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PERFORMANCE REVIEW OF ARTIFICIAL INSEMINATION IN BHUTAN: ENHANCING EFFICIENCY OF AI SERVICE DELIVERY

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ABSTRACT: Artificial Insemination coverage and performance trends in cattle was assessed over the years using annual repository data maintained on AI performance at the national level from 2011 to 2020. One sample T-test was applied and the results are interpreted based on the number of inseminations, progeny born and available breedable cattle population (BCP) in different communities. The total number of AI performance recorded for the 10 years was 83,357, with average AI coverage in total BCP of 8.7±1.1% at the national level. BCP in Gewogs with AI facility and BCP accessible to AI facilities stand at 14.5±4.4% and 35.3±7.1%, respectively. Among the BCP accessible to AI facility, the maximum AI coverage was recorded in west-central region with 43.7±8.7%, followed by east-central, eastern and western region with 34.9±5.5%, 34.6±9.1% and 33.8±3.5%, respectively. A total of 30,172 progenies born were recorded with estimated national average AI success rate (AISR) of 36.1%. The average number of AI services rendered was estimated at 75/centre/year at the national level. The average number of AI recorded at the regional level was 69±8, 74±10, 84±37 and 78±16 AI/AIC/year for the western, west-central, east-central and eastern region, respectively. The annual average AISR recorded were 37.7±5.8%, 36.6±5.7%, 37.2±6.4% and 34.5±4.0% for the western, west-central, east-central and eastern region, respectively. At the Dzongkhag level, only Tsirang Dzongkhag had achieved the national average AI and AISR. Among the operational AICs, only 21% of AICs had achieved both the national average AI and AISR. Up-scaling and engagement of Community AI Technician to deliver AI services, wider application of sexed semen technology, building human resource capacity, creation of awareness on AI among farming communities and regular monitoring of AI performance remains crucial for the success of AI technology. Further, clustering of AICs is suggested to reduce wastage of scarce breeding inputs such as Liquid Nitrogen and imported frozen semen to ensure resource efficient AI services delivery for accelerated breed improvement and rural livelihood enhancement.

Keywords: Artificial Insemination; AI coverage; AI performance; cattle; progeny born; resource efficient.

1. INTRODUCTION

Cattle breeding services are rendered either through Artificial Insemination (AI) and supply of breeding bulls in feasible and non-AI feasible areas, respectively in Bhutan. AI was initiated in 1987 using imported Jersey frozen semen for up-gradation of local cattle population. Bovine frozen semen was produced for the first time in Bhutan in 1994 (Rai et al. 2021). Currently different bovine frozen semen viz: Jersey, Brown Swiss, Mithun and Nublang are produced to offer choice of breeds to the farmers. AI progeny had contributed to 48% of total milk production during the 11th five-year plan (FYP) from 2012-13 to 2017-18 owing to higher productivity from crossbred cattle (Tshering and Tamang 2018).

In view of enhancing livestock services delivery in the country and to reduce turnaround time, four Regional Livestock Development Centres (RLDCs) were established at strategic locations to coordinate the livestock development activities in the client Dzongkhags at the regional level. Specifically, for enhancing dairy productivity in the country via breeding and reproduction management, assisted reproductive technologies (ART) options were provided to the farmers

through the network of the RLDC (Tamang and Dorji 2022). AI services are rendered through network of AI centres (AIC) in feasible areas. The feasibility study for its establishment is conducted by the RLDC in collaboration with the concerned Dzongkhag Livestock Sector (DLS). Based on the feasibility, technical approval for establishment of AIC is accorded by the National Dairy Research and Development Centre (NDRDC), the apex arm of the Department of Livestock (DoL) for the dairy sector development in the country. In 11th FYP, AI coverage in Bhutan was about 17% (NDRDC 2018), and to expand AI coverage and ensure uninterrupted AI services, Community AI Technicians (CAITs) were trained and deployed since 2010 to foster Public Private Partnership (PPP) in cattle breed improvement programme. It also provides employment opportunity to the early school leavers in rural areas besides complementing the livestock field staff in AI services delivery (NDRDC-14 2019). For AI services, frozen semen and Liquid Nitrogen (LN_2) remain critical AI inputs among others. The LN_2 requirement of AI centres (AICs) are met from two LN_2 plants established at NDRDC, Yusipang in 2010 and at RLDC, Kanglung in 2011. However, the aging of LN2 plants and suboptimal production (4.5L/hr against the installed capacity of 10L/hr) vis-à-vis increased number of AICs in the field over the years have been the major impediments on effective AI services delivery (Tamang et al. 2021). The AI services are provided for over three decades, however, a periodic review to reflect back on milestones achieved and the constraints faced at different implementation levels have not been adequately assessed. Further, AI coverage was observed unsatisfactory in the recent years, despite best possible institutional setup for continued logistic support and facilities have been arranged. As such, this study was designed to review the AI performance and propose appropriate recommendation to devise strategic policy direction to enhance AI services for vibrant dairy sector development in the country.

2. MATERIALS AND METHODS

2.1. Data assimilation and validation

2.1.1. Data on breedable cattle population

The secondary data on AI performances maintained at NDRDC, Yusipang as repository from 2011 to 2020 was used for this study. The data includes nationwide breedable cattle population (BCP), BCP at Gewog level having AI facility and BCP actually accessible to AI facility derived from departmental statistics that covers overall livestock population by species, breed and category of animals at National, Dzongkhag and Gewog level. For regional BCP estimation, the information from Dzongkhags under the region (Table 5) was pooled for analysis. The BCP considered in this study were heifers (50%) and all milking and dry cows, which were bred naturally or artificially. The BCP excludes Yaks and Mithun and their crosses as AI services are rarely practiced on those population. On an average, a total of 96,549 cattle were available as breedable female annually for breeding (DoL: 2011 to 2020; Table

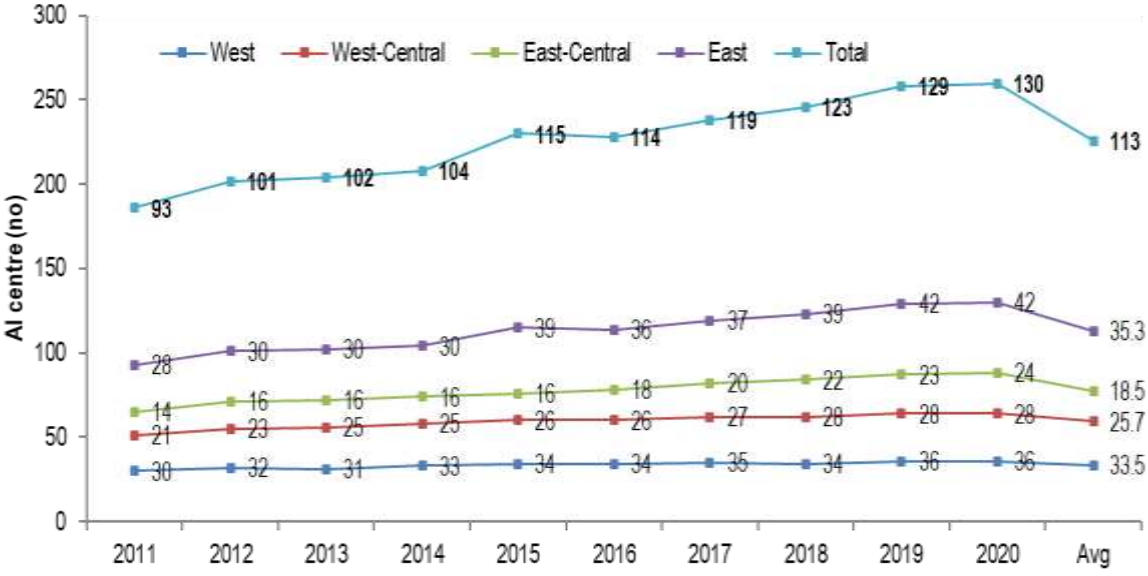

Figure 1 : No of AI centres regionwise on annual basis

Table 1: Breedable cattle population (nos) and AI coverage (2011-2020)

Year	Total BCP*	BCP in Gewogs with AI facility*	BCP accessible to AI facility**	Total annual AI***	AI coverage (%) in total BCP	AI coverage (%) in BCP in Gewogs with AI facility	AI coverage (%) in BCP accessible to AI facility
2011	90,494	40,732	16,700	8,117	9.0	19.9	48.6
2012	90,369	47,183	19,345	9,299	10.3	19.7	48.1
2013	92,628	47,002	19,271	9,358	10.1	19.9	48.6
2014	86,345	50,457	20,687	8,455	9.8	16.8	40.9
2015	95,893	56,934	23,343	7,679	8.0	13.5	32.9
2016	104,009	59,827	24,529	7,444	7.2	12.4	30.3
2017	100,613	67,694	27,755	7,705	7.7	11.4	27.8
2018	101,701	69,148	28,350	8,217	8.1	11.9	29.0
2019	103,179	71,012	29,115	8,333	8.1	11.7	28.6
2020	100,258	67,530	27,687	8,964	8.9	13.3	32.4
Avg.	96,549	57,752	23,678	8,357	8.7	14.5	35.3

Source: *Livestock statistics, DoL: 2011 – 2020, ** AI establishment feasibility reports, *** Annual AI report

1). The BCP actually accessible to AI facility accounts to 35.3% of the BCP in Gewogs with AI facility.

2.1.2. Data on Artificial Insemination

The data used for the study comprised of AI done and progeny born, compiled at NDRDC, Yusipang for ten years (2011- 2020) that were received from the RLDCs in the regions. RLDCs received these data from the regional Dzongkhags, which in turn received them from the Gewogs at regular interval.

The compiled AI data were validated with the AICs in western from 13–28 June 2022 and west-central region from 01–11 Sept. 2022. There were on an average 113 AICs; 93 AICs in 2011 and 130 AICs in 2020 (Figure 1). The AI data were analyzed and results interpreted for AI coverage at National and Regional level based on number of AI done, and AI performance at National, Regional, and Dzongkhag level based on AI done, progeny born and AI success rate (AISR). For uniformity of data interpretation, the AI coverage and AI performance were computed at unit level of AIC on annual basis.

2.2. Statistical analysis

Data compiled were computed in Microsoft Excel spread sheet and performed Statistical analysis using Statistical Package for Social Science (SPSS), version-23. One Sample t-Test was applied to compare the deviation from the reference value at national level for AI coverage, AI done and AISR. The data were expressed as a mean ± standard deviation (SD) and the significance level for deviation (±) from the reference value was set at $p < .05$.

3. RESULTS AND DISCUSSION

3.1. AI Coverage at National level

Among the total BCP, on an average 57,752 cattle were at Gewogs where AICs were established, of which estimated 41% of them (23,678) were accessible to AI facility within the radius of 5km from AIC or one hour walking distance. Based on number of AI done in the country, the AI coverage in total BCP nationwide, BCP in Gewogs with AIC and BCP accessible to AI facilities was 8.7%, 14.5% and 35.3% respectively (Table 1). Similarly, in the neighboring countries, the AI coverage among the total BCP was estimated at 30% in India (NAAS 2020) and 25.5% in Nepal (NLBO 2021), which is indicative that AI coverage in Bhutan for last 10 years was low vis-à-vis BCP in first two scenarios. It could be attributed to scattered nature of villages and inaccessibility of majority of the population to AI facility. This is coupled by lack of mobile AI services and complacency of farmers in availing AI services vis-à-vis coverage by free roaming uncertified breeding bulls in the vicinity of AI facility, compounded by religious stigma against castration of unwanted bulls.

The AI coverage among the BCP in Gewogs with AI facility of 14.5% in this study for ten years is slightly lower than the earlier estimated figure of 17% AI coverage during 11th FYP (Rai et al. 2020; NDRDC 2018).

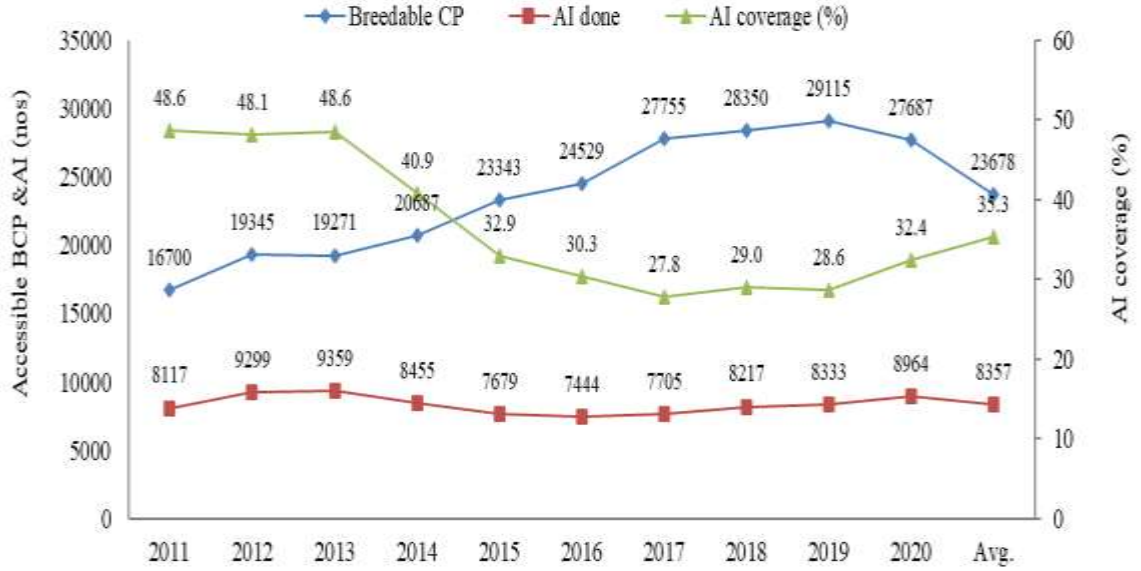

Figure 2: National annual AI coverage among accessible breedable cattle population

However, owing to higher productivity of crossbred cattle born, the AI progeny contributes to 48% of total milk production in the country, which accumulates to annual gross income generation of Nu.1.104 billion by the farmers (Tshering and Tamang, 2018). The steady increase in BCP over the years is attributed to increasing crossbred population with higher fertility as local cattle (Thrabum) were continually ungraded using them as base population. The maximum AI coverage was observed in 2011 till 2013, which could be imputed to insemination of over 2000 imported crossbred cattle during this period. However, owing to non adaptability of imported animals, almost 35% of them died (NDRDC 2017) and the gradual decline in number of AI performed in subsequent years until 2017 could be linked to decrease in AI coverage (Table 1, Figure 2).

3.1 AI Coverage at Regional level

Among the BCP accessible to AI facility in the region, the AI coverage in west-central region (43.7%) was recorded significantly higher (p=.014) than the national average (35.3%). The AI coverage in other three regions was almost equivalent to the national AI coverage and was not statistically significant (Table 2).

3.2. AI performance at National level

A total of 83,357 AI was performed and 30,172 progenies were recorded in ten years, leading to average AI success rate (calving rate) of 36.1% as national average (Figures 3 and Table 3), which is slightly higher than AI conception rate (CR) of 35% reported from India (NAAS 2020). Considering the abortion and stillbirth of 10–40% (Goesels and Kastelic 2003) and late embryonic mortality of about 10–15%, within the abortion and still birth, prior to successful calving (Tamang & Dorji 2022), the AISR in present study is comparable to CR of 50% in Bangladesh (BRAC 2020) and 52% in Nepal (NLBO 2021). In Ethiopia, Tadesse et al. (2022) reported conception rate of 54.2% and 59.7% in

Table 2: Summary of BCP accessible to AI facility, AI done and annual AI coverage by Region (Mean ± SD)

Parameters	Region				National
	Western	West-central	East-central	Eastern	
BCP accessible to AI facility (no)	6860±671	4248±601	4444±797	8126±1587	23678±3515
AI done (no)	2310±284	1886±176	1468±469	2693±336	8357±672
AI coverage (%)	33.8±3.5	43.7±8.7	34.9±5.5	34.6±9.2	**35.3±7.1**
P value	.199	.014	.932	.818	

local and crossbred cows, respectively.

Overall, 53% of AICs (n=113) had achieved more than the national average AISR. The AI performance was recorded above annual average performance in 2012, 2013, 2014, which could be attributed to import of almost 5000 dairy cows and heifers by the farmers through subsidy support during the period whereby farmers availed AI services for insemination of imported animals. The decline in AI done in 2015 and 2016 could be attributed to death of imported animals owing to non-adaptability of the animals in new farming environment (NDRDC 2017). The steady increase in number of AI done from 2017 till 2020, can be linked to the AI refresher courses provided annually to the field AI technicians region-wise whereby skills and precision of service delivery could have improved. The increase in number of AI done in 2019 and 2020 can be linked with the promotion of Sexed semen Technology wherein sexed semen (female) were made available to best performing AICs. In view of farmers' preference for female calf, many farmers are forth coming to take advantage of advanced technology (NDRDC 2020; NDRDC 2021). However, the national average AISR achieved was lower than the success rate of 44.4% for sexed semen and 48% for conventional semen reported from selected areas (Rai et al. 2019). The low AISR achieved in this nationwide study could be attributed to poor follow-up on progeny born after AI by the responsible staff. This view is supplemented by findings of Tshering and Tamang (2018) where the authors have reported that progeny born figures underestimate actual birth of progeny in field by over 14% due to inadequate calf birth monitoring and inaccurate data recording. The average AI performed was 75AI/AIC/year as

Table 3: Summary of annual AI performance by Region (Mean ± SD)

Parameters	Region				National
	Western	West-central	East-central	Eastern	
AI centre (no)	34±2	26±2	19±5	35±7	113±17
AI done (no)	2310±284	1886±176	1468±469	2693±336	8357±672
AI/AIC/Yr	69±8	74±10	84±37	78±16	**75±12**
P value	**.034**	**.758**	**.473**	**.563**	
Progeny born (no)	860±95	695±148	533±152	929±155	3017±427
AISR (%)	37.7±5.8	36.6±5.7	37.2±6.4	34.5±4.0	**36.1±3.2**
P value	**.413**	**.771**	**.599**	**.249**	

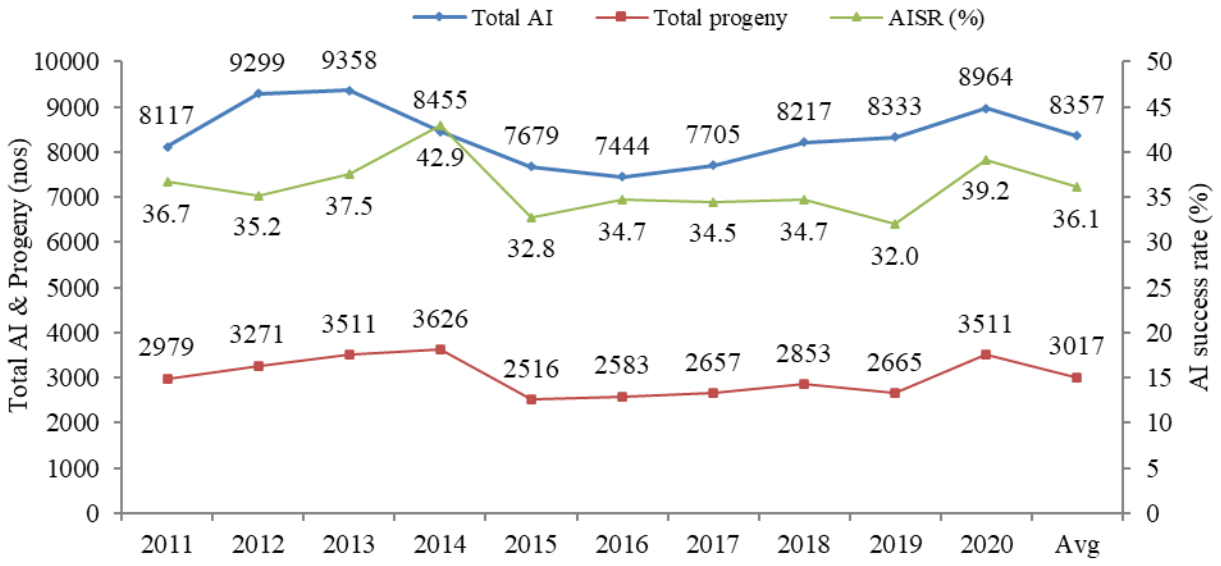

Figure 3: National annual AI performance in the country

Table 4: The Dzongkhags under the region that achieved the national average AI, AISR and both

Region	AI ≥75AI/ year	AISR ≥36%	Both AI & AISR
Western	Paro	Thimphu, Chukha and Samtse	Nil
West-central	Punakha and Tsirang	Wangdue, Tsirang and Gasa	Tsirang
East-central	Bumthang and Sarpang	Trongsa and Zhemgang	Nil
Eastern	Samdrupjongkhar, Pemagatshel and Mongar	Trashigang	Nil

national average (Table 6), which was achieved by 30% of AICs (n=113). Overall, 21% of AICs had achieved both the national average AI and AISR.

3.3. AI Performance at Regional level

The summary of annual AI performance by region is presented in table 3. Among the four regions, eastern and east-central region had performed slightly higher number of AI than the national average of 75AI/AIC/year, whereas western and west-central region had achieved lower performance. In terms of AISR, except for east, the other regions; western, west-central and east-central, had achieved slightly higher AISR than the national average of 36.1%.

The Dzongkhags in the region that had achieved the national average AI, AISR and both the averages are presented in table 4.

3.3.1. Western region

A total of 23,104 AI was performed and 8,602 progenies were recorded in past ten years. The average AI done was 69AI/AIC/year, which was inadequate as compared to the national average and differed significantly (p=0.034). The AISR achieved was 37.7% as regional average, which was slightly higher than the national average but did not differ significantly (Table 3). In the region, none of the Dzongkhags had achieved both the national average AI and AISR (Table 4). Nevertheless, 26% (n=34) of AIC in the region had achieved both the national average AI and AISR.

3.3.2. West-central region

A total of 18,861 AI was performed and 6,947 progenies were recorded in past ten years. The average AI done was 74AI/AIC/year and the AISR achieved was 36.6% as regional averages (Table 3). The average annual AI done and AISR achieved were equivalent to the national averages and did not differ significantly from the national averages. In the region, only Tsirang Dzongkhag had achieved both the national average AI and AISR. Among the AICs in the region, only 15% (n=26) of them had achieved both the national average AI and AISR.

3.3.3. East-central region

A total of 14,679 AI was performed and 5,334 progenies were recorded in past ten years. The average AI done was 84AI/AIC/year and AISR achieved was 37.2% as regional average (Table 3). The average annual AI and AISR achieved in the region were recorded slightly higher than the national averages, but did not differ significantly. In the region, none of the Dzongkhags had achieved both national average AI and AISR (Table 4) and, similar to western region, 26% (n=19) of AICs in the region had achieved both the national average AI and AISR.

3.3.4. Eastern Region

A total of 26,927AI were performed and 9,289 progenies were recorded in past ten years by 35±7AICs. The average AI done was 78AI/AIC/year, which was slightly higher than the national average but did not differ significantly. Similarly, the AISR achieved was 34.5% as regional average (Table 3), which was slightly lower than the national average but did not differ significantly. None of the Dzongkhags in the region had achieved both the national average AI and AISR (Table 4) and only 17% (n=35) of AICs in the region had achieved both the national average AI and AISR.

3.4. AI performance at Dzongkhag level

On an average, 8,357 AI were performed in the country annually. Eight Dzongkhags; Paro, Punakha, Tsirang, Bumthang, Sarpang, Samdrup Jongkhar (SJ), Pemagatshel (PG) and Mongar, had performed ≥ national average AI of

≥75AI/AIC/year with significant difference except for Bumthang and PG (Table 5). At the same time other eight Dzongkhags; Thimphu, Haa, Wangdue Dagana, Gasa, Trongsa, Tashigang (TG), Tashiyangtse (TY) and Lhuentse, had performed significantly lower AI than the national average.

In terms of AISR, the national average of 36.1% was achieved by ten Dzongkhags namely Thimphu, Chukha, Wangdue, Tsirang, Gasa, Bumthang, Trongsa, Zemgang, Trashigang and Mongar, and with significant higher difference for Thimphu, Tsirang and Trongsa (Table 5). On the contrary, AISR was significantly lower than the national average for Dagana and Lhuentse. Overall, only Tsirang Dzongkhag had achieved both AI and AISR significantly higher than the national averages. On the contrary, Haa, Dagana, Tashiyangtse and Lhuentse did not achieve both the national average AI and AISR. Among the operational AICs during the study period, only 21% of the AICs had achieved both the national average AI and AISR (Table 6), though 30% and 53% of the AICs had achieved the national average AI and AISR respectively.

The achievement is indicative that there had been gross underperformance by majority of the AICs in the country as 53% of the AICs did not achieve both the national average AI and AISR. Therefore, the concerned stakeholders need to devise required measures with close scrutiny in operation of the underperforming AICs towards reinforcing resource efficient AI service delivery to the dairy farming communities.

3.5. Closure of AI Centres and AI performance

The AICs that were not performing optimally in resource efficient manner were closed down or relocated to other feasible areas according to the interest of the farming communities. From 2011–2020, ten such AICs were closed down for various reasons despite their establishment with proper feasibility study conducted by the RLDCs in collaboration with the concerned Dzongkhag. The CAITs were trained and deployed to provide uninterrupted AI services to the farming communities under PPP. Until the year 2020, a total of 149 CAITs were trained. For rendering AI services, the required AI inputs such as frozen

Table 5: Comparison of dzongkhag level AI performance against the national level (Mean ± SD)

Region	Dzongkhag	AI centre (no)	AI done (no)	AI/AIC/Yr	P *	Progeny born (no)	AISR (%)	P**
West	Thimphu	7±1	373±104	54±12	0.000	193±76	51.8±13.5	0.005
	Paro	9±1	796±188	89±20	0.050	253±54	33.4±10.2	0.421
	Ha	2±0	94±36	48±16	0.000	29±18	27.6±13.7	0.081
	Chukha	5±1	293±110	62±20	0.058	117±64	39.8±14.5	0.442
	Samtse	11±2	755±176	70±21	0.448	269±63	36.3±8.6	0.947
West-central	Punakha	8±1	751±93	95±11	0.000	245±50	32.8±6.5	0.145
	Wangdue	8±1	388±142	52±23	0.011	157±77	39.5±9.1	0.254
	Tsirang	5±1	487±116	113±35	0.007	215±68	44.5±10	0.029
	Dagana	4±0	196±83	52±21	0.007	52±27	27.4±12.5	0.054
	Gasa	2±0	64±24	32±11	0.000	26±15	37.6±14.6	0.747
East-central	Bumthang	7±1	647±309	88±36	0.278	231±118	35.9±9.3	0.987
	Trongsa	5±1	260±109	56±26	0.050	109±52	47.7±28.2	0.026
	Zhemgang	3±1	181±62	71±42	0.790	72±29	41.0±15	0.339
	Sarpang	3±2	380±75	137±66	0.016	121±40	32.1±9.5	0.211
East	SJ	3±0	338±98	113±32	0.005	110±54	32.3±13.4	0.389
	PG	5±2	403±117	84±23	0.251	137±34	34.6±5.1	0.373
	TG	10±1	657±90	64±12	0.016	267±70	40.6±8.8	0.144
	TY	5±1	163±53	36±20	0.000	52±16	33.1±10.7	0.395
	Mongar	8±1	979±221	119±29	0.001	323±67	33.7±6.0	0.228
	Lhuentse	3±1	153±97	46±30	0.015	40±36	24.0±13.8	0.022

P value based on national averages for AI* @ 75AI/centre/yr and AISR** @36.1%.

semen, LN_2 and AI accessories are provided by the Royal Government and service charge per insemination including mobility for CAIT is paid by the beneficiaries as per the agreement signed between the service provider (CAIT) and the communities.

The underlying reasons are lack of technicians to perform AI owing to mismatch of their

Table 6: The AICs in Dzongkhags that achieved the national average AI, AISR and both

Dzongkhag	AI ≥75AI/ year	AISR ≥36%	Both AI & AISR
Thimphu	NDRDC, Yusipang and DVH Ramtokto	NDRDC, Yusipang, DVH, Ramtokto LECs- Tshaluna, Kabisa and Genekha	NDRDC, Yusipang and DVH Ramtokto
Paro	LECs- Shari, Luni, Shapa and DVH Paro,	LECs- Shari, Luni and Dotey	LECs- Shari and Luni
Ha	Nil	Nil	Nil
Chukha	LECs- Phuntsholing and Sampheling	LECs- Phuntsholing, Darla and RCBC Wangkha	LEC Phuntsholing
Samtse	LECs- Ugyentse, Yoseltshe, Tashicholing and NJBC Samtse	LECs- Ugyentse, Yoseltshe, Phuntshopelri, Sangatsholing DVH Samtse and NJBC Samtse	LECs- Ugyentse and Yoseltshe
Punakha	DVH Punakha, LECs- Talo and Samadingkha	DVH Punakha and CNR Lobesa	DVH Punakha
Wangdue	DVH Petakarpo	DVH Petakarpo, LECs- Sephu, Phobji, Phangyul and Rubesa	DVH Petakarpo
Tsirang	DVH Damphu and LEC Gosarling	DVH Damphu, LECs- Gosarling, Mendrelgang, and Tsirangtoe	DVH Damphu and LEC Gosarling
Dagana	LEC Tsendagang	Nil	Nil
Gasa	Nil	LEC Goendamji	Nil
Bumthang	DVH Bumthang, RCBC Bumthang and LEC Tang	DVH Bumthang, RCBC Bumthang and LEC- Chumey	DVH Bumthang and RCBC, Bumthang
Trongsa	LEC Tangsibji	LEC Tangsibji, DVH Trongsa, LECs- Langthel, Bemji	LEC Tangsibji
Zhemgang	DVH Zhemgang	DVH Zhemgang LECs- Nangkhar and Trong	DVH Zhemgang
Sarpang	LEC Gelephu and DVH Sarpang	LEC Gelephu	LEC Gelephu
SJ	LEC Deothang	LECs- Deothang and Phuntshothang	LEC Deothang
PG	DVH Pemagtshel and LEC Nangkhor	DVH Pemagtshel, LECs- Nangkhor and Yurung	DVH Pemagtshel and LEC Nangkhor
TG	LECs- Kanglung and Khaling	LECs- Kanglung, Khaling, Yangneer, Bartsham, Changmi, Bikhar and Lumang	LECs- Kanglung and Khaling
TY	Nil	LECs-Tongsang and Jamkhar	Nil
Mongar	DVH Mongar, LECs-Chaskar, Ngatshang	DVH Mongar, LECs- Chaskar, Ngatshang, Dremtshe, Drepong and Tsamang	DVH Mongar, LECs- Chaskar and Ngatshang
Lhuentse	Nil	Nil	Nil

placement and transfer, a smaller number of breedable female cattle bred artificially by farmers vis-à-vis depletion of base population of local cattle in some pockets as a consequence of selling less productive animals or cattle with fertility problem. The closure and reduction in number of AICs in 2016 can be linked with the low performance of AI in that year (Figure 1, 2, 3). Therefore, clustering of AICs offers opportunity to continue AI service delivery to the farming communities and enhance AI performance in resource efficient manner.

3.6. Discontinuity of CAITs' services and AI performance

The CAITs greatly complemented the livestock field staff in rendering AI services in the field as well as recorded on an average AI performance of 84AI/AIC/year and 39% AISR (NDRDC 2021). However, the discontinuity of providing AI services by the CAITs, owing to non-remuneration by the beneficiaries as per the agreement drawn, has affected the AI performance and to some extent closure of some AICs. According to Wangchuk et al. (in press, 2022), among the CAITs trained and deployed in eastern region, only 46% of them are active in rendering AI services, and mechanism must be devised for continuity of CAITs' services to enhance AI performance in the country.

3.7. Uptake of Sexed semen Technology and AI performance

Upon achievement of 44.4% AISR and 89.6% female birth with sexed semen AI in heifers and cows up to 3rd lactation during the trial phase under Bhutanese environment (Rai et al. 2019), the wider application of sexed semen technology in the country was initiated under the aegis of "Heifer Production Scheme" in August 2019. The improvement in AI performance was recorded in subsequent years particularly with the sexed semen AI (Table 7). The AISR achieved with Jersey sexed semen under Bhutanese environment is comparable to the findings recorded in Holstein heifers in different studies in the United States of America; 38.2% (Chebel et al. 2010), 39% (Norman et al. 2010) and 43.9% (DeJarnette et al. 2010).

The increase in number of AI performed in each FY can be linked with increasing number of AICs with sexed semen AI provision as well as keen interest of farmers in availing AI services with sexed semen for higher birth rate of female calves and reduction of male calves, which is a burden to the farmers. Similarly, the incremental improvement in AISR in each FY could be attributed to timely reporting by the farmers to the concerned livestock staff in the Gewog for registration of the female calves born by way of national bovine identification number (NBIN) as it fetches better price vis-à-vis unregistered ones including registered male calves. Based on the results, the continuous availability of sexed semen in all feasible AICs can prove to be a boon in augmenting AI performance in the country, if mechanism for its sustainable utilization is carefully devised.

Table 7: The number of AI done and progeny born from sexed semen during the financial year

Financial Year (FY)	AICs with sexed semen	AI Done (no)	Progeny born (no)			AISR (%)	Source(s)
			Male	Female	Total		
2019-20	19	1090*	19	64	83	41.9	NDRDC 2020
2020-21	27	1441	68	545	613	42.5	NDRDC 2021
2021-22	44	1792	73	698	771	43.0	NDRDC 2022

* Considering the gestation period, only 198 AI were accounted for birth of 83 progenies during the FY (July to June).

4. CONCLUSION& RECOMMENDATION

The overall AI coverage as compared to BCP available in the country was low. Thus, measures need to be adopted to intensify the AI coverage with adequate logistic support in terms of providing adequate quantity of required inputs particularly LN_2 through establishment of LN_2 plants at strategic locations in the regions. In the last decade, the national AI performances accomplished were 75AI/AIC/year and 36.1% AISR. Among the functional AICs, only 21% of

AI centers in the country had achieved both the national averages, and the reasons for underperformance were attributed primarily to inadequate advocacy on the benefit of AI amongst the farming communities, scattered smallholder farming system, sparse breedable cattle population, and poor follow-up on AI and progeny born among others. The AI centres manned by CAITs, remunerated adequately for their services in accordance to the agreement drawn between the service provider (CAITs) and the beneficiary (community), had recorded very good performances. The promotion of sexed semen technology by the NDRDC, Yusipang through its supply in feasible AICs is found promising with good performance records both in terms of number of AI performed as well as AISR. Overall, in order to ensure resource efficient AI service delivery; enhancing AI coverage (no of AI) and efficiency (AISR), the study recommends undertaking following interventions;

- Creation of awareness to farming communities on the benefit of AI technology should be a continuous process and it has to be augmented with providing of refresher course to AI Technicians on a periodic basis
- As AI performances are better in areas where there is CAITs' services, training of at least one CAIT per AIC or more in potential pockets according to vastness of AI coverage area needs to be pursued for positive results
- Inclusion of AI services in the Individual Work Plan (IWP) of extension staff responsible for delivery of AI services under the aegis of quality, quantity and time and quarterly monitoring the performance of AICs by the Dzongkhag Livestock Sector should be accorded high priority
- Clustering of nearby AICs with the provision of one LN_2 reserve tank and a portable container at AI outreach centre/ CAIT for delivery of mobile AI services must be instituted to ensure judicious use of LN_2.
- Dzongkhag livestock sector needs to coordinate on the sterilization of uncertified/scrub bulls in the vicinity of AI centres to avoid interference with AI program and regular reproductive waste management in cattle can enhance birth of higher number of crossbred progenies in the field
- Closure or relocation of the AICs that are underperforming for years is suggested to redirect the distribution of AI inputs to the places where intervention can create positive outcomes
- For sustainability of the AI programme in the country, the cost recovery mechanism for AI inputs including sexed semen may need to be instituted in future as deem required.

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