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Research Article

A Case Study on Arna Crossbreed (Bubalus arnae) Buffalos: Socio-Economic Importance and Future Prospects in Koshi Tappu Wildlife Reserve, Nepal

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Abstract

A comprehensive research was done to learn more about the existing situation of Arna (*Bubalus arnae*) and their crossbreed, especially within the farming communities to help develop future strategic options to improve these cross breeds aiming to address the current alarming buffalo meat demands of Nepal. Primary information was collected by using social as well as biological tools. Social data was abstracted from the household survey, Focus Group Study (FGD), and published documents of various reports whereas other parameters of the buffalos and their activities were measured by field observation using appropriate tools and practices. Descriptive, frequencies, ranking and indexing and binary logistic regression were used to quantify the data and analyze them statistically in terms of their level of significance. The findings revealed that the number of Arna cross-breed buffalos is increasing within the buffer zone communities due to domestic buffalo grazing together with wild and feral buffalos in the common pastureland. This has meanwhile resulted in existential threats to the wild as well as domestic buffalo populations in terms of the probability of losing the genetic purity. Moreover, farmers intentionally also leave their buffalo in the core area of the Koshi Tappu Wildlife Reserve (KTWR) due to the intense demand for the crossbreed animals and their strong socio-economic importance for buffalo meat production. Although these already available crossbreds have relatively low milking potential in current management practices, the preliminary results indicated that they have excellent meat value and large body size coupled with higher market demand ($p < 0.001$), reinforcing the hypothesis of broiler buffalo production as well as in promoting existing buffalo fattening program throughout the country.

Keywords: *Arna Cross Breed; Broiler Buffalo; Genetic Potentiality; Threatened Species*

Introduction

Buffalo is well-known for the conventional livestock production system of Nepal contributing to both meat (63%) and milk production (62%) [27]. Present buffalo production system should have been strategically enhanced by improving genotypes, feed, forage, health and other management aspects for commercialization. Besides some domesticated buffalo genotypes in Nepal, there are also wild water buffalo, *Bubalus arnee,* locally called Arna residing in Koshi Tappu Wildlife Reserve (KTWR).

These wild buffaloes are found in some Asian countries, especially South Asian countries such as Nepal, India, Bhutan, Myanmar, Thailand and Cambodia [25,26] in limited numbers of below 4000. These wild water buffaloes are now therefore listed as highly endangered, species by FAO [2,23,25]. They are found in damp grasslands, swamps, and heavily vegetated river basin valleys. In Nepal, the only unified population of Arna are naturally settled on the Koshi River floodplain with an area of 175 sq. km of KTWR covering part of three districts, Sunsari, Saptari, and Udayapur (KTWR 2018). This KTWR is Nepal's first declared Ramsar site as a sanctuary for the last remnants of threatened Wild Water Buffaloes species [20,21,23]. Recently, a second ecologically viable population of Arna was translocated and established in Chitwan National Park for giving them a fighting chance in case of natural calamities. The molecular study on genetic diversity revealed that 80% of wild buffalo samples from KTWR were genetically pure wild genotypes. The pure breeds of this type of buffalo have a larger body size and are more vigor with thrive well in grasslands, but these qualities are limited in indigenous form. The Significant number of crossbreds between wild and domestic buffalo can be found in the farming communities, especially in the periphery of KTWR which is also proven by the molecular study performed on these populations [9-12].

Objective of the Study

The main objective of this research was to understand more about the existing situation of Arna (*Bubalus arnae*) and their crossbreds, mainly focusing on the farm communities to help develop future strategic options regarding arna crossbred production, conservation and maintenance.

Materials and Methods

Data collection framework

A comprehensive survey was done by following the purposive random sampling technique with the selection of 150 farmers for the consecutive three years of the study period from 2017 - 2019 within 10 km periphery of core areas of the Koshi Tappu Wildlife Reserve. Questionnaires were pre-tested by a research team including statistical experts from Nepal Agricultural Research Council. The grazer, local merchant, and middle man were also the key informants. The face-to-face interview, focus group discussion and Key informant interviews (KII) were accomplished in different periods from March-August of each year. 150 households were selected for information collection purposively. Semi-structured close and open-ended questions were asked among the household head of buffalo farmers with at least 2 livestock units in their herd. Likewise, direct observation was made of routine activities of Arna to know how far the farmers could get access up to the core area of the reserve for grazing purposes. The data was taken during the post-monsoon summer months of each successive year from 2016 to 2018 for 10 days period each year. The person familiar with the vicinity and Arna behavior were asked for coordination to identify the location of the herd wherever it was foraging meanwhile Arna shares the same habitat.

The grazing hours data was taken from the vicinity from the herd basis rather than the individual basis, thus the observation of grazing time of individual animals was different. Sometimes it was difficult to measure because animals became invisible either in camera or from the open eye due to tall busy grasses in most of the area of the grazing land. The time spends by the animal during sitting, enjoying with each other, resting was excluded whereas time spends by them occasional rest and rumination was included in the total hour spend by the animals (Table 4). It was not always possible to record the data by direct or camera observation due to tall bushes in the area coupled with unpredicted nature of the buffalo (Table 4).

The data obtained in the biological and social study was processed with descriptive, frequency, ranking and indexing and appropriate graphs by using Microsoft Excel, 2013 and SPSS, Version 16.

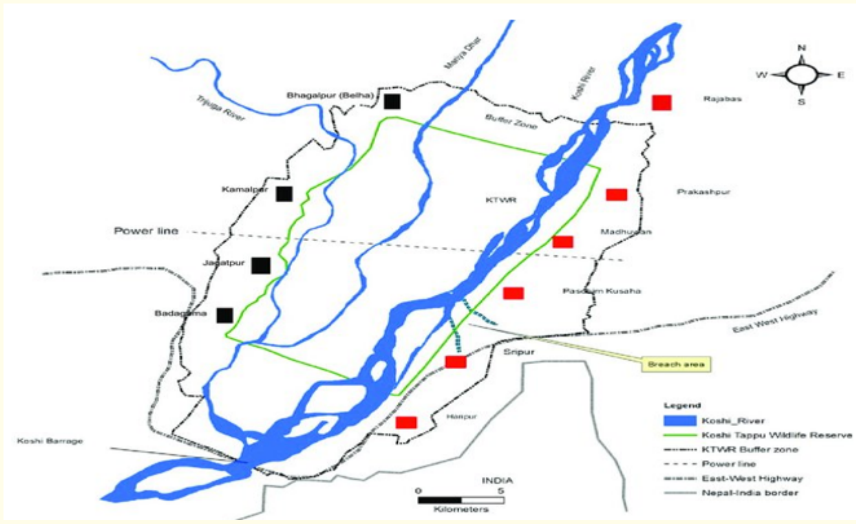

Figure 1: *Range Map of the Arna available area [9].*

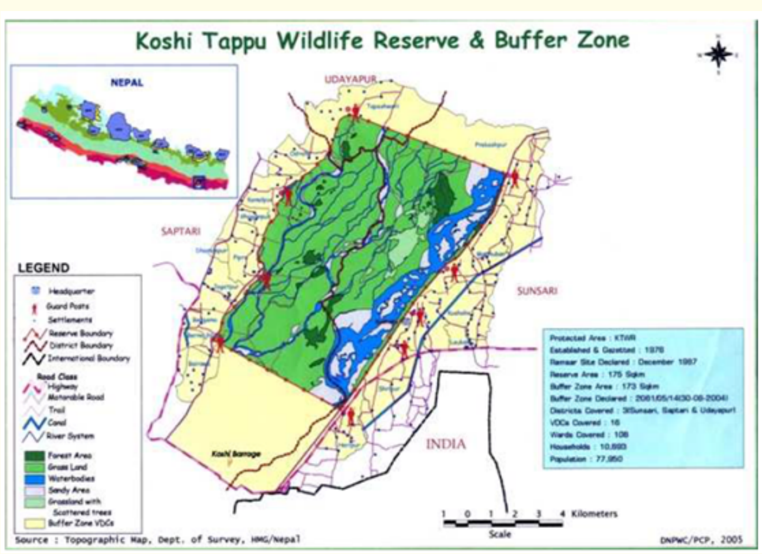

Figure 2: *Range Map of the Arna available area [2].*

Figure 3a *Figure 3b*

Figure 3a and 3b: *Domesticated Arna crossbreds reared by local communities in the periphery of Koshi Tappu Wildlife Reserve (source: field survey, 2018).*

Binary logistic tools were used to access the acceptance level of these crossbred genotypes over the local breed. The outcome variable was hypothesized as the preference of the Arna crossbred animal by the farmers over the locally available indigenous breeds. Nine different predictors were used to identify their relations to the outcome variable. A comparison was made with the locally available breed (Terai buffalo, sometimes crossed with Murrah). The result obtained from this study was simulated to form a model to identify the acceptance level of these crossbreds. The various economic parameters were accessed such as meat quality acceptable quality by local butchers, traders and the mothering quality and behavior, calving interval, general body health condition, body size, grazing behavior with adoption in poor quality grassland, expected sell value, market value and feasibilities, the export possibilities in the neighboring countries and availability of the bulls of crossbred animals.

Logit transformation was defined as follows:

Logit = Log (p/1-p) = log (probability acceptance of the crossbreed / probability of rejection of crossbreed) = log (Odds). It could be defined as:

q = 1 - p = 1 - (e^y/1 + e^y) where q was the probability of the rejection, where y and e^y was defined as:

$$\log\left(\frac{p}{1-p}\right) = y \quad \text{and} \quad \frac{p}{1-p} = e^y$$

The fundamental equation of the generalized linear model was defined as follows:

g (E(y)) = β0 + β1X1 + β2X2+ β3X3…. +eijk...

Here, g () is the link function, E(y) is the expectation of adoption of the appropriate breed, and $\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_2 \ldots \beta_7X_7$ is the linear predictor (β_0, β_1, β_2, $\beta_3 \ldots \beta_7$ to be predicted) and e_{ijk} refers to the errors' correction. The role of the link function was to link the expectation of y to the linear predictor. The constant (β_0) is the point where the curve moves left and right and the slope (β_1, β_2, β_3...β_7) defines the steepness of the curve. The fundamental equation of the logistic regression model was defined as follows (Figure 4):

$$g(E(y)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots \beta_7 X_7.$$

If the all-independent variables tend to be zero, then the outcomes variable tends to be equal to β_0 (constant).

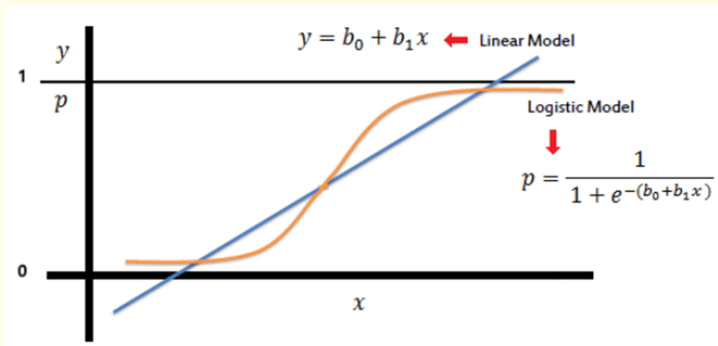

***Figure 4:** Probability of the outcome variable (p on the y-axis indicates probability, x indicates input variables).*

Results

Socio-economic information of the study area

Koshi Tappu Wildlife Reserve is a unique eastern flood plain Terai, a protected ecosystem in Nepal. It is established as a protected area in 1976 and recorded as the first RAMSAR site in 1987. In the south-eastern Terai, the reserve is located on the floodplains of the Sapta Koshi River. It was gazetted in July 1976 under the National Parks and Wildlife Conservation Act, 1973, realizing the significance of the zone for the conservation of the last remnant population of endangered wild water buffaloes and their habitat. The reserve and encompassing buffer zone (173.5 square kilometers) were declared RAMSAR sites in 2004 [1,2,9-12]. The Buffer Zone includes 16 wards with 215 settlements and 14,000 households and 93,300 population. Wild buffalo and feral animals share the large predominant grassland vegetation of the KTWR [1,2,3,5]. Most of the population (87.3%) is dependent on the agricultural sector. Though, the livestock density per household is quite high (1.5 animals/ household), the majority (80%) of the farmer were under acute food insecurity situation [3-5]. These farmers were dependent upon the agricultural activities within the buffer zones. The land area coverage of the buffer zones is included in table 1.

Land cover	Core area (sq. km)	Buffer zone (sq. km)
Agriculture	0.2	104.35
Forest	17.51	5.11
Grassland	92.43	27.68
Sand	25.54	18.14
Water	39.31	17.41
Total	175	173

***Table 1:** Information on the land cover of KTWR.*

Conservation status of the pure line (wild Arna buffalo)

Pure line Arna buffalo was on IUCN Red List as an endangered species in 2008 with only around 200 populations whereas its population in 2018 has estimated more than 550 [1,2,6,7]. Habitat loss with extreme anthropogenic activities was the major threat considered to the wild buffaloes [3,5-10]. Habitat loss was especially due to rice farming in rainy seasons and followed by hunting, crossing, and disease introduction leading to the major existential threat to the pure line wild buffalos' genotypes. The challenge of differentiating wild buffalo, feral animals, domestic stock, and hybrids had made [3,5,8-10]. Population survey, a challenging task. Several authors had also suggested that there may be no genetically pure wild buffalo remaining, since interbreeding with domestic buffalo was too widespread, though it might not be necessarily true because the wild buffalo were more vigorous, stronger, and win in a face to face combat against their local counterpart. Therefore, it would not allow local male entertainer its periphery, especially during the breeding season [9-12]. However, these events couldn't be always true inside different circumstances happening within the forest such as running and going for grazing (Table 2).

The wild buffalo was recognized by some contrasting behavioral and phenotypic traits such as white chevron, socks, and the tip of tail, and larger, relatively straight, pale-colored horns (similar to swamp buffalo). In earlier studies, these criteria were also used for identifying wild buffalo from feral backcrosses [5-9,12,19-21]. Though the preliminary finding strongly suggests that the number of purebred animals is on the increasing trend, maintaining the purebred number and its genetic purity is always questionable.

Years	Adults		Calves		Total	Calves/Cow ratio	Sources
	Male	Female	1st year	2nd year			
1976	12	18	22	11	63	0.61	[5]
1987	32	29	14	16	91	0.55	[11]
1988	37	33	8	15	93	0.45	[11]
2000	56	53	17	19	145	0.36	[12]
2004	54	63	24	18	159	0.29	[12]
2009	55	119	22	23	219	0.19	[Present study]
2016	120	182	130 (categories unspecified)		432		[21]

Table 2: *Population structure of wild buffalo in KTWR from 1976 to 2016, with the calves to cows ratio.*

Source: [21].

The population of crossbreed buffaloes in the study area

The average number of crossbred Arna within the selected household was in increasing trend with wide variation. The average number was 5.18 ± 1.13 per household. The farmer who used to graze their buffalo within core area of the reserve had a greater chance of getting their buffalo mated with Arna. Farmers usually construct the temporary shed inside the core area of the reserve either intentionally, or grazing land within the buffer area of the reserve is quite poor and insufficient to meet the requirements of graziers, leading to sharing of the common grazing land with their wild counterpart. According to the information accessed during the survey, Indian farmers equally practice grazing within the buffer areas. These practices maximize the chances of getting matted between wild and domestic buffalo in the common grazing area. These mated animals are the ultimate source of cross-breed animals either for the farmers or the other user group from butcher to draft users.

Buffalo breeds and crosses in the study sites

Different breeds of buffalo were found in the study sites. These breeds mainly include Terai buffalo, Arna pure-line, crossbreed Arna and Murrah buffalo. Though the genetic purity of this breed was not accessed in this study, the categories were made based on their physical traits. Identification occasionally became problematic because of the visible similarities between wild and cross-breed genotypes. The Majority of the species (78.90) includes local buffalo and Murrah crossbreeds (17.08). This equally signified that the majority of the buffalos kept in the study area were aimed for duel (meat and milk) purposes. Therefore, different line strains focusing on either milk or meat were not adopted by the farmers.

Breeds	Frequency	Percentage
Terai buffalo	531	78.90
Murrah pure/crossbreeds	115	17.08
Arna pure/crossbreeds	27	4.01
Total	673	100

Table 3: *Buffalo breeds in the research area and herd size in the core area of the reserve.*

Source: (Field survey, 2018); n = 150.

Cross-breed buffalos and the existing scenario

Farmer experiences were collected on several cross breed within Nepali and Indian farmers. The findings well revealed that the shorter the distance of the shed of the farmer from the core areas of the reserve, the greater the chance of a number of crossbreed animals they usually have. The reason behind this was exclusively due to leaving their animal for mating with wild genotype. The greater number of sheds constructed inside the area and the higher range number of the animal also bolster the assumption that they preferably have a higher number of crossbreed animals than their Nepalese counterparts (Table 3) (94% Indian farmer grazer in the inner part of the reserve). This signified that Indian farmer were more informed about the importance of the crossbred animals either for genetic improvement purposes or for more economic benefit as crossbred buffalo gets higher prices in the market (Field survey, 2018). The other quality aspects considered might be, such as quality meat (more tenderness) and large body size, fight muscles and well acceptance of meat quality among the consumer.

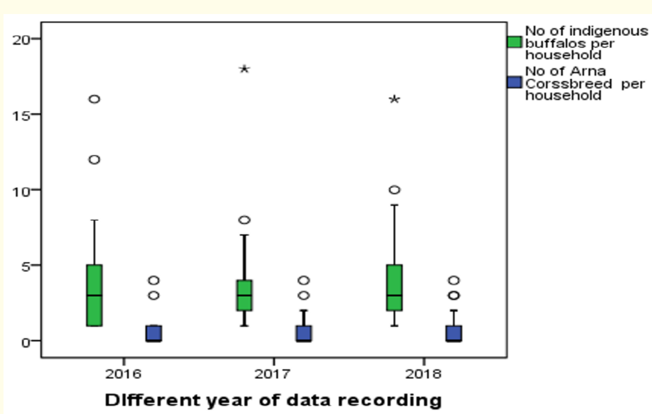

Figure 5: *The average number of buffalo per household (consecutive 3 years) (Source: field survey).*

Grazing practice

The majority of the farmers (80.08%) responded that they have to share the common grazing land. This signified that there was a higher chance of being mated during grazing time at common grazing land whenever local buffaloes express their heat period. Small herders do not necessarily graze their buffalo inside the core area of the reserve, but the case for large herder was different. They used to graze in common grazing land leading to possible natural interbreeding of the two genotypes (Table 5).

It was also revealed from the study findings that total time spent by the buffaloes for wallowing during the daytime was higher. Comparatively the calf spent more time for wallowing than the mature one though it was affected by different factor such as daytime sunshine and human interfere to the herds.

Grazing behavior			
Time periods	**Hours Spent by the Arna on grazing**		**p-value**
	Inside the buffer zone	**Inside the core area of the reserve**	
Morning (7 - 10 am)	2.32 (0.5 - 2.5)	4.33 (1 - 4.11)	$p < 0.01$
Day (12 - 3 pm	0.33 (0.01 - 0.1.08)	0.11(0.01 - 0.2)	
Evening (3 - 6 pm)	0.30 (0.02 - 1.02)	1.66 (0.09 - 2.19)	
Wallowing behavior			
Wallowing time	**Mature**	**Calves**	
Morning (7 - 10 am)	0.22 (0 - 1.13)	0.21 (0 - 1.42)	
Day (12 - 3 pm	2.01 (1.21 - 3.66)	2.63 (1.12 - 2.83)	$p < 0.01$
Evening (3 - 6 pm)	0.71(0.32 - 1.78)	02.64 (1.10 - 2.19)	

Table 4: *Grazing and wallowing behavior of pure breed Arna in the study sites.*

Note: Figure in the parenthesis indicates mean value of range, (the record was herd basis; not the individual animal) (Source: Field survey, 2018).

Population trend of the Arna crossbreed available within the farming communities

Respondents' response on the trend of number of these cross-breed animals was well recorded (Table 7). As compared to the past, the number of cross-breed buffaloes was increased mainly due to the readily available adult male in the reserve area since the number of Arna (wild buffalo) has been increased compared to the past years. Both Nepalese and Indian respondents opined that they used to graze their livestock in the KTWR area. The average number of cross--breed Arna was higher in the case of Indian farmers and they prefer crossbreed for mainly to use as draft purpose. The core area of the reserve is also shared with a higher number of Indians buffalo's herder (90%) (Table 5). Major reason behind the preferences by the farmers over local breed was due to the good market value of buffalo meat coupled with -based export opportunities to Bangladesh. This finding matches well to those reported by Heinen and Shrestha [16] where the author had emphasized that herders grazed large numbers of cattle and buffalo inside the core area reserve to get the opportunity to increase the number of cross-breed animals.

Acceptance level of cross-breed buffalo in the farming communities

Farmer prefers to get Arna crossbred due to various purposes (Table 5 and 6). The various reasons for crossing the animal were ranked. Accordingly, the highest probability value of the farmer response would get unit value whereas the lowest get zero. The major reason behind crossing was for higher meat quality It is also suggested that the quality of meat of Arna cross breed had better consumer acceptance than their counterpart, namely the local genotype [1,8,9]. The meat possibly had greater tenderness and better tight fleshes with lower fat tissues. Moreover, this had extended export opportunities to Bangladesh at a greater prices. Sometimes farmers used to sell their cross breed animal to the local collector and the collector finally export the animals as a whole.

Subsets	**Variables**	
Grazing in the core area	**From Nepali herder (numbers of buffaloes)**	**From Indian herder (numbers of buffaloes)***
Number of herds	22 (20-25)	47 (40-50)
Number of animals	300 (220-420)	750 (470-100)
Cross breed buffalo available	90 (80-100)	350 (300-400)
Major area of grazing by the farmer	**Number of Nepali herders (Percentage)**	**Number of Indian herders (Percentage)**
Share core area with the Arna	60 (50.08)	108 (90)
Buffer zone	36 (30.00)	5 (4.16)
Graze far apart from buffer zone	24 (20.00)	7 (5.83)
Total	100%	100%
Purpose of cross breed	**From Nepali herder (ranked value after indexing)**	**From Indian herder (ranked value after indexing)**
Quality meat production	0.8	0.4
Export to Bangladesh	0.6	0.3
Draft purpose	0.3	0.75
Other (local consumption by the butcher etc.)	0.1	0.3

Table 5: *Grazing practices by the Nepalese and Indian herders inside the KTWR.*

Source: Field survey, 2018.

Potentiality of cross-breed buffaloes

The relation of different input variables and output variables was extracted by using the binary logistic regression function. The Arna cross breed animal have different qualitative and quantitative traits which was more preferable and overcome to their counterpart (local buffalos) in most of the economic parameter. Among most of the measured parameter, such as meat quality, breeding vigor, health vigor, grazing behavior, acceptable meat quality, market price, market opportunities, meat export potential, the Arna crossbred had far better superiority ($p < 0.01$) than the local breed. Though the availability of these animals was quite tricky, there is a huge scope of materializing this concept into legal and social practice. Therefore, these breeds possibly could be utilized for future genetic improvement programs as well (Table 5 and 6).

Outcome variable	Predictor	Wald Score	df	p value
Preference of Arna crossbred buffalos over local breed	Meat quality	10.952	1	.001
	Breeding vigor	12.267	1	.002
	Health condition	5.834	1	.016
	Grazing behavior	24.643	1	.000
	Widely acceptable meat quality	19.714	1	.000
	Market price	15.165	1	.000
	Market opportunities	6.887	1	.009
	Export potential	19.862	1	.000
	Availability of male	3.320	1	.068

Table 6: *Preference of the crossbred buffaloes by the farmer over local indigenous buffalo breed (Predictor and predicted variables' relationships with significance level outside the equation).*

Note: Independent variable entered: meat quality, breeding vigor, health, grazing behavior, better flesh, market value, Availability of male, (Outcome (dependent) variable entered: Preference of Arna cross breed buffalos).

Model prediction and its significance

A model was predicted to identify whether the possible function can be developed by the use of potential variables. The "variables in the equation" table show the contribution of each independent variable to the model and its statistical significance. The test was used to determine statistical significance for each of the independent variables. Results revealed that almost the entire variable did not add their contribution significantly to the model. We can use the information in the "variables in the equation" table to predict the probability of an event occurring based on a one unit change in an independent variable when all other independent variables are kept constant. For example, the table showed that the probability of selection of cross breed buffalo due to acceptable meat quality ("yes" category) was statistically non-significant at 95% confidence level. This means that the contribution of predictor variable (acceptable meat quality) could have a non-significant effect on the predicting variable if other variables were kept constant.

The predicted model that could affect the acceptability of the Arna crossbred buffaloes can be extracted as:-

$$Y= -35.181-1.78X_1 +18726X_2 +58.168X_3 -36.272X_4+15.762X_5+15.762X_6-35.181X_7 +321.56$$

Whereas this model is not significant in all constant levels. That means, the equation couldn't be possibly valid at 95% probability level in case the individual predictor was taken alone. This revealed that every predictor should be considered to derive asignificant functional relationship.

Variables	Sequences (X)	β	df	Significance level
Meat quality	1	-1.784	1	p > 0.05
Breeding vigor	2	18.726	1	
Health	3	18.413	1	
Grazing	4	58.168	1	
Better flesh	5	-36.272	1	
Market value	6	15.762	1	
Availability	7	15.762	1	
Constant		-35.181	1	

Table 7: *The significance of predicted model on the preferences of the crossbred buffalo.*

Note: β is the constant value for each parameter; df is the degrees of freedom.

Validation of the model

The step-wise relation of outcome and predictor variables was not significant for majority of the cases. However, the model equation was highly significant ($p < 0.001$). Moreover, different variables could be directly co-related to each other and that could affect the validity of the model. The relationship among independent variables was not calculated because visible co-linearity would not be functional among the unrelated predicting variables wherever the relationship may or may not be an exit in real case scenarios. The Cox and Snell R^2 square value, which is not true but pseudo R^2 value was calculated to be 0.596. Pseudo R^2 value interpreted that there exited certain relationship and chances of selection by the farmer were 59.6% wherever this model is loaded as a function.

Parameters	Chi-square	Df	p value	Cox and Snell R^2 value
Step	28.777	8	.000	0.596
Block	28.777	8	.000	
Model	28.777	8	.000	

Table 8: *Tests of model coefficients in terms of use and validation based on information collected and used in the study area.*

Discussion

Local feral buffalos either from Nepal and India share the common pasture land with wild buffalos, perhaps leading to grazing land degradation in several instances. The activity is either deliberate, or by chance due to lack of grazing land on the buffer zones and poor state of management. The probability of producing crossbred, for example, buffaloes with the crosses from wild Arna is negligible mainly due to the predominance of bigger and stronger wild male counterpart though occasional crossing that also has huge probability for existential threats to wild genotypes. Any 2 of the predefined as wild buffalo and 7 as of predefined domestic buffalo showed evidence of mixed ancestry in the genetic examination of wild water buffalo elsewhere [14-18] that shows the degree of probability of getting crossbred in Nepal as well In deed grazing domesticated animals within the ecosystem will compete for space with the wild type along with food, wellbeing perhaps leading to loss of pure genotype due to periodic cross breeding [23,26,28].

The hypothesis assumed for this study was that these genotypes should be provided to the farmer strategically and subsequently completely restrict their livestock's easy access to graze within the place where Arna shares the habitat. Consequently, the large number of crossbreeds still available within the farming communities can be used strategically for future breeding purposes, so the purity of the wild type can be maintained over a long period of time. These concepts could incapacitate the national buffalo fattening programs to strengthen the 'Broiler buffalo' production concept in the long run through strategic breed improvement programs. More concisely, the past research activities were mostly oriented with the development of the dual-purpose breed resulting a kind of confused state. The newer hypothesis has been also thus conceptualized from this research with the possibility of producing a broiler buffalo by following a scientific and strategic breed improvement program.

Many of these domestic animals were kept in semi-wild, or tended, free ranging state to facilitate cross breeding with Arna in the expectation that hybrid calves would in return give them the higher price [10-12]. This had caused competition within limited pasture and reduced the quality forage to the wild pure line as well. Disease and parasites transmitted by domestic livestock also could be existential threats to these threatened species [1,2,4,15,26,27]. There was an immediate need for the forbidden of these local buffalos to share the common grazing area with wild buffalos. The improvement of the grassland of the buffer zone and implementing the forage production and support programs among these herders within the buffer zone could reduce the burden systematically and cordially within the societies. This will probably lead to reduce the huge burden of KTWR for controlling the feral animals to conserve the natural habitat, grasslands and ecosystem functions of the reserve [1,15] (Table 5).

Indeed the broiler buffalo production could be conceptualized by maintaining the parallel pure line for meat and milch type aiming to underscore the vast demand for buffalo meat throughout the country. Additionally, the broiler buffalo could be hypothesized as a young buffalo calves grown up to a defined years exclusively to produce large sized and with highly acceptable flesh quality for the purpose of being slaughtered. Those grazing farmer who do not consume the buffalo meat might be reason due to which the overall farmers preference level was negative to the flesh quality of the cross breed. This justifies that farmer were not aware of the flesh quality but interested to have large body size of the animals in order to get higher market price. Higher market value of the cross breed animals specially from the butcher widen the scope of the further research on the quality aspects of the meat ultimately broadening the scope of different buffalo fattening research arena of country.

It could be more sustainable to increase the quantity and quality aspects of meat through these broiler buffalo than the prevailing double purpose breed. Even though there is a limited exploration on this program of crossbreed young calf fattening, we attempted to explore the ground root information on the current breeding, feeding, overall management and socio-economic aspects of these Arna crossbreed buffalo.

Threat to local breed, especially to Arna need to be emphasized together with the promotion of Arna crossbreds [7]. There is an immediate need of maintaining each wild and domestic pure genotypes as well with in-depth study on possibilities of crossing to get superior genotypic buffaloes. Policy needs to be developed to strengthen the protection of local breed and Arna before promoting Arna crossbreds.

There is a huge demand of male buffalo in the country for meat purpose. The demand of buffalo meat is not fulfilled yet [4]. Buffalo meat contains low amount of cholesterol so more people are attracted to buffalo meat. It was reported that cholesterol content in buffalo meat is (46%), sheep (68%) and goat (58%). Most of the buffalo meat is produced from aged buffalo which have been used as draft (males) and milking (females) [27]. There is demand for the improvement in efficiency of buffalo meat production. The alternative use of young male calves may have advantage over old animals if they can be reared by feeding of nutritious diets [22]. Though different grazing and feeding regimes for buffalo fattening, this cross-breeding program could have been milestones in fattening program within days to come.

Conclusion

Findings of this research suggest that Arna crossbred buffalo has excellent physical as well as socio-economic potentialities coupled with pronounced acceptance level in the farming communities. In spite of existential threats due to increased anthropogenic activities to the ecological functions of wild genotypes of Arna, there is need of immediate potential options to protect these animals. Simultaneously, the already available crossbreds within the farming communities could be utilized strategically for future research program. Indeed, there is huge scope of incorporating Arna crossbred genotypes in domesticated buffalo, also focusing to fattening them with the concept of producing 'Broiler Buffaloes' for a quality meat production but by not limiting its potential for milk production.

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Bibliography

1. Aryal A., *et al*. "Call to Conserve the Wild Water Buffalo (Bubalus arnee) in Nepal". *International Journal of Conservation Sciences* 2.4 (2011): 161-168.
2. BPP. "Biodiversity Assessment of Terai Wetlands". Biodiversity Profiles Project Pub. No.1. HMG, DNPWC, Kathmandu, Nepal" (1995a).

3. Dahmer TD. "Status and distribution of the wild Asian buffalo Bubalus bubalis in Nepal". MS thesis, University of Montana, Missouri, Montana (1978).

4. Devkota NR and Kolachayapati MR. "Forage based Buffalo fattening technology for meat Production". Institute of Agriculture and Animal Science, Rampur/National Agriculture and Research Development Fund, Kathmandu (2008): 28-33.

5. Dahmer TD. "Status and Distribution of the Wild Asian Buffalo (Bubalus bubalis) in Nepal". MS Thesis. University of Montana, Missoula, Montana (1998).

6. Flamand JR., *et al*. "Genetic identification of wild Asian water buffalo in Nepal". *Animal Conservation* 6 (2003): 265-270.

7. Flamand JRB., *et al*. "Genetic identification of wild Asian water buffalo in Nepal". *Animal Conservation* 6 (2003): 265-270.

8. Hedges S. "Asian Wild Cattle and Buffalo: Draft Status Report and Conservation Action Plan (Parts I and II)". Unpublished Report, IUCN Gland, Switzerland (1995).

9. Hedges S., *et al*. "In: IUCN. IUCN Red List of Threatened Species" Version (2012).

10. Heinen JT. "Population viability and management recommendations for wild water buffalo (Bubalus bubalis) in Koshi Tappu Wildlife Reserve, Nepal". *Biological Conservation* 65 (1993a): 29-34.

11. Heinen JT. "Park-people relations in Koshi Tappu Wildlife Reserve, Nepal: a socio-economic analysis". *Environmental Conservation* 20 (1993b): 25-34.

12. Heinen JT. "Phenotypic and behavioral characteristics used to identify wild buffalo (Bubalus bubalis) from feral backcrosses in Nepal". *Journal of the Bombay Natural History Society* 99.2 (2002): 173-183.

13. Heinen JT and Kandel R. "Threats to a small population: a census and conservation recommendation recommendations for Wild Buffalo Bubalus arnee in Nepal". *Oryx* 40 (2006): 324-330.

14. Heinen JT and Mehta JN. "Emerging issues in legal and procedural aspects of buffer zone management with case studies from Nepal". *Journal of Environment and Development* 9 (2000): 45-67.

15. Heinen JT and Paudel PK. "On the translocation of wild Asian buffalo Bubalus arnee in Nepal": Are feral backcrosses worth conserving? Conservation Science 3 (2015): 11-21.

16. Heinen JT and Shrestha SK. "Evolving policies for conservation: an historical profile of the protected area system of Nepal". *Journal of Environmental Planning and Management* 49 (2006): 41-58.

17. Hosmer D and Lemeshow S. "Applied Logistic Regression (Second Edition)". New York: John Wiley and Sons, Inc (2000).

18. IUCN. "An Interpretation and Education System for Koshi Tappu Wildlife Reserve and its Buffer zones". IUCN Nepal 47.

19. IUCN. "IUCN Red List of Threatened Species" Version.4, IUCN, Gland, Switzerland (2010).

20. Kandel RC. "Arna/Wild Buffalo Count". A Report. Koshi Tappu Wildlife Reserve (2004).

21. KTWR. "Koshi Tappu Wildlife Reserve and It's Buffer Zone Management Plan (2074/75 – 2078/79)" Koshi Tappu Wildlife Reserve Office, Paschim Kushaha, Sunsari, Nepal (2018).

22. Mahmoudzadeh H., *et al*. "Response of Male Buffalo Calves to Different Levels of Energy and Protein in Finishing Diets". *Pakistan Journal of Biological Sciences* 10 (2007): 1398-1405.

23. Mishra N., *et al*. "Arna / Wild Buffalo (Bubalus bubalis) census in Koshi Tappu Wildlife Reserve, Nepal" (2009).

24. Petersson D. "What is happening at Koshi Tappu Wildlife Reserve? Danphe" 7.1-2 (1998): 6-7.

25. Sah JP. "Koshi Tappu Wetlands: Nepal's RAMSAR SITE IUCN Nepal" (1997): 254.

26. Shrestha TK., *et al*. "Bubalus arnee Forage under Threat: An Assessment of Koshi Tappu Wildlife Reserve". *Nepal International Journal of Research Studies in Zoology* 4.3 (2018): 22-27.

27. Khanal P., *et al*. "Sustainable Livestock Production in Nepal: A Focus on Animal Nutrition Strategies". *Agriculture* 12.5 (2022): 1-20.

28. Tulloch DG. "The water buffalo, Bubalus bubalis, in Australia: reproductive and parent offspring behavior". *Australian Wildlife Research* 6 (1979): 265-287.

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