Defence Life Science Journal, Vol. 6, No. 2, April 2021, pp. 187-195, DOI : 10.14429/dlsj.6.16229

Role of DIBER-DRDO Technologies in Improving Livelihood Opportunities and Curtailing Migration in Uttarakhand: A Case Study and Impact Assessment

Sanjay Mohan Gupta, Vandana Pandey, Ankur Agarwal, Basant Ballabh and Madhu Bala*

DRDO-Defence Institute of Bio-Energy Research (DIBER), Haldwani - 263 139, India

**E-mail: madhubala@diber.drdo.in*

ABSTRACT

Migration of local population of Uttarakhand (UK) border areas is presently serious issues for national security since; this State is sharing international border (~650 km) with China/Tibet and Nepal. Among the various factors reported for migration, few notables are search for better livelihood, unemployment, difficult remote terrain and poor land connectivity, less productivity from agriculture due to abiotic and biotic stresses *etc*. Hence, measures to increase the livelihood opportunities in these border areas to curb the problem of migration through intervention of modern agro-animal technologies are essentially required. In this attempt, Defence Institute of Bio Energy Research (DIBER) has already developed various agro-animal mature technologies, in terms of high yielding and genuine quality seed/seedlings, protected cultivation technology, soil-less cultivation technology, angora farming, mushroom cultivation, medicinal and aromatic plants (MAPs) cultivation technology, hydro-fodder, *etc* that shown great promise and impact in increasing the farm income and livelihood opportunities for civil inhabitants of these marginal regions. This article highlights the DIBER outreach extension efforts for ensuring better livelihood opportunities to farmers of border area and also to curtail migration that will in turn increase strategic support to Army and paramilitary defence forces deployed in three border Distts (Uttarkashi, Chamoli and Pithoragarh) of UK.

Keywords: Agro-animal technologies; Agricultural extension; Central Himalayan agriculture; Farm income; Impact assessment; Migration; Socio-economic status

1. INTRODUCTION

Uttarakhand (UK) shares ~650 km long international border with China/Tibet and Nepal. The residents of these border areas face a number of specific problems namely, high altitude agricultural problems, lack of basic amenities for livelihood, land connectivity mainly during winter and rainy months, difficult remote terrain, frequent landslides, unemployment and many more[1]. Moreover, migration of local population from these border areas is presently major issues for national security[2]. At these border areas, establishments of armed forces namely, Army, ITBP, SSB, BRO *etc* are deployed along with civil populations.

It is a fact that rate of migration from border villages of Uttarakhand has increased rapidly in recent past. According to a Rural Development and Migration Commission report published during September 2019, out of 16793 villages of UK, about 1702 villages have almost negligible inhabitants and other 405 villages are having very less inhabitant (less than 10 no of population)[3,4]. This shows the grim situation of our border villages, which is also a challenging situation for security forces considering strategic reasons. Among the various factors reported for migration some important are search for better basic amenities for livelihood and less agricultural productivity due to harsh climacteric conditions and problem of treats to crops from wild animals[2]. Hence, measures are required to increase the livelihood/ new employment opportunities in these border areas to curtail the migration problem through intervention of suitable customised agro-animal technologies[5] specific for hilly regions.

Defence Institute of Bio Energy Research (DIBER) is actively engaged in carrying out research and development activities in the area of bio-energy and bio-fuel and striving hard to develop bioenergy technologies for defence use. This institute is also carrying out research and development in the field of conserving Himalayan biodiversity and its judicious utilisation for development of various products for defence and civil applications. A large number of agro-animal technologies specific for mid to high hills of Central Himalaya region have been developed by DIBER[6]. These mature agro-animal technologies namely, protected vegetable cultivation technologies, soil-less cultivation technology, high value exotic vegetable production, medicinal and aromatic plants (MAPs) cultivation technology, mushroom production, hydro-fodder technology, angora rabbit farming, *etc* have been customised to low to high altitude region of UK and are being demonstrated by DIBER to border villagers. The main objective of these activities is to increase livelihood opportunities in these border areas and also to curtail migration that will in turn increase strategic support to Army and paramilitary defence forces deployed in these border locations. At present three border Distts (Uttarkashi, Chamoli and Pithoragarh) of UK have

Received : 21 May 2020, Revised : 09 April 2021
Accepted : 16 April 2021, Online published : 03 June 2021

been selected as a part of project 'SARHAD'. After successful completion of a pilot study with selected 12 progressive farmers of Pithoragarh Distt (where farm income of the villagers was increased about 02 folds), a comprehensive extension study for enrolling and supporting 10,000 farmers from aforesaid 03 border Distts of UK has been initiated, which is now one of the monitored programme at national level.

This article highlights the DIBER efforts in increasing livelihood opportunities and curtailing migrations in border areas of UK through intervention of DIBER, DRDO developed agro-animal technologies that has shown great promise and impact in increasing the farm income and productivity commensurating with vision of Hon'ble PM "Double farmer income by 2022"[7-8].

Table 1. Migration status from gram panchayats (in %) in Uttarakhand.

Uttarakhand Distts	Average no. of reported migrated people (in %)		
	Age less than 25 years	26 to 35 year old	More than 35 years of age
Uttarkashi	30.68	36.56	32.77
Chamoli	26.71	43.49	29.79
Pithoragarh	28.32	42.58	29.10
Rudraprayag	28.97	41.83	29.20
Tehri Garwal	29.26	40.92	29.82
Dehradun	38.41	34.47	27.12
Pauri Garhwal	29.23	41.67	29.10
Bageshwar	33.92	42.10	23.97
Almora	29.19	42.22	28.59
Champawat	25.23	45.49	29.29
Nainital	29.48	44.57	25.96
Udham Singh Nagar	16.66	43.34	40.00
Haridwar	13.99	52.79	33.22

Source: Adapted from Rural Development and Migration Commission Report, Sep. 2019[3,4].

2. STATUS AND TRENDS OF MIGRATION IN UTTARAKHAND DURING COVID-19 NATIONAL LOCKDOWN

The biggest problem of UK is migration from border areas to move comfortable area in lower lands or to metro cities (Table 1)[3-4]. The unbalanced government policies, which lead to more development in the plains as compared to hilly regions, were mainly responsible for this significant migration[1]. Many people have left the village and shifted to the city due to unemployment and the villages are lying deserted. But after the national lockdown due to COVID-19, many migrants from cities have come back to the native village in 10 districts of UK that resulted into significant increase in reverse migration trend. As per recent reports, in UK around 95 thousand people returned to the mountains in lockdown and now decided to stay at their native even after the lockdown period is really has come as a boon on the mountains[2]. It is being anticipated that the number of people doing reverse migration after lock-down may increase even more. The reverse migration data suggest that there are 30 per cent people who have migrated to the cities of UK, 65 per cent are people who have migrated to different states of the country and rest 5 per cent have returned to their villages from abroad. As per state migration commission report, these 30 per cent of people who returned to their native village during lockdown and expressed a wish to continue stay after lockdown is really good news for armed forces considering strategic reasons[9]. However, it is very tricky to forecast about those people who returned to their native village during COVID-19 pandemic period, will stay permanently for longer time. They might go back to urban cities for employment, when the COVID-19 pandemic situations become under control[9,10]. Since, it is not possible to set up any industries immediately at their native villages. Also, most of these migrated persons are daily or contractual workers, who may not find employment at their native villages, will go back. As a consequence, the State government and local administration are presently dealing with the situation of unemployment and taking steps for generating employment in rural areas in view of economic rehabilitation. DIBER, DRDO is also contributing in sustaining the reverse migration rate in UK through intervention of various modern agro-animal technologies to increase livelihood opportunities to migrants along with marginal farmers.

3. DIBER SPIN-OFF AGRO-ANIMAL TECHNOLOGIES

DIBER has developed following potential agro-animal technologies for improving livelihood and farm income of marginal farmers and support to Army services in remote border areas of UK.

3.1 Protected Vegetable Cultivation Technology

The production of vegetable crops under protected condition such as polyhouse/trench/plastic low tunnels, shade net houses, walk in tunnels, plastic mulches *etc* under controlled environmental conditions is known as protected cultivation technology. Protected cultivation of vegetables is an essential feature of sustainable and profitable agriculture in mid and higher reaches of Indian Himalayas[11]. The Himalaya has a very peculiar ecosystem extending from 27°N to 38°N longitudes with mountain ranges stretching over a distance of about 3000 km, covering an area of approximately 5,23,000 km^2. Depending upon the topography, soil, microclimatic conditions, the Indian Himalaya has been divided in three major regions: Western (J&K, HP), Central (UK) and Eastern Himalaya (NE States). The Central Himalayan State of UK experiences three major seasons, summer (April-June), monsoon (July-September) and winter (December-February). Therefore, customised structure for growing vegetable crops has been developed commensurating to the unique environmental conditions of the area for sustainable and profitable yield. DIBER, DRDO

Figure 1. Customized different innovative hydroponics systems under low cost shade net at DIBER, Haldwani.

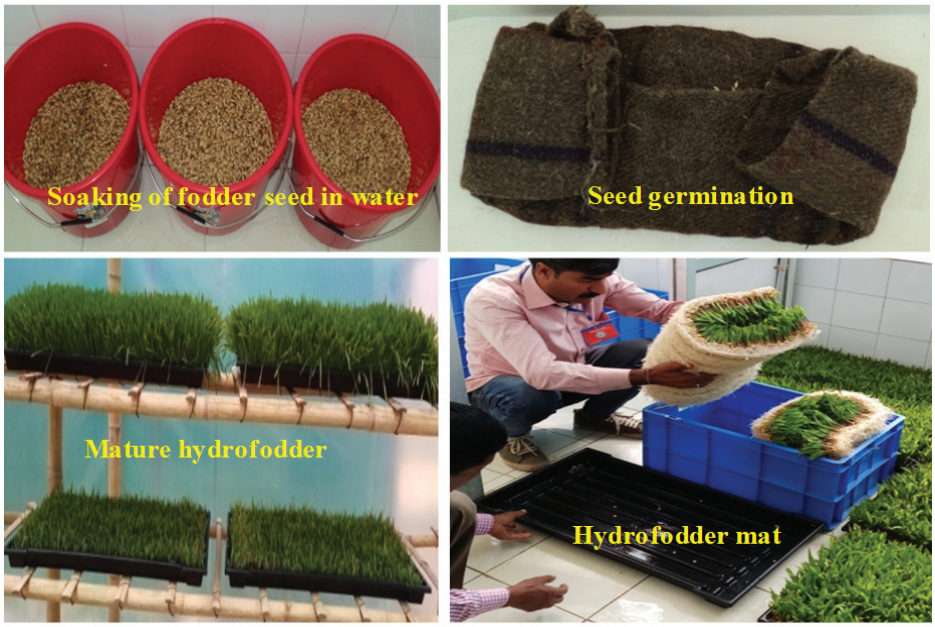

Figure 2. Customization and demonstration of hydro-fodder technology.

through its research stations in three agro-climatic zones of Central Himalaya *viz*, *tarai* (Haldwani), lesser Himalayan zone (Pithoragarh) and trans-Himalayan zone (Auli and Harsil) has standardised technology for construction of polyhouse customised to the need of area and user, which has been widely accepted by the users in remote border areas of UK.

The main benefits of protected cultivation technology includes, (a) seed germination and growing early nursery; (b) off- season vegetable cultivation; (c) enhancement of cropping intensity coupled with production; (d) extending production area and cropping season; (e) increasing productivity and quality; (f) higher water use efficiency and nutrient use efficiency; (g) higher income per unit area; (h) employment generation and self reliance; and (i) protection from wild and grazing animals[12-13].

DIBER has developed the core competence in protected vegetable cultivation technologies suitable for different altitudes in Central Himalayan region and developed 21 vegetable varieties and hybrids that have been released at National/State level. Rapid increasing demand of fresh vegetables in middle and high altitude areas due to deployment of troops, enhancement of tourism by Government and mono-cropping concept led to the development of green house technology by the institute[14]. DIBER has successfully demonstration this technology to various progressive farmers and Army units of Dist Pithoragarh UK. The data on vegetable production received from progressive farmers since Dec 2019 showed significant increase that will surely help to improve socio-economic status of border area farmers and support to Army for fresh green vegetable at forward post.

3.2 Exotic Vegetable Cultivation Technology

There is a potential of producing good quality exotic (European vegetables) in the hills of Central Himalayas since the weather conditions are similar to Europeans countries. Seed production of these exotic vegetables is very challenging as the climatic requirements are very peculiar and isolation strategy is also required to avoid the cross contamination to keep the seed quality high. DIBER field stations at Pithoragarh and Auli are suitable places for seed production of these vegetables. Besides hills, in some parts of plains, these vegetables can be grown but

Figure 3. Dissemination of angora wool technology at wool village in Pithoragarh.

seed production is possible in hills only. Also due to increased tourism avenues in UK, the demand of exotic vegetables is increasing regularly in hotels and other international chains like McDonald's, KFC, and Subway forayed into India. They are called low volume high value exotic vegetables *viz*. red cabbage, chinese cabbage, pak choi, brussel's sprout, lettuce, broccoli, celery, parsley, cherry tomato, bush squash, leek, swede *etc*, which are nutritionally rich and having strong antioxidant potential[15].

The farming of these exotic vegetables has tremendous importance in horticulture since exotic vegetables are of short duration, low volume with high nutraceutical values. The cultivation these vegetables will provide significant economic benefits to border farmers of hilly regions of UK with handsome remunerative prices of crops even during off-season[16].

3.3 Soilless/Hydroponics Technology for Vegetable Production

Historically hydroponics culture of crops has been known to world since last three decades but in India this technology was introduced through British colonisation and generally known as 'Bengal System of Hydroponics' in 1946. Hydroponics is basically a method of growing crops without using soil; the essential mineral nutrients were supplied through liquid solutions. The main advantages of hydroponics over conventional system of cultivation of crop includes mainly, (a) a soil-less system saves 70 per cent - 80 per cent less water; (b) efficient utilisation and optimisation of mineral nutrients for growing various crops in single liquid medium; (c) more productivity of crops due to vertical farming that requires less space; (d) diseases and pest free healthier crops due to devoid of soil and under controlled environmental condition; (e) farm produce is purely organic due to not involvement of harmful chemicals like pesticides *etc*; (f) efficient utilisation of indoor and roof tops spaces; (g) reduces transportation cost of fresh farm produce due to installation of unit at user place; and (h) vegetables cultivation could be made possible in harsh climacteric conditions (snow bound areas *etc*) and even on futile lands[17].

This institute has been a leading institution in customizing technology of hydroponics specially NFT (Nutrient Film Technology) and its demonstration from hills to polar islands (Antarctica). This institute has successfully demonstrated hydroponics technology during 9th, 10th and 11th Antarctic expedition during 90s[18]. Hydroponics system have been successfully customised by DIBER for various altitudes such as Haldwani (foot hill), Pithoragarh (5000' asl) and Auli (9000' asl). The recent efforts of our institute in developing various customised hydroponics and vertical farming units as per user need and requirements and also developing single nutrient solution to grow multiple vegetable crops successfully[19] (Fig. 1). Recently, our institute has successfully demonstrated the cultivation of fruit, leafy and root vegetables under customised hydroponics system using single nutrient solution to various marginal farmers of UK[20].

Hydroponics is one among few agro-technologies that has tremendous potential to transform agriculture scenario specifically in remote areas and also offers plenty new job opportunities for improving livelihood to the villagers and entrepreneurs with less capital investment and technical skill. Though some challenges also exist like constant monitoring is required for maintaining nutrient balance in growing media, lack of affordable automation technology[18] *etc*. However, the key advantages are protection of crops from threats of wild

animals since topographical challenges most of the time do not make it possible to condon the farm area with fencing and thus make it vulnerable to attack by grazing and stray wild animals. Vertical farming also allows farming in a less surface area with considerable water saving due to reuse and recycling of liquid solutions, therefore, the dependency on rain can be minimised for crop farming.

3.4 Hydro-fodder Technology

It is a new method of growing green fodder without soil in controlled environments like growing of vegetables in liquid medium (hydroponics). Today farmers are switching to grow hydroponic fodder instead of using conventional production methods, because fodder produced by hydroponic method are quick, highly nutritious and palatable, easily digestible and also provide sustainable fodder production round the year. Hydro fodder takes only 1-10 days duration to develop from seed to fodder, while conventional fodder takes 45-60 days for to grow. Also, the system uses 99 per cent less land than conventional production method. The technology is highly advantageous for Himalayan region especially during winter season when there is acute scarcity of green fodder. In this context DIBER has customised and demonstrated of low cost hydroponic fodder production system to support farmers and army equines deployed at high altitude forward post (Fig. 2). Success has been achieved in producing hydro-fodder of Maize, Barley, Oats and Wheat. The main advantages of hydro-fodder technology includes, (a) less water requirement; (b) less area required due to utilisation of vertical space; (c) fast growing (8 days); (d) round the year availability possibility; (e) more nutritive and digestive; (f) Organic in nature; (g) ensures women safety as reduce chance of wild animal attack during search of fodder and no wild life threats; (h) improves milk yield; and (i) it also has potential for supplementing Army equine fodder requirement.

3.5 Medicinal and Aromatic Plants Cultivation Technology

Medicinal and Aromatic Plants (MAPs) cultivation technology offers vast opportunity to strengthen food, health and nutritional security to farm families and also provide ecological services to the environment. Commercial significance of MAPs in recent years is expanding due to diversified uses of various herbals in nutraceutical, pharmaceutical, agro-chemical and cosmetic industries. India is the second largest exporter of raw medicinal plant material, next to China and has its own domestic market of Rs ~14,000 crores for MAPs. Location specific cultivation, improved varieties, alternative cropping system, high tech cultivation (including quality seed and planting material, nursery management, micro propagation, protected cultivation, harvesting *etc*) and post harvest management, marketing and value chain are the technologies for improving productivity of MAPs.

Now a day due to increasing demand and popularity of herbal products *i.e*. in medicines as well as in cosmetics, Himalayan medicinal plants are getting unprecedented attention throughout the world. The occurrence of different climatic zones and soils of this region provide very congenial condition to grow a number of medicinally important herbal species. But due to irregular, unscientific and over exploitation of these herbs from their natural habitat, there is tremendous pressure on these plants. Keeping this problem in view, DIBER have made sincere attempts for the *ex-situ* conservation of these valuable heritage at different locations of DIBER *viz*. Pithoragarh (5500' asl), Auli (9000' asl) and Haldwani (1400' asl) in form of herbal garden. Agro-technology of various economically important MAPs namely, *Artemisia annua*, *Ammi majus*, *Bergenia ligulata*, *Acorus calamus*, *Withania somnifera, Aloe vera*, *Allium ampeloprasum, Saussurea coestus*, *Thymus serphyllum, Spilanthes acmella*, *Micromeria biflora, Cymbopogon citratus*, *Ocimum kilimandscharicum* has been already developed by DIBER.

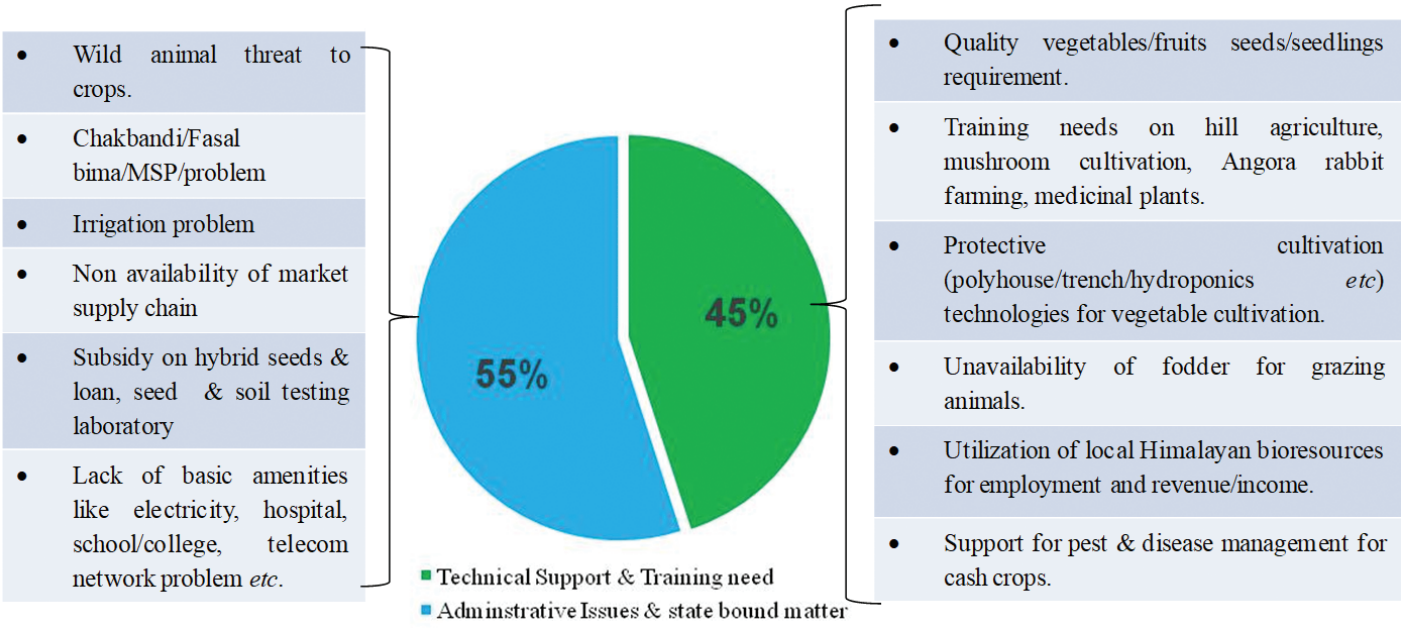

Figure 4. Feedback analysis of selected border farmer.

DIBER had developed various herbal products by using aforesaid MAPs namely, (a) Anti-leucoderma Ointment and Oral dose; (b) Anti-eczema ointment; (c) Anti-toothache herbal solution; and (d) Aloe vera based herbal health drink. The transfer of technology (TOT) of first three herbal products has been already done with AIMIL Pharmaceutical (India) Limited, New Delhi. This technology is also transferred to other reputed companies like International Herbal Corporation Haridwar, BIPHA Kottayam, Kerala and SRB Pharmaceuticals, Anand Gujarat. However, commercial cultivation of these MAPs has not been taken up by the residents in Himalayas. Therefore, farmers of Narayan Seva Ashram, Pithoragarh and other nearby villages are being motivated to take up the cultivation of important MAPs like Satavar, Tulsi, Kalajera, Mandookparni, Aloevera, Akarkara, Punernava, Tejpatta, Reetha, Harad, Aonla, Chura, Geranium, Lemmon Grass, Lavender, Timur, Pama Rosa, Turmeric, Ginger, Cardamom, Cinnamonon on large scale, which can be helpful for improving their livelihood and socio-economic status. Therefore, production of MAPs ensuring quality standards will definitely fulfill the goal of 'Health for all' and household health and nutritional security.

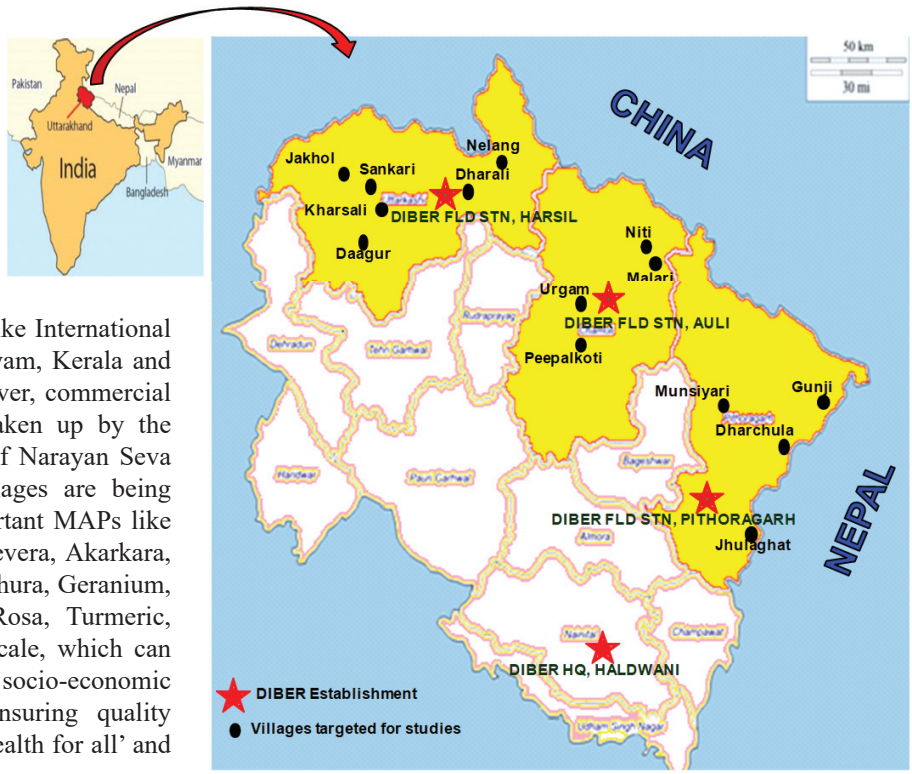

Figure 5. Selected villages for technology dissemination and technology adoption in 03 border Distts (Uttarkashi, Chamoli and Pithoragarh) of Uttarakhand.

3.6 Mushroom Cultivation Technology

DIBER has been working on mushroom cultivation technology for more than a decade to standardised mushroom cultivation techniques for the hills for improving farm income of farmers and support to Army units deployed at forward post of UK. DIBER R&D efforts resulted into standardisation of various key steps of this technology such as compost preparation technology, spawning, casing and proper harvesting. Button mushroom technology is very popular in farmers and progressive farmers are utilizing it for improving their income and livelihood security. Army units also have shown their keen interest in this technology and they are establishing in their small units for fresh food.

The salient features of DIBER mushroom cultivation technology includes, (a) especially suited to micro climatic conditions of hilly region, (b) first harvesting can be taken in 20-25 days of sowing; (c) 16-18^{o}C temperature required for mushroom growing; and (d) maximum 35 Kg mushroom can be produced from one ton of compost.

3.7 Angora Wool Production Technology

DIBER has developed the Angora rabbit rearing and wool production technology and established at Munsiyari (Pithoragarh), as wool village. This technology is suited for hilly regions due to colder climatic condition required for angora rabbits for wool production. DIBER has successfully demonstrated this technology in various adopted village of munsiyari region in Dist Pithoragarh of UK. The adopted 19 villages include about 286 beneficiary's families, which are provided with total 1430 angora rabbits by DIBER. This technology has provided employment to around 1548 nos of border villagers of munsiyari region. These people are making various products out of angora wool like shawl, pullover, muffler, cap, snow suit *etc.* (Fig.3). After the value addition (~4 to 5 fold) of angora wool in form aforesaid finish products has resulted in significant increase in their input:output ratio::1:2.4.

4. DIBER OUTREACH ACTIVITIES: TARGETS AND PLAN OF ACTION

In order to support the farmers of border villages, extensive surveys were made in 03 border Distts (Uttarkashi, Chamoli and Pithoragarh) of UK during Sep-Dec 2019. A total of 3284 progressive farmers from these villages were identified and registered to collect scientific data through proforma on user requirement, land use pattern, resource availability, technology gaps, potential area of intervention and possible impact of DIBER intervention. This database was scientifically analysed and action plans were formulated for DIBER outreach activities. The ongoing outreach extension work in these border villages has been divided in following modules:

- Survey and registration of farmers
- Training needs analysis and technology gap assessment.
- Identification of potential and promising farmers.
- Extending sustained agro-animal technological support to border villages farmers.
- Collection of data for every crop season.
- Impact analysis of DIBER intervention.

The time-lines for above mentioned DIBER outreach action plan were grouped in 3 phases. During phase I, a total of 3284 farmers have been registered. After analysis of feedback

Table 2. Impact of DIBER, DRDO technological intervention on farm income of progressive farmers of Pithoragarh District.

Farmer's name	Village	Income before adopting technology (Rs)	Income after adopting technology (Rs)		
			(1st YEAR; 2016)	(2nd YEAR; 2017)	(3rd YEAR; 2018)
Shi Harish Chand	Bhula Gaon	30,000	65,945	1,00,000	1,80,000
Shi Bahadur Singh Bora	Pakuti	25,000	52,920	1,25,000	2,00,000
Shi Rahul Tamta	Ganga Seri	12,000	23,950	94,000	1,55,000
Shi Bhupendra Singh	Sangeti,	10,000	16,245	65,000	90,000
Shi Deepak Chandra Joshi	Dhamora,	6,000	20,650	55,300	93,000
Shi Keshav Dutt Maukholia	Nera	15,000	50,000	83,000	1,17,000
Shi Deewan Singh	Dungri	40,000	85,000	1,00,000	1,50,000
Shi Harish Bhandari	Mudd	46,500	67,000	80,000	1,30,000
Shi Harish Bhatt,	Kumdyar	42,000	93,000	1,25,000	1,65,000
Shi Hoshiyar Singh	Siroli	10,000	60,000	95,000	1,15,000
Shi Jai Prakash Joshi	Malan	27,000	1,37,000	1,50,000	1,80,000
Shi Fakeer Ram	Silpatta	20,000	50,000	91,000	1,10,000

Table 3. Impact of DIBER, DRDO technologies on net farm production and income of progressive farmers of Pithoragarh District.

Farmers' name	Net production (q/2000m^2)			Net profit (q/2000m^2)		
	Farmers' practice (data of 2016 year) (x)	Technology demonstration (Avg. data of 2017, 2018, 2019 yrs) (y)	% increase over farmer's practice (y-x)÷x ×100	Farmers' practice (data of 2016 year) (x)	Technology demonstration (Avg. data of 2017, 2018, 2019 yrs) (y)	% increase over farmer's practice (y-x)÷x ×100
Sri.Hoshiyar Singh	70	95	35.71	1,50,000	2,14,034	42.68
Sri.Bahadur Singh	75	105	40.00	1,60,000	2,35,555	47.22
Sri.Liladhar Pandey	65	96	47.69	1,38,000	2,01658	46.12
Sri.Harish Bhandari	70	94	34.28	1,55,000	2,25,804	45.68
Sri.Fakir Ram	12	21	75.00	43,000	81521	89.58
Sri.Harish Chand	150	191	31.74	1,65,000	2,45,704	48.91
Sri.Dewan Chand	60	96	60.00	90,000	107395	19.32
Sri.Anand S. Dhami	25	41	64.00	50,000	86,800	73.60
Smt Kunti Devi	45	79	64.58	75,000	98747	31.66
Sri.Chander S. Anna	50	75	50.00	95000	1,38,394	45.67
Sri.Bhupendra Singh	30	45	50.00	60000	98767	64.61
Sri.Manohar S.Mehar	30	46	63.33	55,000	92715	68.57
Sri.Ram S. Mehta	25	41	64.00	60000	93103	55.17
Sri.Prem S. Dhami	60	96	60.00	75000	138511	60.72

data of 3284 progressive farmers from 85 border villages of UK, various issues and technical needs were identified that can be broadly classified into following two categories, namely administrative and technical issues (Fig.4). Target of 5,000 farmers will be completed during phase II and phase III is likely to cover 10,000 farmers by 2021.

Technical support and demonstration of DIBER, DRDO agro-animal technologies for increasing livelihood opportunities at selected village level in collaboration with State administrative authorities is being implemented (Fig.5).

5. IMPACT ASSESSMENT

The mature aforesaid DIBER, DRDO agro-animal technologies were successfully demonstrated to selected farmers of border villages (85 in no) for increase their livelihood opportunities and curtail their migration. Also, these DIBER, DRDO technological training and support was extended to various Army/ paramilitary units deployed in the border region of UK for providing fresh green produce, rehabilitation programme, eco-restoration work, strategic linkage between Army and civil etc.

A pilot project was executed with 12 selected progressive farmers of Pithoragarh district for assessing the impact of intervention of DIBER, DRDO developed other technologies on their farm income during 2016 to 2019. The technological interventions helped in significant increase (about ~2 to 4 folds) in the farm income of farmers (Table 2 & Table 3). The continuous increase in net profit of selected farmers helped in gaining confidence in all vegetables (solanaceous, cucurbits, leafy, leguminous and exotic) production and boosted technology absorption and adoption. Many other villagers were also motivated after seeing the socio-economic improvement and farm income of these selected farmers.

The efforts made by the institute not only helped the farmers to increase farm productivity and improve their socio economic status but also their nutritional security. This helped in quick technology adoption and absorption in adjoining villages. We are confident that dissemination of these customised technologies will uplift the socio-economic status of locals by increasing the employment in the region and in turn also help in curtailing migration from border regions of UK.

6. CONCLUSIONS

Migration from deep border area of Uttarakhand (UK) is a complex multilayered socio-economic and ecological problem that has to be tackled at different levels. The main reasons for migration of civil inhabitants from the deep rural border areas of UK includes, economic/livelihood, ease of living, market linkage, quality of services, infrastructure, governance, social/ cultural and aspirational *etc*. The various migration issues of border farmers can be broadly categorised into two categories, firstly administrative and secondly technical issues. The administrative issues can be handled at policy level through involvements of State Govt and Central Govt administration and NGOs. However, the technical problem can be taken up by various government research institutions to develop customised solution for these problems. DIBER, DRDO has developed area specific and customised agro-animal technologies suitable for mid to high hills of Central Himalayan region. The intervention of these technologies, which are being demonstrated to border villagers has shown significant impact in increasing of their livelihood opportunities and shown potential to curtail migration from border regions by increasing employment opportunity. However, UK border area is vast and highly inaccessible due to climatic and geographical reasons, therefore, combined efforts is required from all concern government organisations to resolve both administrative and technical issues concurrently to address the issue of depopulating border villages, which is a national security concern also.

ACKNOWLEDGMENTS

Grant received from Defence Research and Development Organisation (DRDO), Ministry of Defence, Government of India under project SARHAD (TD/17-18/DIB-78) is duly acknowledged. The technical support received from team members of project SARHAD is also acknowledged.

REFERENCES

1. Mamgain, R.P. & Reddy, D.N. Out-migration from the hill region of Uttarakhand: Magnitude, challenges, and policy option. *In* Rural labour mobility in times of structured transformation, edited by D. Reddy & K. Sarap. Palgrave Macmillan, Singapore, 2017. pp. 209-235. https://www.palgrave.com/gp/book/9789811056277. (Accessed on 08 August 2020).
2. Jangwan, A. & Upreti, P. Status of migration in Uttarakhand: A case study of Rudraprayag District. *Environ. Conser. J.*, 2019, **20**, 61-72. doi: 10.36953/ECJ.2019.20309.
3. Rural development and migration commission report on "Analysis of schemes and programmes in the rural development sector and recommendations for strengthening the rural socio-economy in order to mitigate out-migration", Sep. 2019. https://spc.uk.gov.in/upload/contents/File-98.pdf. (Accessed on 08 August 2020).
4. Interim report on the status of migration in Gram Panchayats of Uttarakhand, Migration Commission, Apr. 2018. https://spc.uk.gov.in. (Accessed on 10 August 2020).
5. Venkatasubramanian, V.; Sajeev, M.V. & Singha, A.K. Technology demonstration: Concepts, approaches and methodologies for technology application and transfer. The Zonal Project Director, Zonal Project Directorate, Zone–III, Indian Council of Agricultural Research, Umiam, Meghalaya–793103, August 2009.
6. Gupta, S.M.; Kumar, K.; Joshi, R.K.; Gupta, S. & Bala, M. Frankia: A promising N-fixing plant growth promoting rhizobacteria (PGPR) improved drought tolerance in crops at higher altitude. *In* Microbiological advancement for higher altitude agro-ecosystems & sustainability, Rhizosphere Biology, edited by R. Goel, R. Soni, D. C. Suyal. Springer Nature Singapore Pte Ltd, 2020, pp. 411-431. doi: 10.1007/978-981-15-1902-4_20.
7. Sariyal, A.K. Doubling farmers' income: A model for hilly

and mountainous region. *Himachal J Agri. Res*. 2016, **42**,101-114. http://www.hjar.in/index.php/hjar/article/view/119985. (Accessed on 12 August 2020).

8. Chatterjee, S. & Mukherjee, D. Strategies for doubling farmer's income through horticulture. *Agriculture & food: e-Newsletter* 2019, **1**, 5-7. http://www.agrifoodmagazine.co.in/category/volume-1-issue-5-may-2019/. (Accessed on 14 August 2020).

9. Verma. In Covid-19 crisis, Uttarakhand sees reverses migration opportunity, The Indian Express, 2020. https://indianexpress.com/article/india/in-covid-19-crisis-uttarakhand-sees-reverse-migration-opportunity-6370059. (Accessed on 20 August 2020).

10. Parveen, S. & Mamgain, P. A study on reverse migration of human resources: a study of Uttarakhand state. *PalArch's J. Archaeol. Egypt/ Egyptology (PJAEE)*. 2020,**17**(7), 933-9347. https://archives.palarch.nl/index.php/jae/article/view/3882. (Accessed on 20 August 2020).

11. Devi, B. & Thakur, N. Protected cultivation as an emerging Agri Entrepreneurship in hilly regions of India. *Popular Kheti*. 2013, **1**, 21-25. http://popularkheti.com/Issue-2013-1.php. (Accessed on 21 August 2020).

12. Papnai, G.; Sachan, V.K.; Nautiya, P. & Manisha. Performance of front line demonstrations in hill region of Uttarakhand. *Ind. J. Hill Farm*., 2017, **30**, 286-289. http://kiran.nic.in/pdf/IJHF/Vol_30-2/22.pdf. (Accessed on 21 August 2020).

13. Santosh, D.T.; Tiwari, K.N. & Singh, V.K. Influence of different protected cultivation structures on water requirements of winter vegetables. *Int. J Agri. Environ. Biotech*., 2017, **10**, 93-103.
doi: 10.5958/2230-732X.2017.00004.3.

14. Pandey, V.; Ahmed, Z. & Kumar, N. Effect of green house models on plant growth and yield of Capsicum. *Ind. J. Hort*., 2005, **62**, 312-313. https://www.indianjournals.com/ijor.aspx?target=ijor:ijh&volume=62&issue=3&article=030. (Accessed on 21 August 2020).

15. Pandey, V.; Ranjan, R.; Pandey, H.; Dwivedi, S.K. & Bala, M. Cherry tomato: Performance in Pithoragarh, Uttarakhand. *New Age Protected Cultiv.*, 2019, **5**, 41-42. https://www.slideshare.net/BrahmaSingh1/new-age-protected-cultivation. (Accessed on 25 August 2020).

16. Prasad, R.; Vishwakarma, A.K. & Agrawal, S. Economics of cultivation of exotic fruits and vegetables in Chhattisgarh. *Res. J. Humanit. Soc. Sci*., 2017, **8**, 89-91. doi:10.5958/2321-5828.2017.00013.4.

17. Pant, T.; Agarwal, A; Bhoj, A.S.; Joshi, R.P; Prakash, Om & Dwivedi, S.K. Vegetable cultivation under hydroponics in Himalayas: Challenges and opportunities. *Def. Life Sci. J*., 2018, **3**, 111-119.
doi: 10.14429/dlsj.3.12575.

18. Pant, T.; Agarwal, A.; Bhoj, A.S.; Joshi, R.P.; Prakash, O. & Dwivedi, S.K. Vegetable cultivation under hydroponics in Himalayas- challenges and opportunities. *Def. Life Sci. J*., 2018, **3**, 111-115.
doi: 10.14429/dlsj.3.12575.

19. Agarwal, A.; Prakash, O.; Sahay, D. & Bala, M. Innovative horticulture: hydroponics (soil-less cultivation) for urban farming. *New Age Protected Cultiv.*, 2019, **5**, 38-40. https://www.slideshare.net/BrahmaSingh1/new-age-protected-cultivation. (Accessed on 25 August 2020).

20. Agarwal, A.; Prakash, O.; Sahay, D.S.; Dwivedi, S.K. & Bala, M. Performance of lettuce under different soil-less cultures. *Prog. Hort*., 2019, **51**, 81-84.
doi: 10.5958/2249-5258.2019.00013.7.

CONTRIBUTORS

Dr Sanjay Mohan Gupta is presently working as Scientist-E at DRDO-DIBER, Haldwani. In this study, he conceived the study, executed agricultural extension work, analysed data and wrote the manuscript.

Mrs Vandana Pandey is presently working as Scientist-E at DRDO-DIBER, Fld Stn, Pithoragarh and contributed in generation of impact assessment data.

Dr Ankur Agarwal is presently working as Scientist-E at DRDO-DIBER, Haldwani and contributed in manuscript editing and proofreading.

Dr Basant Ballabh is working as TO-B at DRDO-DIBER, Haldwani and helped in execution of agricultural extension activities.

Dr Madhu Bala is presently working as Scientist-G & Director DRDO-DIBER, Haldwani. she gave guidance in experimental designing, critical suggestions in agricultural extension work, editing and proofreading of the manuscript.