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BREED IMPROVEMENT, MILK PRODUCTION AND SOCIO-ECONOMIC BENEFIT OF CONTRACT HEIFER AND BULL PRODUCTION PROGRAM IN WEST AND WEST-CENTRAL REGION OF BHUTAN

DHAN B RAI*, NAR B TAMANG, LOKAY THAPA AND ABI N KOIRALA

National Dairy Research and Development Centre, Department of Livestock, Ministry of Agriculture and Forests, Yusipang

*Author for correspondence: draib2005@gmail.com

ABSTRACT: The study assessed breed improvement of cattle, milk production and socio-economic benefit of Contract Heifer and Bull Production Program (CHBPP) in west and west-central region of Bhutan. The data were gathered using semi-structure survey questionnaire in May and June 2019. A total of 471 households were visited and interviewed. Jersey cross (JX) population and animals registered under CHBPP increased by two and three folds, respectively. The study found that with the initiation of CHBPP (2007-2012) the Artificial Insemination (AI) services through adoption of progeny tested semen had contributed significantly in breed improvement (p=0.000) of the herd. Most animals in the CHBPP herds are farm born (96%) indicating adequate replacement heifers for the herd. With breed improvement over the period the average daily milk production had increased significantly (p=000) from 5.9±2.3 l (inception) to 7.8±3.0 l in 2019. The productivity of JX cows of blood level 50%, 62.5%, 75%, 87.5% and 93.75% was 5.8±1.7, 6.5±2.2, 8.4±2.3, 10.7±3.2 and 13.5±4.0 l/day respectively, differing significantly (p=0.000) in every blood level. Gross income generation by the CHBPP members through sale of milk in 2019 was four times higher than at inception. Besides, the members sold excess animals to generate added income. Thus, dairy farming with improved breed holds promise for the future as it was major source of income for 72% of farmers interviewed. Additionally, initiation of CHBPP triggered formation of dairy groups/cooperatives in the country, promoting a harmonious society and social cohesiveness. The government livestock staffs though provided adequate AI services, follow up on progeny recording remained inadequate at the moment. Further difficulty in disposal of bull calves born in the herds, irregular AI services/repeat breeding of cows remain a challenge in dairy sector development. Some critical area of interventions is timely supply of vital AI inputs adopting wider use of sex sorted semen, intensify and incentivize Community AI Technicians, upgrade skills of existing AI Technicians, and ensure effective recording system and reproductive waste management services.

Keywords: Breed improvement; contract production; jersey; productivity; socio-economic benefit.

1. INTRODUCTION

Artificial Insemination (AI) and supply of breeding bulls are the main cattle breeding services provided in Bhutan. AI is provided in accessible areas, whereas breeding bulls are supplied to inaccessible areas. The average AI coverage recorded was 17% in 11th five-year plan (NDRDC 2018) and as result the annual breeding bulls demand, particularly for Jersey exceeded far more than the production capacity of the government nucleus farms. To complement the government nucleus farms in production and supply of breeding bulls the Contract Heifer and Bull Production Program (CHBPP) was initiated as multiplier herds for Jersey. However, the areas selected to implement the CHBPP have to be accessible to AI facility, minimum of 10 members interested on it and each member should have at least one breedable Jersey cow/heifer with minimum 50% Jersey inheritance.

The farmers meeting said criteria become member upon signing a contract agreement with the Government for compliance on Do's and Don'ts of the Program. The registered farmers are provided with progeny tested imported frozen semen for faster genetic progress and productivity enhancement in their herd. As of 2019, there are 55 CHBPPs established across the country covering 20 Dzongkhags (districts) (NDRDC 2018). Arrangement

is made to procure breeding bulls from CHBPP by National Jersey Breeding Centre (NJBC), Samtse, for further distribution to Dzongkhags while members themselves sell excess heifers to other farmers. CHBPP program has been initiated for little over a decade, but no comprehensive assessment was made so far. Hence, performance of CHBPP in West and West-central region was assessed with the objectives to ascertain breed improvement progress and milk production by blood level, socio-economic benefit to the CHBPP members and their compliance to CHBPP norms, services provided by the govt. and hindrances if any in pursuit to find a way forward to improve dairy breeding program.

2. MATERIALS AND METHODS

2.1 Data Collection

The data were collected from 471 registered CHBPP members (H/h) selected randomly from west and west-central regions using semi-structured survey questionnaire. The questionnaire was designed to capture relevant information on CHBPP management, milk production, socio- economic benefits being part of the program, and challenges faced in the implementation of the program. Survey was conducted in three Dzongkhags; Chukha, Samtse and Paro with seven CHBPPs and in Western region and four Dzongkhags; Punakha, Wangdue, Dagana and Tsirang, with eight CHBPPs in West-central region (Table 1) from May to June 2019.

The quantitative data on breed improvement was collected from herd book and milk production from individual bovine register maintained for animals by the rmers. A total of 1793 milk records of 718 milking cows were compiled. The milking cows were segregated into two groups based on exotic inheritance of 50-75% jersey as baseline (available at the inception of CHBPP) and >87.5% as progress in breed improvement in 2019 (Table 2). Data pertaining to annual breeding bull procurement and supply from CHBPP were collected from NJBC, Samtse.

2.2Data analysis

The data were analyzed using student t-test, Chi-square test and ANOVA in Statistical Package for Social Science (SPSS) version 23. Field observations and impressions were described.

3. RESULTS AND DISCUSSION

3.1 Households and animals at inception and review

The increase in Jersey cattle population and CHBPP members at review in 2019 was significant (p=0.000) than at inception year. The increase was three folds for members, particularly in west central (Table 1) and two folds for animals. The higher increase in membership could be attributed to advantages of joining the program such as imported progeny-tested semen, ear-tagging of animals which fetched higher price and better health care services members can receive, whereas only two folds increase in no. of animals could be attributed to limited land holdings of the farmers. The comparison of no. of animals between the two regions both at inception and review revealed significantly higher no. in west than in west-central region (Table 3). According to FAO (2018), the benefits farmers can derive through ownership of improved dairy cattle is positive indication of pathways to poverty reduction.

Table 1: CHBPP areas, households and survey coverage

Region	Dzongkhag	CHBPP	Inception year	H/h at inception (nos)	Existing H/h (nos)	Coverage (H/h) (Nos)	(%)
West	Chukha	Darla	2012	99	150	45	30
		Sampleling	2011	25	74	29	39
	Samtse	Ugyentse	2007	26	55	29	53
		Yoseltse	2007	20	68	42	62
	Paro	Shari	2011	45	105	36	34
		Wangchang	2011	40	86	34	40
		Shaba	2011	13	40	20	50
	Sub-total			*268*	*578*	*235*	*41*
West-central	Punakha	Guma	2012	30	82	30	37
	Wangdue	Tshogom	2010	25	60	26	43
	Dagana	Goshi	2011	20	50	28	56
		Tsendagang	2011	25	64	39	61
		Tashiding	2011	17	42	18	43
	Tsirang	Kikhorthang	2008	16	89	42	47
		Rangthaling	2010	25	75	24	32
		Gosarling	2008	16	89	29	33
	Sub-total			*174*	*551*	*236*	*43*
	Total	15/32		442	1129	471	42

Table 2: CHBPP cattle population and milking cows by exotic blood level in surveyed areas

Region	Dzongkhag	CHBPP	Cattle registered with CHBPP during the inception period		Cattle registered with CHBPP in 2019		No. of milking cows owned by the respondents	
			50 - 75%	>87.5%	50 - 75%	>87.5%	50 - 75%	>87.5%
West	Chukha	Drala	83	0	140	42	65	8
		Sampheling	87	0	97	68	42	31
	Samtse	Ugyentse	48	0	91	46	38	5
		Yoseltse	80	0	172	74	72	7
	Paro	Dopshari	100	0	113	33	51	8
		Wangchang	71	1	83	20	43	6
		Shaba, Paro	45	0	64	10	30	4
	Sub-total		514	1	760	293	341	69
West-central	Punakha	Guma	73	0	82	12	33	7
	Wangdue	Tshogom	52	0	77	18	30	2
	Dagana	Gozhi	47	0	63	20	31	5
		Tsendagang	52	0	80	8	44	2
		Tashiding	25	0	31	17	16	3
	Tsirang	Kilkhorthang	77	0	138	31	56	8
		Rangthangling	36	0	65	13	23	5
		Gosarling	43	0	69	41	27	16
	Sub-total		405	0	605	159	260	67
Total			919	1	1365	452	601	117

Table 3: Animals in the CHBPP at inception and review (2019)

Region	HH	Animals at inception	Animals at review (2019)
West	235	2.187	4.481
West-central	236	1.716	3.237
p value		0.001	0.000

3.2 Contribution to breed improvement

Assessment of breed improvement program by way of breeding bull procurement/supply (from CHBPP *vis-a-vis* NJBC, Samtse) for 10 years revealed that the CHBPP supplemented 69.8% breeding bull demand, which was a noteworthy in term of contribution it made for propagation of Jersey germ-plasm to wider beneficiaries. Similarly, the increase in population of Jersey cattle (>87.5% blood level) is significantly higher at the time of review compared to inception (p=0.000), indicating substantial contribution of the CHBPP in breed improvement program in the targeted herds. The analysis of progress in breed improvement by blood level revealed that animals in both categories were significantly higher in West than in West central region, which indicates that western region is ahead in dairy breed improvement front (Table 4)

3 Production of replacement heifers from own herd to curtail import

The study revealed that 95.2% (n=471) of the CHBPP members interviewed did not import animals in their herd in the past for a decade because members could produce replacement stock from their own herd. According to Pennsylvania State Extension (2011), replacement heifers are the source of new genetics for the herd and are a long-term investment. Thus, production of sufficient heifers in the own herd is an approach to sustainable breed improvement program whereby

Table 4: CHBPP members and animals by blood level in two regions

Parameters	Blood level	West (n=235)		West-central (n=236)		*P value*
		Mean	Std. dev.	Mean	Std. dev.	
Animals selected initially	50-75%	2.187	1.8648	1.716	1.0478	0.001
	87.5% and above	000	000	000	000	
Animals at review (2019)	50-75%	3.234	2.2285	2.564	1..7577	0.000
	87.5% and above	1.247	2.0669	0.674	0.9405	0.000

members need not import animals in future to avoid implications such as poor adaptability of imported animals, high mortality and incursion of exotic diseases.

3.4 Productivity by blood level and lactation number

The assessment of productivity of CHBPP cows revealed steady increase in average daily milk yield in every blood level with increasing exotic inheritance (Table 5).

Table 5: Milking cows and daily milk yield (l) of CHBPP animals by blood level and lactation number in 2019

Lactation number (n)	Blood level					Avg.
	50% (550)	62.5% (271)	75% (689)	87.5% (223)	≥93.75% (59)	
L-I (653)	4.9±1.33 (191)	5.5±1.76 (92)	7.1±1.73 (259)	9.4±2.99 (82)	12.5±3.42 (29)	6.8±2.72
L-II (452)	6.0±1.46 (136)	6.7±2.11 (65)	8.9±2.19 (181)	11.4±3.19 (52)	14.7±4.12 (18)	8.24±3.1
L-III (306)	6.6±1.58 (97)	7.9±2.25 (47)	10.1±2.3(119)	12.5±2.81 (36)	15.8±4.84 (7)	9.1±3.2
L-IV (186)	6.5±1.68 (63)	7.7±2.34 (34)	9.5±2.05 (64)	11.9±3.01 (22)	14.0±4.58 (3)	8.5±2.9
L-V (91)	6.0±1.41 (27)	7.1±2.13 (15)	9.0±1.76 (33)	11.0±2.53 (15)	12.0±0 (1)	8.2±2.6
L-VI (50)	5.9±1.67 (15)	5.8±1.29 (7)	8.3±1.94 (19)	10±2.43(9)	-	7.6±2.4
L-VII (21)	5.4±1.01 (7)	4.7±0.87 (4)	7.4±1.20 (6)	8.5±3.0(4)	-	6.4±2.1
L-VIII (17)	5.4±0.89 (5)	4.5±1.50 (3)	6.3±1.21 (6)	8.3±2.89 (3)	-	6.1±1.9
L-IX (9)	4.9±1.36(6)	5.0±1.41 (2)	6.0±0 (1)			5.1±12
L-X (7)	4.7±0.58 (3)	4.5±2.12 (2)	4.0±0 (1)	-	7.0±0 (1)	4.9±1.3
Avg. (l/day)	**5.8±1.69**	**6.5±2.23**	**8.4±2.32**	**10.7±3.18**	**13.5±4.01**	**7.8±3.04**

Table 6: Mean difference of daily milk yield (l/day) by blood level

Blood level	Milk Yield	50%	62.5%	75%	87.5%	93.75%
50%	Mean difference		-0.784*	-2.683*	-4.990*	-7.790*
	p value		0.000	0.000	0.000	0.000
62.5%	Mean difference	0.784*		-1.899*	-4.206*	-7.005*
	p value	0.000		0.000	0.000	0.000
75%	Mean difference	2.683*	1.899*		-2.307*	-5.107*
	p value	0.000	0.000		0.000	0.000
87.5%	Mean difference	4.990*	4.206*	2.307*		-2.799*
	p value	0.000	0.000	0.000		0.000
93.75%	Mean difference	7.790*	7.005*	5.107*	2.799*	
	p value	0.000	0.000	0.000	0.000	

**The mean difference is significant at the 0.05 level*

The overall mean daily milk yield at the time of review was 7.8±3.04 l, which is a significant increase ($p<0.000$) from the inception of the program (5.9±2.31 l), indicating considerable improvement in breed and productivity. The current finding is almost at par with the findings of Periyasamy et al. (2019) who reported average yield of 8.06 l/day for crossbred Jersey cattle maintained at Veterinary College and Research Institute, Orathanadu, Tamil Nadu, India.

Similarly, analysis of daily milk yield by lactation number reveled that production increased steadily from 6.8±2.72 l in 1st lactation to 9.1±3.2 l in 3rd lactation and then production declined thereafter (Table 5). This finding is coherent with the findings of Tamang et al. (2019) for Karan Fries breed but deviates for Jersey pure breed where peak production was observed in 4th lactation.

However, the analysis of difference in daily milk yield by blood level revealed significant difference ($p<0.000$) in every blood level (Table 6). Similarly, varying degree of differences in production were observed between lactation numbers (Table 7).

Milking cows were mostly reared until 4th lactations, and members cull off as productivity declines after 5th lactation. Farmer's improved awareness on maintaining productive herds, disposing off less productive animals by 6th lactation is eminent.

3.5 Income generated by CHBPP members

In the study area 920 animals were registered to CHBPP (at the inception) and total estimated milk production was about 6,348 l/day earning a gross income of Nu.222,180 daily (@ Nu.35/l).

Over the years, animal registered increased to 1817 heads with increase in no. of animals with exotic inheritance level as well as productivity. Estimated milk production during the time of review (2019) was 22,167

Table 7: Mean difference of daily milk production(l) by lactation number

Lactation no.	Milk prodn.	Lactation Number									
		I	II	III	IV	V	VI	VII	VIII	IX	X
I	Mean diff.		-1.473*	-2.288*	-1.756*	-1.396*	-0.80	0.34	0.68	1.71	1.91
	p-value		0.00	0.00	0.00	0.00	0.21	1.00	0.95	0.30	0.32
II	Mean diff.	1.473*		-0.815*	-0.28	0.08	0.67	1.814*	2.154*	3.187*	3.385*
	p-value	0.00		0.00	0.87	1.00	0.49	0.00	0.00	0.00	0.00
III	Mean diff.	2.288*	0.815*		0.53	0.892*	1.485*	2.629*	2.969*	4.002*	4.200*
	p-value	0.00	0.00		0.16	0.01	0.00	0.00	0.00	0.00	0.00
IV	Mean diff.	1.756*	0.28	-0.53		0.36	0.95	2.096*	2.436*	3.469*	3.668*
	p-value	0.00	0.87	0.16		0.94	0.12	0.00	0.00	0.00	0.00
V	Mean diff.	1.396*	0.08	-0.892*	-0.36		0.59	1.736*	2.077*	3.109*	3.308*
	p-value	0.00	1.00	0.01	0.94		0.84	0.02	0.01	0.00	0.00
VI	Mean diff.	0.80	0.67	-1.485*	-0.95	-0.59		1.14	1.48	2.516*	2.715*
	p-value	0.21	0.49	0.00	0.12	0.84		0.53	0.26	0.03	0.04
VII	Mean diff.	-0.34	1.814*	-2.629*	-2.096*	-1.736*	-1.14		0.34	1.37	1.57
	p-value	1.00	0.00	0.00	0.00	0.02	0.53		1.00	0.83	0.78
VIII	Mean diff.	-0.68	2.154*	-2.969*	-2.436*	-2.077*	-1.48	-0.34		1.03	1.23
	p-value	0.95	0.00	0.00	0.00	0.01	0.26	1.00		0.97	0.95
IX	Mean diff.	-1.71	3.187*	-4.002*	-3.469*	-3.109*	-2.516*	-1.37	-1.03		0.20
	p-value	0.30	0.00	0.00	0.00	0.00	0.03	0.83	0.97		1.00
X	Mean diff.	-1.91	3.385*	-4.200*	-3.668*	-3.31	-2.715*	-1.57	-1.23	-0.20	
	p-value	0.99	0.00	0.00	0.00	0.00	0.04	0.78	0.95	1.00	

* The mean difference is significant at the 0.05 level

l/day earning an income of Nu.886,680 daily (@ Nu. 40/l) or four times higher than at inception.

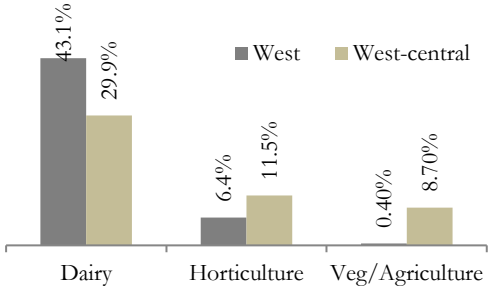

Figure 1: Major income sources of CHBPP member by region

Besides excess animals sold from CHBPP to other members in the neighborhood as well as outside the program generated additional income of Nu. 944,000.00 for the CHBPP members. Thus, the Government support to Bhutanese dairy farmers is steadily bearing fruits. Similar studies on public and industry funding by Dairy Australia on program called "Dairy Moving Forward (DMF)" (Melcolm and Paine 2005) found that investment in DMF to build expertise of dairy farmers had earned a return on capital that justifies the investment.

Dairying is reported to be major source of income for 72% of farmers interviewed, followed by horticulture (17.8%) and vegetable/ agriculture production (9.1%) (Figure 1). Present finding is higher than findings by Bhujel & Sonam (2014) who reported that smallholder

dairy farming in three agro-ecological zone of Bhutan contributes to 18% of the household annual income (of which 14% is through milk and dairy product sales, and 4% from live animal sales). Wide difference could be because present study purposively focused on CHBPP members with good sample size whereas later studies had only 90 random samples which could have affected the results. Similarly, in Nepal dairy contributes 52% and 45% of total household income for small and medium livestock-holders and in India, milk constitutes the major share (67%) and is the single largest commodity contributing from agriculture (Payal et al. 2018). Dairy farming therefore contributes to large share of household income in other countries too.

3.6 Economic benefits

Income generated from improved dairy farming/milk production enabled farmers to repair house or built new houses, meet expenditure of school going children, buy daily household needs including purchase of food items and household appliances. Thus, CHBPP has provided multiple benefits to improve their living. Studies elsewhere also provide strong evidence that dairy has the power to provide individuals, families, and communities basic necessities of life: food, water, shelter and clothing and accessible pathway to come out of poverty (FAO 2018). While other authors suggest that milk production and expenditure is better measure of household welfare than income (Chuveret 2011).

3.7 Socio-economic benefit derived from CHBPP

With the initiation of CHBPP there had been social benefits too. Every location where CHBPP was initiated triggered formation of dairy groups/cooperatives whereby farmers solve the challenges they encounter on the farm collectively, working in group for a common cause. This enhanced social cohesiveness for a harmonious society. Besides, on-farm employment generation through dairy farming for livelihoods and income are other benefits. U.S. African Development Foundation [USADF] (2018) supported the view that dairy cooperatives increase food security, nutrition and incomes of farming families and empowers women in particular to be bread winners for their families.

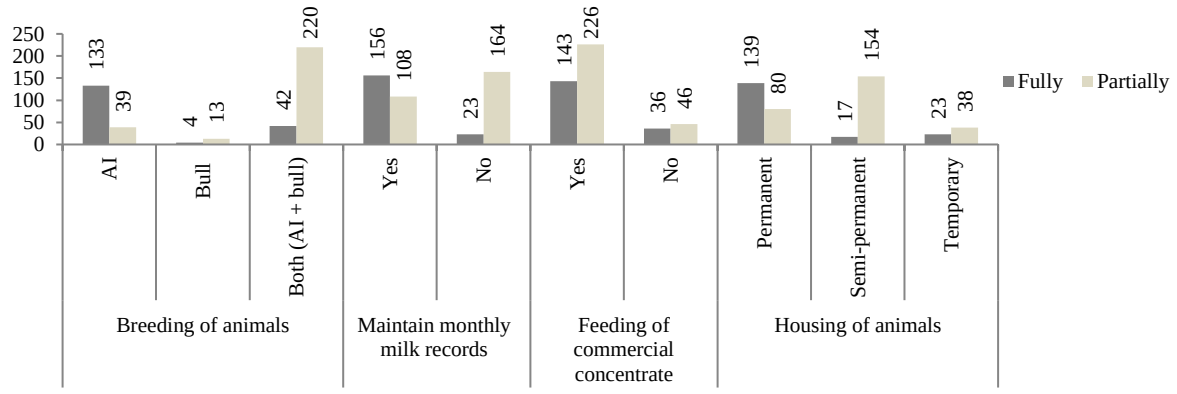

Figure 2: CHBPP members' compliance to norms and services

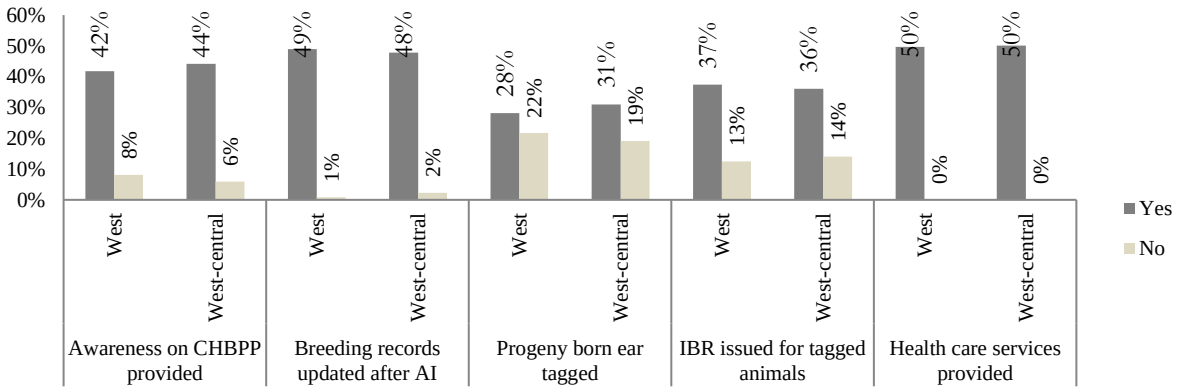

Figure 3: Services provided as per CHBPP contract agreement

3.8 Compliance to CHBPP norms and Services delivery and Hindrances

3.8.1 Compliance of CHBPP members to the contract agreement

The CHBPP members as expected to comply with contract agreement: to avail AI services at all times avoiding use of breeding bull, maintain monthly milk records and ensure proper feeding and management of animals registered. Chi Square ($\chi 2$) test revealed significant compliance (p=0.000) for all activities, except for feeding concentrate (Figure 2) which could be because feeding commercial concentrate was not affordable or commercial feeds supplier may be absent in some of the study areas.

3.8.2 Services provided to CHBPP members

When the services provided were compared between the region, Chi-Square ($\chi 2$) test confirmed no significant association ($p>0.05$), hinting that the services provided were uniform in both the regions (Figure 3).

The services provision from Government to members as per CHBPP contract agreement included keeping proper records after AI, ear-tagging of progeny born, issuance of Individual Bovine Register (IBR) for tagged animals and health care facilities.

3.8.3 Hindrance to CHBPP implementation

Study found that 73.3% farmers expressed no hindrances while 26.7% expressed some hindrances existed while implementing the program.

Difficulty in disposal of bull born from the CHBPP is reported to be a major constraint though irregular AI services, repeat breeding AI and infertility cases were also reported. The problem of bull disposal could be attributed to saturation of bull demand or no demand for bulls of lower blood level < 75% Jersey. Irregular AI services are attributed to shortage of AI technician with current staffing policy of one extension staff per gewog, and requiring to deliver multiple animal extension services.

4. CONCLUSION

The CHBPP since its inception has gained momentum as more farmers have joined the program with added number of quality animals in their herd. Thus, the program met the intended purpose to facilitate and create awareness among farmers on uptake of AI technology through use of progeny tested semen. CHBPP with the capacity to meet about 70% of bull requirement in the country annually has immensely contributed to breed improvement program nation-wide and is supplementing Jersey bull demand of NJBC. There had been significant increase in Jersey cattle population above F3 generation ($\geq$87.5% Jersey blood) during study/assessment period in 2019 especially in western region, confirming that breed improvement milestones have been met through this intervention. This can provide platform for identification of high yielding cows nearing pure-line blood level as "Bull Dam" for selection of young bulls intended for frozen semen production in the near future.

Genetic progress made in CHBPP herd has invariably improved productivity of the dairy herds. Dairy thus has emerged as the primary source of income to 72% of CHBPP members in the study area. Members generated household income through sale of milk, milk products and excess animals and helped to be economically better off for a decent living.

Disposal of bull progeny born is one of the major hindrances. Thus, wider use of sex-sorted semen having assurance of about 90% female calf birth is recommended in CHBPPs. Issue pertaining to irregular AI services and repeat breeding can be overcome through training and deployment of Community based AI Technicians and regular refresher courses to field AI Technicians. Besides, provision of adequate input generation and transportation facilities including effective reproductive waste management services can strengthen breed intensification and overall dairy production initiatives.

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REFERENCES

Asaminew T and Seifu E (2009). Smallholder dairy system and emergency of dairy cooperatives in BahirdarZuria and Mecha Woredas, northern, Ethiopia. World J. Dairy and Food Sci. 4: 185-192.

Bhujel A and Sonam T (2014). Smallholder Dairy Farming as a Source of Livelihood: A Case Study from Three Agro-Ecological Zones of Bhutan, Bhutan Journal of Natural Resources &Development, 1(1): 11-17.

Chuvert J (2011). Dairy farmers reap the benefits of working together in a co-operative society, Package 94: Participatory Radio Campaigns and agricultural co-operatives, Africa

FAO (2008). Asia Smallholder Dairy Development Strategy and Outline Investment Plan. Common Fund for Commodities Animal Production & Health Commission for Asia and the Pacific, Bangkok

FAO (2018). Dairy Development's Impact on Poverty Reduction. Food and Agriculture Organization of the United Nations, the Global Dairy Platform and IFCN Dairy Research Network, Chicago

Malcolm B and Paine M (2005). Dairy Moving Forward. Charles Sturt University and University of Melbourne. Australia

NDRDC (2018). Annual Centre Report. National Dairy Research and Development Centre (NDRDC), Yusipang, Thimphu

Payal J, Hemkant C and Ashulata N (2018). Contribution of dairy farming in employment and household nutrition in India.International Journal of Avian and Wild life Biology, 3(1):78-79.

Periyasamy VK, Arunasalam S, Paramasivan S, Masilamani R and Richard C (2019). Production and Reproduction Performances of Crossbred Jersey Cows. Veterinary Research International, 7(2): 56-59.

PSE (2011). Replacement Heifers Selection, Penn State Extension, The Pennsylvania State University, USA.

Singh M and Maharajan KL (2005). Dairy production and its implication in household income in the Tarai Region of Nepal: A case study of Chitwan district, Nepal. CNAS Journal, 32 (2): 213-231

Tamang NB, Rai DB, Dhendup T, Koirala AN, Tshering L, Wangchuk P and Timsina, MP (2019). Karan Fries vs. Jersey Cattle in Southern Foothills of Bhutan. Bhutan Journal of Animal Science, 3 (1): 27-32.

USADF (2017). Three reasons why dairy farming is empowering, U.S. African Development Foundation (USADF) Africa.