67	–2.13

Table 3. Real price elasticity of supply of chosen medicinal plants

Medicinal plants	Average quantity in the terminal years in quintals (Q_2)	Average quantity in the base years in quintals (Q_1)	Average price in the terminal years (P_2)	Average price in the base years (P_1)	Elasticity of supply
Chilgoza	47.28	112.67	1003.70	770.37	–3.11
Kala jeera	140.00	120.00	1023.81	969.70	2.83
Dhoop	94.00	125.67	63.89	63.45	–0.85
Karoo	73.49	270.90	638.18	457.07	–3.47
Kuth	9.33	20.07	134.81	114.07	–4.38

Table 4. Scarcity ratio of the chosen medicinal plants supplied during 2011–12 to 2020–21

	Chosen NTFPs				
	Chilgoza	Kala jeera	Dhoop	Karoo	Kuth
Year	Quantity (quintals)				
2011–12	138	50	48	231.71	10
2012–13	160	130	119	259	35
2013–14	40	180	210	322	15.21
2014–15	33	150	115	200	7.25
2015–16	15.66	85	90	115	115
2016–17	33	90	96.5	48	46.43
2017–18	32.5	120	115	35	105.3
2018–19	22	80	48	57.5	13
2019–20	32.85	200	30	62	10
2020–21	87	140	204	100.96	5
Scarcity ratio	–0.09	–0.06	–0.26	–0.37	0.01

naturally in forest areas. The forest dwellers collect the mature seeds from these areas and sell them for a very high price (between ₹ 1000 and ₹ 1500 per kg). It was observed that kala jeera is being grown extensively as a cash crop in the study area for both commercial and non-commercial uses. Since it has huge demand, it will be challenging to find kala jeera in the marketplaces even a month after harvest. As a result, its positive price elasticity revealed a positive supply–price relationship, which may be the result of an oligopoly market. Increased pricing for customers is the result of a limited number of powerful sellers controlling the sales. Whereas chilgoza (–1.57), dhoop (–0.26), karoo (–2.77) and kuth (–2.13) showed negative price supply elasticity relationships, thus revealing their inelastic nature, i.e. commensurate change in the price brought about no change in the quantity supplied.

Real price elasticity

The price elasticity calculation at a constant price showed similar results (Table 3). With the exception of kala jeera (2.83), the real price elasticity of all the examined species was negative, demonstrating the high degree of elastic behaviour in kala jeera, wherein a proportionate change in price results in a striking change in the quantity supplied. It is implied that more quantity will be supplied at a higher price and vice versa, as indicated by positive relationship between price and amount supplied. Four medicinal plants, including chilgoza (–3.11), dhoop (–0.85), karoo (–3.47) and kuth (–4.38) had negative price elasticity or were inelastic in real terms. The most elastic species was found to be kala jeera (2.83).

Scarcity ratio of the chosen medicinal plants

The scarcity ratio for the chosen species was estimated by comparing the change in real prices during 2011–21 (Table 4). The collected species that showed a positive scarcity ratio were considered scarce. Kuth showed a positive ratio (0.01) but was not highly scarce in nature. Being an endemic species to the Himalayas, its distribution is confined to an extremely narrow geographical range[29]. Also, its cultivation

is restricted to a few villages[30], which makes it an endangered medicinal plant[31–34], listed in Appendix I of the Convention of International Trade in Endangered Medicinal plants of Wild Fauna and Flora (CITES). It has been prioritized among the medicinal plants of high conservation concern[35–37]. In the case of chilgoza (–0.09), kala jeera (–0.06), dhoop (–0.26) and karoo (–0.37), the scarcity ratio was negative, indicating that these medicinal plants were easily available and not scarce.

Conclusion

Medicinal plants are widely used throughout the world. Natural remedies are increasingly being used by people to treat common ailments like cold, allergy, stomach upset and toothache. In spite of the increasing demand for these medicinal plants, future endeavours face many challenges. The loss of medicinal plant species as a result of excessive use of these resources is one of the problems facing the medicinal plant industry. Due to extensive harvesting and habitat loss, many species are at risk of becoming extinct. Consequently, it is important to take into account the environmental code of ethics that protects biodiversity when using medical plants to find new species.

In order to take action and develop plans for the protection and sustainable use of plant species in forest tracts, practitioners of traditional medicine, foresters and planners will find the information provided in this study to be useful.

Policy implications for the promotion of medicinal plants

- The Government should take action to nationalize the sale of processed versions of medicinal plants instead of their raw counterparts.
- Utilizing cutting-edge technologies will allow for the extraction of significant wild plants.
- Giving attention to *in situ* and *ex situ* conservation, together with the artificial regeneration of rare species, can improve the production of medicinal plants.
- Local collectors are being exploited as there is no regulated market structure for medicinal plants; therefore, the government should take the required actions to improve the marketing of medicinal plants.

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