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Millets for Livelihood and Environmental Sustainability: An Assessment of Millets Production and Productivity in Hill Districts of Uttarakhand

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Abstract: Millets have been central to the food security system of the hill districts of the Uttarakhand States. Of late the area under millets is declining not because the green revolution has made inroads in the agriculture system of the region but because of endogenous factors. The demographic changes – because of the out migration of a large number of people, the holdings of out-migrant households left fellow have turned barren. Because of a shortage of manpower, many households have reduced the area under plough. The other serious issue is the menace of wild animals compelling households to leave the land on the fringe or exterior of the village uncultivated. Using historical data and exponential forecasting methods this paper argues that if the existing trend continues there will severe reduction in area under millets. The rising per-hectare productivity of millets – will not be sufficient to salvage the impact of the reduction in area. The paper also argues that rising awareness about millets and expanding market –upcoming entrepreneurs and marketing channels are the glimmer of hope – that the millets of the hill districts of Uttarakhand, which are produced organically – will be effective instruments in realizing the economic potential of millets. This paper examines the trends in the area, production and productivity of millets in the ten hill districts of the State of Uttarakhand.. It makes a modest endeavour to ascertain the reasons for changes in the three attributes of millets – area, production and productivity.

Keywords: Millets • Baranaja • Value Chain • Entrepreneurship • Sustainability

Introduction:

Various researchers have established that millets have the potential role in salvaging the adverse impact of climate change on food security and nutrition. (Government of India, Ministry of Agriculture 2014, Saxena 2018) Millets have the potential to contribute to achieving some of the Sustainable Development Goals (SDGs) -2030 of the United Nations (Pandey, 2023). Seemingly, facing similar issues - like low productivity, and inadequate market channels, the reasons behind these challenges may vary across countries and regions. An example of this is the comparative picture of the millets at the national level in India vis-à-vis Uttarakhand state. Pearl Millet -Bajara has the highest share followed by Sorghum-Jawar and Ragi in the total areas and millet production in India (Government of India APED 2023). In comparison, in the hill districts of Uttarakhand, farmers do not raise Pearl millet Sorghum crops. The millet cultivation scenario in the state is dominated by Finger millet and Barnyard millet (Government of Uttarakhand Agriculture Department 2023). It is also important to mention that Uttarakhand accounts for a small percentage of the area and production of millets in India – about 0.89 and 1.01 per cent respectively, but this small

acreage is a treasure of bio-diversity of millets. Traditionally, in Kharif; crops the cropping season of monsoon, a typical agriculturist, is supposed to harvest 12 grains known as *Barananaja (Twelve Grains) in the regional cultural traditions*(Vijay 2007) In the higher altitudes area above 1800 Mean Sea Level, Phapahar (Tartary Buckwheat -*Fargopyrum atrium*) Uwajau (*HodreumHimalayens*)and Oggal (Kuttu – Palthi Buckwheat Fargopyrum esculentum) were important crops. *This crop diversity in which millets have a dominant role, is waning*. Similar is the story of the cultural practices associated with agriculture in general and millet cultivation in particular. Since millet cultivation is labour intensive many activities – like weddings have to be completed, within the intermittent rains, therefore collective labour and labour sharing *(Sahel and padiyal in* the local language) were common. Now many of the crops are waning, and so are the labour practices and cultural traditions associated with them. Therefore, there is a need for comprehensive documentation of issues and challenges faced in the value chain of millets; producers, processors, marketing channels, the taste and preferences of consumers, and cultural traditions associated with millets, across the regions.

Material and Methods:

The paper is based primarily on the data of area, production and productivity of different crops in the Hill districts of the state of Uttarakhand, from the Agriculture Department's official website: https://agriculture.uk.gov.in/ and various other reports, research etc available on public domain. There is specific mention of the source of the data, at appropriate places. The data of area, production and productivity for different crops for the period from 2011 (2010-11) to 2021 (2020-21) have been collected from the above-mentioned official website of the government of Uttarakhand. For projecting the area, production and productivity the exponential smoothing forecast method has been used. The forecast sheet tool in Excel 2019 was used for the same. The function used in this regard was FORECAST.ETS (target date, values, timeline, [seasonality], [data completion], [aggregation]**)**. Using this statistical tool in Excel – forecast for area and production has been done for ten years. The FORECAST.ETS.CONFINT function is used to calculate the confidence interval for a forecasted value. The projection of the data has been done at a confidence level of 95 per cent or 0.05 level of significance.

Study Area:

Uttarakhand extends from 28º 43' N to 31º 27' N longitude and 77º 34' East to 81º 02' E latitude in northern India. Uttarakhand state in the north and northeast shares the international boundaries of India with China (Tibet Autonomous Region) and Nepal respectively. Himachal Pradesh and Haryana form the Western border. In the south and southwest Uttarakhand shares borders with Uttar Pradesh. Carved out from the state of Uttar Pradesh on 9th November 2000, the state of Uttarakhand has 13 districts that have been organised into two divisions (or commissionaires) Garhwal and Kumaon. The Garhwal Division has the following seven districts Chamoli, Dehra Dun, Haridwar, Pauri-Garhwal, Ruder Prayag, Tehri -Garhwal and Uttar Kashi. Kumaon Division has six districts Almora, Bageshwar, Champawat, Nainital, Pithoragarh and Udham Singh Nagar (US Nagar).The state has two distinct topographical regions- the southern region has plain and flat topography – covering approximately 14 per cent (7448 Square Kilometres) and the northern mountainous regions accounts for about 86 per cent (about 46035 Square kilometres) of the total geographical area of 53483 square Kilometres of the state. Here it mentioned that only Two districts of the state Haridwar (in Garhwal Division) in Gangetic plains and US Nagar (

in Kumaon Division) in Tarai – foothills of the Himalayas are of plain topography. *Eleven districts are mountainous, however, a*mong these eleven districts, two districts; Dehra Dun and Nainital, also have areas of plain topography. The Doon valley, enclosed by the Shivalik and Himalayan ranges, which houses the State Headquarters city, Dehra Dun in Dehra Dun District and the Tarai Bhabar area of Nainital District are such areas Thu– 9 districts - Chamoli, Pauri-Garhwal Ruder Prayag, Tehri Garhwal, Uttar Kashi (of Garhwal Division), Almora, and Bageshwar, Champawat, Pithoragarh (of Kumaon Division) mountainous. The total population of these eleven districts is about 65.48 lakhs (about two-thirds of the total population of the state).

Result & Discussion

The elevation of the region gradually increases from 7817 meters Mean Sea Level (MSL) to meters forming the Nada Devi Peak the second-highest peak in India and the highest among all the Himalayan peaks in the region. In the year 2020-21, two-thirds of the total reported area of the mountains of Uttarakhand (5477729 hectares) was under forests and a substantial part of the region is barren, permanently snow covered hence uninhabitable. Only 6.8 per cent of the reported area was reported as a Net Swon Area (NSA). The region is drained by numerous tributaries of river Ganga and Yamuna, however, close to eighty per cent of the Net Sown Area (NSA) of the region is rainfed. As the following table 1 suggests Net Sown Area, in the last decade, has shirked from 9.0 per cent of the total reported area to 6.8 per cent and fallow; current, other and barren land is on the increase.

Table-1: Land use in Hill Districts of Uttarakhand state -2010-11 to 2020-21 (Area in Lakh hectares and % is to Reported Area

Land use	Year 2020-21		Year 2010-11	
	Area	Per cent	Area	Per cent
Reported Area	54.8	100	51.4	100
Forest	36.3	66.3	33.0	64.2
Barren and not suitable for cultivation	2.5	4.5	2.2	4.3
Other than agricultural uses	1.2	2.2	1.6	3.1
Cultivable waste	3.3	6.1	3.1	5.9
Pasture	2.1	3.8	2.0	3.9
Other trees/ plantation	3.9	7.2	3.8	7.4
Current Fallow	0.8	1.5	0.4	0.7
Other Fallow	0.9	1.6	0.8	1.5
Net Sown Area	3.7	6.8	4.6	9.0
Net Irrigated areas @	0.77	20.0	0.86	17.0

@percentage of irrigated areas is to Net Sown areas. Source: (Government of Uttarakhand, 2013, pp. 52-53; Government of Uttarakahnd 2023, pp. 56-57)

In the hill topography cultivation is possible only by terracing, which also has limited scope in higher altitudes, and is an odorous task. Therefore, these constraints: land ownership and topography, set the limits of the availability of arable land, which as a rule tends to decline with the increase in altitude. The land use data is presented at the district tehsil and even at the block level because inherent limitations of averages and aggregation capture a limited picture of the availability of arable land in the region, where topographic and associated soil and climatic changes are often abrupt. The micro-level studies show that in the villages situated in higher altitudes in many cases, the availability of arable land is limited to one or two per cent of the total geographical or reported area of the villages (Juyal, R P, 1985, p. 65). Besides soil conditions- thin soil, deficient in Nitrogen and

inflicted by wind and water (rainfall) caused erosion, also set limits to arable land.The relative scarcity of arable land and institutional factors like laws of inheritance have resulted in sub-divisions of land, and more than three-fourths of the total agriculture holdings are marginal holdings. As the figure indicates subdivision of land is making land holdings smaller and smaller. As the following figure suggests within 15 years the proportion of marginal holdings has increased by four percentage points and that of holding larger than one hectare has decreased.

Table-2: Size of Holdings in the Hill Districts of Uttarakhand

Size/ Number of the land holdings	2005-6	2010-11	2015-16
Total Number of Holdings	508071	511053	516695
Less than one hectare	73.3	75.7	77.3
1-2 Hectare	17.8	17.3	16.2
2-4 Hec	7.3	5.8	5.4
4-10 Hec	1.5	1.1	1.0
More than 10	0.1	0.1	0.1

Source : (Government of Uttarakhnad, 2020, pp. 45-47; Goverernment of Uttarakhand, 2016, p. 45)

Trends in Area and Production of Millet:

A look at the bottom row of the Table 3 shows that in the last decade 2011-12 to 2021-22, the Total Area under food grain, cereals (other than millets), millets and pluses, barring a few occasions, have been consistently on a decline. The proportionate decline in the area under millets and cereals been - almost identical (about 40.18 per cent and 39.47 per cent. As a result, the proportionate share of *cereals and millets over the period has remained almost the same- around 30 per cent under millets and around 58 per cent under cereals – paddy, wheat, barely, maize etc however the* share of pulses has increased from 7.64 percent to 11.40 per cent, These changes have to be seen in the complex context of ongoing socioeconomic changes in the region and also with some limitations The first and important context is the NSA is on the decline and holdings are getting smaller and smaller. The NSA has declined largely because of the demographic changes – brought by outmigration and the slowing of the population growth rate. The land holdings of migrants – in many cases, have been left fallow. People residing in the villages for multiple reasons – as discussed in the last section of this paper are not willing The relative share of millets, cereals and pulse has to be seen in the context of the unique crop rotation pattern in the region. In the crop rotation system, practiced in the Hill land is divided into two parts and by rotating crops, cultivators take three crops in two years. In Kharif season – in one part of the land Finger millet and various legumes are raised and another paddy, Barnyard Millet and Fox Tail millets are grown. In Rabi season one part of the land is left fallow and in other wheat and legumes (masoor) In the crop rotation system – millets and legumes/lentils have some advantage over cereals – paddy and wheat, in acreage. In a kharif cropping season the acreage under millet (Finger millet, Barnyard millet and Fox tail millet), is often equal to or more than the area of paddy. For the reasons that Barnyard millet and Fox Tail millets are raised independently in a particular field and as well as mixed with paddy. Likewise, legumes/lentils crops – either independently, as mono-crop in a field or in some cases - with Finger millet. In this system, if the cultivated area shrinks for any reason, the reduction in the area of millet does not shrink radically. (for more on crop rotation see the box – Crop Rotation in the Hill Districts of Uttarakhand.

Table-3: Area of Different Crops in the Hill Districts of Uttarakhand 2011-12 to 2021-22 (Area in hectares, percentages are Area total food grains)

ear	otal Food Grain		lajor Millets		Cereals (other han millets)		luses /Lentils	
	rea		rea	er cent	rea	er cent	rea	er cent
011-12	36512		01362	1.64	86526	0.73	8624	.64
012-13	62326		76145	1.32	39538	0.38	6643	.29
013-14	40231		68879	1.26	24871	0.14	6481	.60
014-15	43365		5984	3.98	16550	6.66	0831	.35
015-16	30925		61695	0.46	19981	0.27	9249	.28
016-17	27174		63400	1.00	15458	9.84	8316	.17
017-18	99218		54365	0.92	95444	9.18	9409	.90
018-19	70406		47595	1.38	71993	7.82	0818	0.80
019-20	IA		IA		IA		IA	
020-21	33651		28036	9.53	54495	8.69	1120	1.79
021-22*	99912		20439	0.12	33952	8.50	5521	1.38
ecrease in Area in the Decade 2011-12 to 2021-22								
eriod	otal Food Garin		lajor Millets		Cereals (other han millets)		luses /Lentils	
	rea	ercent	rea	er cent	rea	er cent	rea	er cent
011-12 to 021-22	36600	7.17	0923	0.18	52574	9.47	103	.38

NA = Not available , * Provisional Estimates

Source : (Government of Uttarakhand, Agriculture Department, 2023 (a)) (Government of Uttarakhand Agriculture Department, 2023)

One can notice that keeping the demands of pluses/ lentils among the diaspora of Uttarakhand, some cultivators who have access to the market are shifting from millets and other cereals to pluses/ lentils. Interacting with households it becomes clear that they have a special taste for locally grown millet and lentils. They specifically mentioned that they buy wheat and rice from the ration shops (fair price shops / public distribution system) and if needed can approach to open market to buy these gains. But millets – Finger Millets and Barnyard millets are not available in the neighborhood market. So is the case with locally grown -lentils. Therefore, as per their dietary habits and taste – every farmer allocates some area for millets and lentils. Some cultivators have specifically mentioned that millets have more and better fodder content than paddy and wheat. In winters –at higher altitudes when it becomes extremely difficult to collect fodder from forests/pastures and cattle can also be not lost to graze in the pasture, the stems of millets -especially of Barnyard millet stored are fed to cattle.It is a fact that the area under cultivation is declining but the reasons, mentioned above millets, despite being considered inferior, to cultivate them is labour intensive, the area under millet is changing in tandem with cereals like paddy and wheat

Proportionate share of different millets in total area under millet cultivation:

The data given in the table below show that finger millets and Barnyard millets account for little less than two-thirds and one-third of the total area under millets, respectively. A small percentage of the total area under millet about

3 to 4 per cent is allocated to Amaranth. This trend has by and large persisted for a long. Here it is to be mentioned that Amarnath is a main crop in the higher altitudes approximately above 1800 meters.

Table 4: Proportionate share of different millets in total area under millet

Year	Total Area Under Millets	Percentage to total Area under Millets		
		Finger Millet	Barnyard Millet	Amarnath
2011-12	201362	63.39	33.59	3.02
2012-13	176145	64.07	32.18	3.76
2013-14	168879	64.14	32.31	3.55
014-15	75984	70.91	21.26	7.83
2015-16	161695	65.09	31.26	3.66
2016-17	163400	64.90	31.39	3.71
2017-18	154365	65.63	30.14	4.23
2018-19	147595	63.57	32.58	3.85
2019-20	0	#DIV/0!	#DIV/0!	#DIV/0!
2020-21	128036	65.06	30.62	4.31
2021-22*	120439	64.62	31.20	3.02

NA = Not available , * Provisional Estimates

Source : (Government of Uttarakhand, Agriculture Department, 2023 (a)) (Government of Uttarakhand Agriculture Department, 2023), (Government of Uttarakhand, Agriculture Department, 2023 (a)) (Government of Uttarakhand AgricultureDepartment, 2023)

Trends in Production and Productivity:

Table 6 also indicates productivity of Amarnath fluctuates more vis–a–vis of finger millet and barnyard millets. A comparison of Table 6 with 4 indicates that although the area under millets over the period 2011-12 to 2021-22 has declined by 40 per cent, however, the fall in the production is around 30 per cent (from 260347 to 181998 metric tones). This reduction seems to be less because of some rise in per-hectare productivity, but even this simple arithmetic calculation leads to the conclusion reduction in area under millets per se, the decline in cultivated area, is of such a magnitude that the small increase in productivity, is not capable of offsetting the loss in production because of reduction in the area.

Table-5: Trends in Production & Productivity (Production in Metric Tonsand Productivity per hectare in quintals)

Year	Total millet		Percentage to total Millet Production			Productivity		
	Production	Average per hectare	Finger Millet	Barnyard Millet	Amarnath	Finger Millet	Barnyard Millet	Amarnath
2011-12	260347	12.93	65.3	33.6	1.1	13.3	12.9	4.84
2012-13	236962	13.45	66.4	31.9	1.7	13.9	13.3	5.91
2013-14	223616	13.24	66.4	31.9	1.7	13.7	13.1	6.34
2014-15	94685	12.46	73.5	22.0	4.5	12.9	12.9	7.18
2015-16	220970	13.67	67.2	30.3	2.5	14.1	13.3	9.28
2016-17	235214	14.39	66.7	30.7	2.6	14.8	14.1	10.14
2017-18	208896	13.53	66.4	30.3	3.3	13.7	13.6	10.58
2018-19	183076	12.40	62.4	34.4	3.2	12.2	13.1	10.40
2019-20	NA	NA	NA	NA	NA	NA	NA	NA

2020-21	190831	14.90	65.8	30.3	3.9	15.1	14.8	13.32
2021-22*	181998	15.11	63.2	33.3	3.6	14.8	16.1	12.88

NA = Not available , * Provisional Estimates

Source : (Government of Uttarakhand, Agriculture Department, 2023

The contribution of finger millets, barnyard millet and Amaranth in the total production of the millet, corresponds to the share in the total area of millet. Finger millet accounts for about two-thirds of the total area and production of millet. Barnyard Millet and Amarnath account for close to one-third and four per cent of the area and production of millets respectively. As far as per-hectare production of millets is concerned, a look at table 6 over the years it ranges between 13 to 15 quintals per hectare, which is a bit more than the national average of 12 to 13 quintals per hectare (Government of India APED, 2023).

Possible Future Trend in Millets: Area, Production and Productivity:

Using exponential forecasting tools -, it is estimated that the area under food grains, by the year 2031 will be around 2.06 lakh hectares – about 1.93 lakh hectares less than present (3.99 Lakh hectares i.e. almost half than it is today. The year-to-year scenario of the area under food grains and production for the period 2021 to 2031 is given in the following table. A perusal of the table gives an idea that, as per the existing trend in the best of scenario the area under food grain will be 3.17 lakh hectares – about 0.72 lakh hectares than in the year 2021.The impact of this possible scenario on production will be equally serious. The total production of food grains will be about 4.84 lakh metric tonnes – about 1.51 lakh metric tons less than it was in 2021. In the best of scenario, the production of food grains may be 6.46 lakh metric tons just (about 0.11 lakh metric tons, more than it is today. Although in this working paper, we have not attempted to project population growth, believing that the present trend of slowing down of population continues – the (projected) food grains available per capita, from the production of the region, will be less than what it is today.

Table-6: Projection of Area and Production of Food Grain in theHill Districts of Uttarakhand-2031

Year	Area in hectares			Production in metric Ton		
	Forecast (Values)	Lower Confidence Bound (Values)	Upper Confidence Bound(Values)	Forecast (Values)	Lower Confidence Bound (Values)	Upper Confidence Bound (Values)
2021 Actual	399912	399912	399912	635633	635633	635633
2022	381827	343307	420347	617787	552284	683291
2023	362328	310479	414177	602935	521016	684853
2024	342830	280415.	405244	588082	492494	683669
2025	323331	251879	394783	573229	465666	680792
2026	303832	224346	383318	558376	440016	676736
2027	284333	197539	371127	543523	415246	671800
2028	264835	171287	358382	528670	391167	666173
2029	245336	145477	345195	513817	367646.	659988
2030	225837	120030	331644	498964	344591	653338
2031	206338	94888.	317789	484111	321929	646293

As presented in the following table – as per the exponential forecasting method by 2031 – the area under millets in the hill districts of the state will be approximately 0.74 lakh hectares- down by about 0.46 lakh hectares – about 38 per cent less than it was in 2021-1.20 lakh hectares The worst and best scenario project of area under millets are given in table 7.

Table-7: Projection of Area and Production of Millet in the Hill Districts ofUttarakhand-2031

Year	Area in hectares			Production in metric Ton		
	Forecast (Values)	Lower Confidence Bound (Values)	Upper Confidence Bound (Values)	Forecast (Values)	Lower Confidence Bound (Values)	Upper Confidence Bound (Values)
2021	120439	120439	120439	181998	181998	181998
2022	119904	56163	183644	106335	22343	190328
2023	114764	49046	180481	199017	112398	285635
2024	109624	41972	177275	217838	128652	307025
2025	104483	34936	174031	203108	111405	294811
F2026	99343	27936	170750	112056	11019	213093
2027	94203	20970	167437	204737	101437	308037
2028	89063	14034	164093	223559	118028	329090
2029	83923	7126	160720	208829	101096	316562
2030	78783	245	157321	117777	1871	233682

The production will not fall drastically. Most probably it will be somewhere around 2.10 lakh metric tonnes – about 20 thousand metric tonnes more than it was in 2021 (1.81 lakh metric tonnes. The other important inference of exponential forecasting is the relative share of finger millets, Barnyard millet and Amaranths will be approximately same -as it is prevailing 64, 31 and about 5 per cent respectively.

Conclusion & Policy Implication:

The above discussion leads to the conclusion that the trend of reduction in the area under millet cultivation in hill districts of Uttarakhand is not because of any significant exogenous factor but a result of endogenous socio-economic process. What is important to mention is that the factors resulting in the decline of the area under millets are not extraneous or superficial but deep-rooted in the socio -economic system of the region. The reversal of some of which – like slowing down of birth rate may not be possible soon. The other fact or out- migration may decelerate shortly- depending on the economic transformation of the districts - specifically on the availability of jobs and quality services – like education and health care. However, with the increasing awareness about millets of the region which are produced organically, cultivators developing links with marketing agencies – Self-Help Groups (SHGs) upcoming Marketing Societies and marketing entrepreneurs will have a positive impact. The support price provided by the Government of Uttarakhand to Finger Millet Growers it seems will have a positive impact on millet promotion

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