

**Creation of a Viable Breeding Satellite Population of
Great Indian One-Horned Rhinoceros (*Rhinoceros Unicornis*) in
Bhadhi – Churella Taal sector of Dudhwa National Park**



View of Bhadhi Taal area – Proposed additional Rhino Area inside DNP/TR

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1. BACKGROUND

The Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*) was once widely distributed from Hindukush Mountain Range (Pakistan) to Myanmar and also all along the flood plains of Ganges River. In the last 200 years over-hunting, fragmentation of habitat by clearing forest for cultivation, desperate land use for agriculture, extension of tea gardens, reclamation of grasslands and swamps for fulfilling the basic needs of expanding livestock and human population and uncontrolled fires are the major causes of elimination of Indian Rhinoceros from most of its former range of distribution. The last Rhino in Uttar Pradesh was shot in the Pilibhit district adjacent to the Dudhwa National Park in 1878. At present the Indian Rhinoceros population of around 2855 is restricted to protected areas in Assam, West Bengal, Uttar Pradesh and Nepal. The Kaziranga National Park in Assam has 2048 Rhinos and the Royal Chitwan NP in Nepal has 408(2010).

By considering the highly restricted distribution with poaching pressure, habitat specificity and considering the scattered small population, it becomes imperative to re-introduce the species in suitable habitats in its former range of distribution as one of the measures to be adopted for the long-term survival of this species.

The IUCN Rhino Specialist Group and the Rhino Sub-committee of the Indian Board of Wildlife (IBWL) recommended the establishment of an additional Rhino population in India.

2. RHINO REINTRODUCTION IN DUDHWA NATIONAL PARK

Of the various areas considered by the sub-committee, Dudhwa National Park was thought to be the most promising because similarities of the habitat to that of Kaziranga National Park, the fact that the Rhinos have been recorded in this area till the last century and the adequacy of the protection available. The suitability was confirmed by Prof. Schenkel, Chairperson of Asian Rhino Specialist Group and was further supported by the vegetation studies by the Botanical Survey of India, which revealed the presence of various preferred species of rhino.

The reintroduction of Rhino in Dudhwa took place in two phases. The first phase in 1984, in which five Rhinos comprising 2 males and 3 females were captured, and translocated to Dudhwa from Pobitora WLS, Assam. These animals were released in Rhino Reintroduction Area (RRA) in specially constructed stockades for health care and for experiencing electric fence before final release into the main fenced area of RRA. Of these five animals, one female died of stressful abortion before she could be released. The first batch of animals was released in Dudhwa on 20.04.1984. The large male was held back until the others had settled and released after radio-collaring a few days later. Another female died on July 31, 1984 after a bid to tranquilize her to treat a wound. With only one female and two males left, an urgent need was felt to translocate some more Rhinos. The collaboration of the Govt. of Nepal was obtained in the exchange of four young female rhinos for sixteen elephants. The rhinos captured from near Royal Chitwan National Park arrived in Dudhwa in April 1985. Thus these seven rhinos, two males and five females made up the seed population of rhinos.

The first evidence of breeding in the reintroduced population was detected under unfortunate circumstances when remains of a newly born calf were discovered in a patch of tall grass in August 1987. The first successful calving occurred in 1989. Four more calves followed this in the same year. Unfortunately, in 1991, out of five female rhino one adult female died of stressful abortion after fighting and chasing by Male rhino Banke to save her male calf. Later her calf was also killed in 1992. The breeding success followed then and the seed population of 5 has since increased to 30 with four females and a male of founder members. In the current rhino population there are total 16 adult females in an age group of 8-29 years and among adult males total number is 10 males in an age group of 6 to 32 years. Rest of 4 calves' falls in an age group of couple of months to 5 years (2010).

All the rhinos are kept in an area of 25 sq. km. encircled by a power fence. The five stranded outer fence, the inner partitioning three-stranded mini fence of 1993-94 and the additional fence created in 1997 are serviced by staff and labour. Main rhino monitoring centre is based at Salukapur and staff with elephants at Base-camp to carryout rhino monitoring from other side. Two energizers based at these places for power of the fence. In 2009, location of fence in Salukapur side to earlier entrance gate has been slightly shifted right in the middle of the un-asphalted road. Now patrolling elephants directly enter into the rhino fence area from Salukapur. Every day, four riding elephants were used to locate all the rhinos, seldom were all the rhinos sighted everyday due to poor sighting in the tall grassland condition. Except for a short period after the burning of grasslands when most of the rhinos were located. Rhinos were also sighted on foot, using a motorcycle and from machan tops. All the adult rhinos are identified individually by recording different physical traits and name has been given to individual rhino.

3. NEED TO ESTABLISH A SEPARATE RHINO POPULATION INSIDE DUDHWA NATIONAL PARK

(i) Genetic Variability and check Inbreeding

Initially, the original objective was aimed at releasing 30 rhinos in Dudhwa National Park which has achieved in 2010. The precise reason why this was not carried out after release of two batches is both financial and administrative. However, due to breeding the number has increased from five to 30 rhinos which includes the 5 rhinos of founder population and rest 25 rhino calves born in Dudhwa.

In the beginning out of the seven seed population, only two were male named Raju and Bankey. Initially, Raju had asserted his dominance but with passage of time Bankey became dominate and killed Raju in one of their regular fights in October 1988. During 1991 an attempt was made to counter the anticipated problem of inbreeding by introducing a male, named Rohit, from Kanpur Zoo. He was repeatedly attacked by Bankey and severely injured. This animal had to be taken out, treated and returned to the zoo after it had recovered. The existing rhino population in RRA has two more adult males but they are unable to assert themselves in front of the dominant

male Bankey. Bankey continues to be the dominant male even today. All the calves born till today are progeny of this dominant male – Bankey. Because all these calves surviving now are born after 1989, there is little chance of mating with Raju who died in 1988. In absence of any other male even the sexually mature daughters are mating with their father. The two adult males, though unable to assert are also the progenies of same rhino Bankey and if in the future they will mate with the females, same type of genes will be transmitted to the next generation. If this situation prevails for few successive generations, it may cause inbreeding depression, which is a threat for genetic viability. So, there is an urgent need to introduce some other male with different genetic base. And keeping in view the past experiences with Bankey's behaviour newly translocate male rhinos should be kept in the rhino area of Bhadhi Taal - Churella Sector to avoid the chance of fighting among them. And hence, there is an urgent need of enlarging rhino habitat (*Sinha, 1991 and 1999*).

(ii) To Reduce conflict amongst males in existing RRA

Earlier in 1986, Bankey has driven one of the two adult males in existing population out from the main fence on several occasions and finally another male lost its horn and became submissive. Therefore, separate contiguous mini fence has been created to provide safe heaven to one of these animals. The two males are often seen parading on their respective sides of the common section of the fence and even functional fence also are unable to restrict the rhinos from fighting. Thus, there is an urgent need to create another rhino habitat (*Sinha, 1991*).

Male calves born in rhino area are now mature enough to breed but are driven out by the founder male Banke. Although the founder male is losing its dominance but it is still active in breeding and from time to time drive the young males out of the fence. But due to lack of escape space inside the existing rhino area male rhinos usually go out of the fence area or shifting the area frequently to avoid any direct conflict. It is therefore possible that some of the fully mature male rhino are straying out side the rhino area in nearby areas.

(iii) Use of the Rhino Reintroduction Area (RRA) by migratory elephants

Another problem, which is going to be a major problem unless until precautionary measures are taken in maintaining the fence intact, is the presence and movement of migratory herd of wild elephants in Dudhwa National Park. Till 1992, usually elephants of 4-35 in a group used to migrate from Pilibhit forest to Kishapur WLS to Sathiana Forest Range and then to Banke Taal. These elephants till the sugar cane was available in fringe cultivation adjacent to rhino area, used to raid during late evening hours then come back to Salukapur and shared the sugar cane provided to riding elephants and go back to Banke Taal grassland or Bhadhi Taal area. Occasionally, they tried to go inside the rhino area due to inactive fence. These elephants make two groups one with females and calves and another is exclusively males of different age.

In the recent past group size has also increased in number over 60 elephants in single herd. Usually males of different ages are daring enough to bend the fence pole and come inside the rhino area and stay for days and go out. During this period they can be a threat to riding elephants with visitors or Patrolling team.

These herds also visit the Bhadhi Taal and Churella area and precaution should be taken because after completion of fence these herds will try to push poles from different side to enter the area. There is need to erect latest designed electric fence made against the elephant's attacks by pushing and bending of fence poles. Another important factor is for the safety of the people working in around fences area patrolling party and protection staffs along with riding elephant have to stay near by should be given protection by erecting a separate fenced area to avoid any unwanted incidences. Usually elephants go in search of food and salt to such camps and raid during late nights.

(iv) Increasing Population in the existing RRA

Increasing population of rhino in the existing area is also a major problem. The current rhino population is 30 rhinos in 25 sq km of RRA which is a fenced area. Either a new area can be selected for rhino translocation in Dudhwa Tiger Reserve or the enclosure should be removed. In case of the removal of the enclosures, there are chances of crop depredation by rhinos in the adjoining areas, which is very close to the southern boundary of the Rhino Re-introduction Area (RRA). Recently four rhinos went outside the RRA and are regularly raiding the croplands. The rhinos also killed two villagers. In response to these situations, it is better to keep the rhinos in enclosure. And hence, there is a need to select some new area inside the Dudhwa National Park. In the light of above facts, in 1991, there was a recommendation for the urgency of creating another viable breeding population of rhino in Dudhwa National Park and proposed Bhadhi-Churella Taal sector in Belraya Range of Dudhwa National Park.

4. PROPOSAL

I. Priorities in the selection of rhinos for introduction in the New Rhino Area- Bhadhi Taal – Churella Sector in Belraya Range of Dudhwa NP

Priority Options:

(i) Rhinos straying outside the existing Rhino Reintroduction Area

It has been observed that from time to time rhinos stray out of the rhino area. These rhinos cause crop damage in the neighbouring cultivation. During daytime they take shelter in the buffer forests. Efforts have been made to push these rhinos inside the fence with the help of riding elephants but efforts were futile. On many occasion female with calf tried to attack the elephants and people on foot. Earlier the female rhino has been killed a villager in the buffer forested area. Therefore it is essential to

translocate these animals as early as possible after the installation of fencing around Bhadhi Taal area. Migratory herd of elephants enter the rhino area by pushing fence pole which damages the fence and makes escape routes for rhinos. There are possibility that some of the rhinos can go out of rhino area when fence is open and unnoticed in those areas where approach is not easy especially during the monsoon months and for some days fence is non-functional.

(ii) Rhinos from Existing Population in Dudhwa NP

Translocation of young males and females from the existing population to a newly fenced satellite area so as to provide immediate relief from infighting between the dominant and young males and inbreeding. The area identified is well drained out suitable grassland for Rhinos and is physically separated from the existing RRA so as to minimize the operational difficulties and intra specific conflict situations arising out of operational failures of the fence.

(iii) Translocation of rhinos from Katerniaghat WLS

Since 1989, 3 to 5 rhinos from Bardia NP regularly move to Katerniaghat WLS and also breed. In view of their security and safety these rhinos can be translocated to Bhadhital area along with few rhino from existing rhino area of Dudhwa NP to maintain genetic vigour. This should be done with consent of Nepal authorities and common understanding.

(iv) Wild rhinos from other population with in the country or from Nepal

Wild rhinos can be procured from Jaldapara WLS and Gorumara NP, West Bengal. Other alternative is to procure rhinos from Royal Bardia NP or Royal Chitwan NP, Nepal. Matter can be pursued at the Government level and such a effort would incur more time and expenses.

II. Hiring Experts for Rhino Immobilization, Translocation Operation to translocate Rhinos into the New Rhino Area

In the case of mega herbivore immobilization, its translocation and shifting of animal in to the new area needs special skill and expertise. Total cost of the entire translocation operation has been included in the proposed budget of the project. The amount will cover all the operation cost which includes hiring charges of experts, travel cost, per diem, transportation, Immobilization, labour involved and building of stockade or mini fence before release of the rhinos into the main fence.

5. POLICY STATEMENT ABOUT FUTURE PLANS FOR RHINOS IN DUDHWA NATIONAL PARK

As per the final recommendations of the Rhino Sub-committee of the Wildlife Status Evaluation Committee of IBWL (1980) in the Translocation of Great India Rhinoceros in Dudhwa National Park:

1. The U.P. Forest Department had proposed an area of approximately 90 sq kms in the southwest part of the park (South Sonaripur and South Bellarian Ranges): as providing most suitable rhino habitat. It includes a 15 km long tract of grassland on the southern boundary of the park bordering the Suheli River. Fifty percent of the area is subject to seasonal floods and an area of 560 hectares is permanently swampy and water logged. The Committee felt that area was highly suitable. A disadvantage of the area proposed is that an adjacent to the southern boundary of the park (Suheli River), which lack of buffer zone and outside of which is an area of dense human occupation and cultivation. There is thus a danger of rhinos wandering across the river and causing damage to cultivation and possibly to human life.
2. In order to prevent rhinos from wandering across the park boundary from the proposed release area, a rhino-proof barrier should be erected parallel to the right bank of the Suheli river from the point where the Dudhwa/South Sonaripur inter-range bordering joins the southern park boundary to a point on the park boundary south of Salukapur FRH. The distance is approximately 11 km. The type of barrier erected initially as experimental. Size of the trench will be 2X2X1 m the outer slope being brick lined to prevent scouring. 60 m sections of the trench will be alternated with 15 m sections of iron fencing so as to avoid water flow in these trenches turning it into 'Nullah'. Regular maintenance of the trench will be necessary.
3. An initial release should consist of six young adult animals (2 males: 4 females).
4. Further release in Dudhwa should be planned based on the experience with the initial six animals. A total release of up to 30 about over 5 years, in the South Sonaripur /South Bellarain Range is recommended. The area of 90 sq km proposed as suitable for rhinos are able to accommodate a maximum 90 animals but clearly rhinos must leave space for future population growth by reproduction. A limiting factor might prove to be the availability of funds for further fencing of the southern boundary depending on which type barrier eventually proves to be most suitable.
5. IUCN, Species Survival Commission, Asian Rhino Specialist Group in their, February, 1999, conference at Kaziranga National Park considered rhino population to be viable if their minimum number is 2500 in the wild in atleast 10 population, each of minimum 100 rhinos in each sites. With the present pace of growth in the population this figure will be achieved in 25 years. Till that period present electric fence is to be expended and maintained.
6. As the boundary of the park conjoins agriculture and human habitation almost all over, man animal conflict with respect to the rhino is invariable, the moment electric fence is removed. In order to avoid such conflict it is advisable to construct trench cum fence this

will prevent not only rhino but also almost all the wild animals straying out side Dudhwa National Park. Resources for this purpose will be gathered either internal funding or with the help of other funding agencies in the field conservation particularly wildlife.

6. AREA SELECTION FOR CREATING SATELLITE POPULATION

In early 1980's , The Rhino Subcommittee of Indian Board for Wildlife (IBWL) had identified the Bhadhi - Churella sector in Belraya Range as one of the possible sites for re-introduction of rhino in their original recommendation. Feasibility study with regard to the habitat availability for the re-introduction of rhino in Dudhwa was carried out by the Botanical Survey of India (Hajra, 1980), and Sinha and Sawarkar (1991), Sinha et.al, (2003). Detailed survey of the vegetation of Dudhwa special reference to Bhadhi Taal area in relation to the rhinos feeding ecology. The detailed study clearly established a number of floral elements common to Dudhwa National Park and Kaziranga both of which are excellent rhino habitats.

The Bhadhi – Churella Taal area identified by Sawarkar and Sinha (1991) was also recommended in the management plan of Dudhwa NP by Dey (2001) and Mishra and Tewari (2002), for the creation of a satellite rhino population. In 2003 and again in 2009, the area was surveyed for its habitat suitability and found fit for rehabilitation of Rhinos. A detailed vegetation study in proposed rhino area in Bhadhi – Churella Sector was carried out by Sinha et.al (2003). In 2002-2003 erection of power fence and poles was started around Bhadhi Taal - Churella sector but due to some reasons could not be completed. The area to be power fenced in the Bhadhi Taal –Churella Taal sector was on the basis of number of animals in the population to be translocated. Currently the area supports migratory herd of elephant, swamp deer, sambar, spotted deer, hog deer, barking deer, otters and large number of migratory and resident birds along with tigers.

The advantage of the area selected is that it is in the central location of Belraya Range. There is no danger of rhino wandering in the human habitation and cultivation in case of failure of power fence. While in case of existing rhino re-introduced area, it is adjacent to the southern boundary of the park, with dense human settlements and cultivation. Bhadhi-Churella sector is centrally located and sufficient forested area is available in northern part and demarcated by Mohana River as the international boundary with Nepal.

The habitat requirement of Rhinos, the Bhadhi –Churella Taal sector fulfills the basic need like adequate forage availability, wallowing, shade of woodland for resting and calving and for free movement. The area comprises of Sal and Mixed forests (2,416.36 ha), Grassland (1,203.68 ha) and Wetland/ Swamp (129.00 ha), which fulfill the need of rhino, and is one of the prime rhino area in Dudhwa.NP.

The proposed rhino area of Bhadhi-Churella sector will comprise of 25 kms long fencing enclosing an area of 3036.72 hac as rhino area. (Map 1.)

The details of the area to be fenced are as follows:

Block/ Comp.	Sal Forest (ha)	Grassland (ha)	Wetland/Swamps (Ha)
Bhadhi -1a,b	189.39	-	-
Bhadhi-2	180.09	-	-
Bhadhi-3a,b (part)	369.47	300.00	-
Bhadhi-3c	4.86	354.88	105.00
Bhadhi-6a	88.63	9.31	-
Bhadhi-6b	-	53.83	-
Bhadhi-7 a,b	346.81	4.36	-
Laudaria-1 a,b	466.61	40.06	-
Laudaria-2 (part)	35.39	15.0	-
Laudaria-3a,b	294.21	346.00	24.00
Laudaria-4 (part)	9.72	20.30	-
Laudaria-5	128.69	25.4	-
Laudaria-6	182.51	40.42	-
TOTAL	2,416.38	1,203.68	129.00

(Source: Management Plan of Dudwa TR by Rupak Dey (2001)

Total Fenced Area - Approx 3036.72 hac or 30.367 sqkms

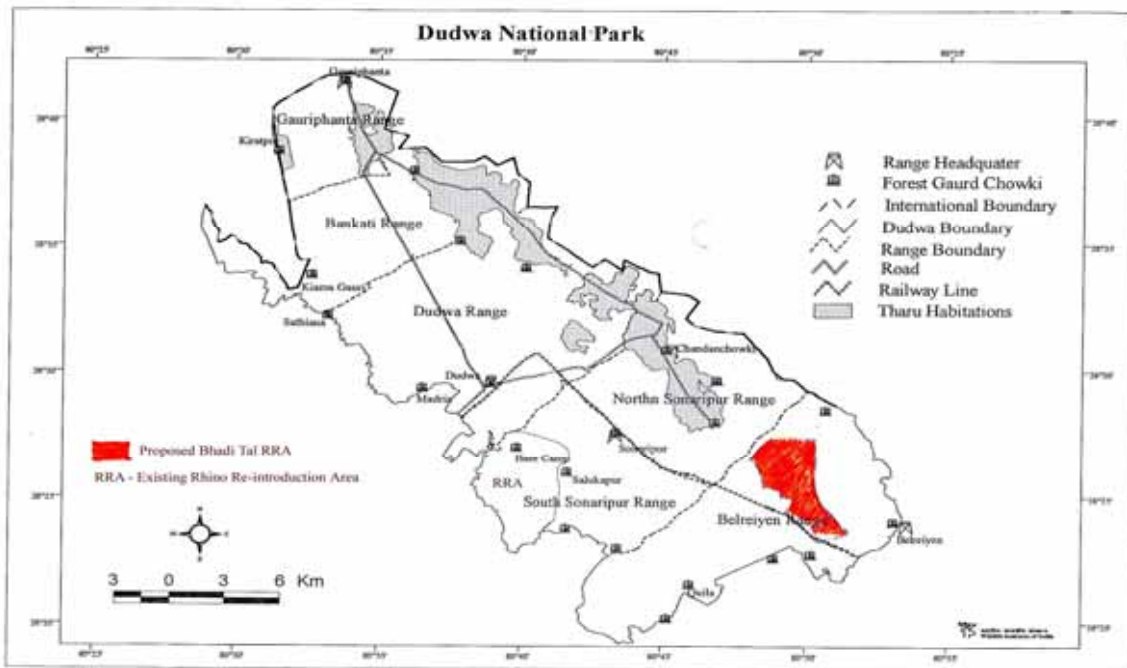
Total length of the fence – Approx 25 Kms

7. CONSTRUCTION OF HEAVY DUTY STOCKADE

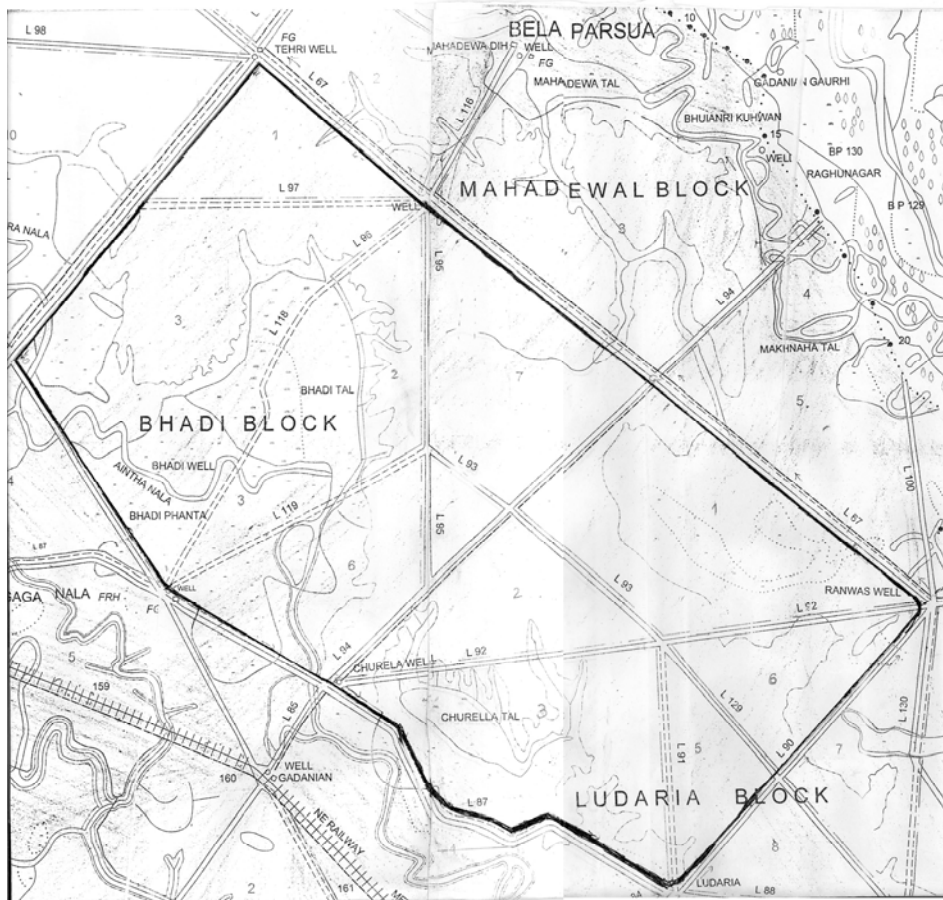
Before releasing the translocated animals into the main fence, Animals are kept in stockade for at least for 2-3 weeks till the animal gets acclimatized with number of factors provided with least human disturbances. Total area inside the individual stockade unit should be 54 sq m, female with calf then area should be increased. Details are given in the figures. In this particular period animal cool down after a stress period and get established.

The big confined wooden cage / enclosure on the ground should be provided with small water ditch and container with fresh water. Regularly locally available fodder grass, sugar cane and bersene should be provided. Since animal do not have prior experiences of electric shock of a fence or might have forgotten the earlier experience. It is advisable have to have an electric fence around stockade. So when animal is released from stockade it should experience the shock. Otherwise direct release into the main fence will not be effective and animal will break the fence and go away repeating the same story.

Map 1. Dudhwa NP & Proposed Rhino area (in Red Color)



Map.2. Showing demarcation of proposed Rhino Area in Bhadhi - Churella Taal Sector in Belraya Range of Dudhwa National Park



(Scale 1 cm: 250 m)

8. COSTING

Besides fencing the area by erecting rhino and elephant proof fence, maintenance of existing roads, elephant shed; check post & barracks needs to be constructed for the monitoring staff. The Rhino Monitoring Station is proposed at Chhanganala. After the translocation of Rhinos monitoring of individual animal will be carried out till the translocated animals get established in the proposed RRA in Bhadhi - Churella Taal area. The total Costing of the current project is given in the Table.1.

9. EXPECTED OUTCOME

The creation of the Bhadhi satellite area for the Rhinos will reduce the prevailing conflict situation among the males and severe inbreeding in the existing population. Moreover, intensive management efforts to be applied for Rhinos are bound to benefit the existing take-off population of the highly endangered Swamp Deer in the area. The all round increase in the status of protection of the area will help to proliferate other endangered wildlife such as Hispid Hare and Bengal Florican. These expectations are based on the observations recorded in the main RRA. This area will also ready to receive fresh batch of Rhinos. Moreover, there exists a viable connectivity between the existing and proposed RRAs through the grasslands of Bankey Taal and Rehta sector. Thus the two populations can also be joined in due course of time when the Rhino population increases by extending the fenced areas and only possible if the railway line is dismantled in near future which is the major barrier between two potential rhino areas.

Table.1. Proposed Budget (Five year project to be regularize with Rhino Project of Dudhwa NP for further funding)

No	ITEM OF WORK	UNITS	RATE (In Rs.)	COST (In Rs.) 1& 2 year budget	3 year
1.	Installation of the rhino & elephant proof fence (Includes GI poles, heavy coated GI wires, Energizers, Solar panel, Batteries, Installation charge etc.)**	25 km (Five strand)	Approx 3 to 4 lac per km	75,00,000.00 (Calculated @ 3 lac per km)	-
2.	Ground leveling and clearing of ground for fence installation	L.S.	-	2,00,000.00	-
3.	Construction of Gates to enter the fenced area	06	20,000.00 per gate	1,20,000.00	-
4.	Construction of Elephant shed	02	4,00,000.00 per shed	8,00,000.00	-
5	Construction of Forest Guard chowkies, Barrack, Kitchen etc. for forest guards, Mahouts, Chara-cutters and Fence watchers.	LS	-	15,00,000.00	-
6.	Salary/wages of Mahouts for 24	04	5000.00 per	4,80,000.00	2,40,0

	months*		month		00
7.	Salary/wages of Chara-cutters for 24 months *	04	3000.00 per month	2,80,000.00	1,40,000
8.	Salary/wages of fence watchers for 24 months*	10	3000.00 per month	7,20,000.00	3,60,000
9.	Cost of translocation of Rhinos from different locations including hiring experts	L.S	-	15,50,000.00	-
10.	Purchase of Arms and ammunitions	L.S	-	3,00,000.00	-
11.	Purchase of four departmental elephants	LS	5 lac per elephant	20,00,000.00	-
12.	Alignment of roads for patrolling inside and outside the rhino fence area	L.S	2.5 lac per year for 2 years	5,00,000.00	2,50,000
13.	Trench inside & outside the fence	L.S	-	10,50,000.00	-
14.	Deepings of water bodies	L.S	-	10,00,000.00	-
15.	Construction of heavy duty Stockade	L.S	5 Unit fenced/partition	8,00,000.00	-
16.	Habitat and grassland management	L.S	Inside the fenced area	6,00,000.00	3,00,000
17.	Research project on Monitoring of rehabilitated rhinos : 1. Project Coordinator (1) 2. Field Biologist (1) 3. Field Assistant (1)	3 year	Rs 19,70,000 for first year, for second and third year Rs 10,20,000 for each year	29,90,000.00	10,20,000
TOTAL				2,23,90,000.00	23,10,000
(Rupees Two crore and twenty three lac and ninety thousands only)					

* Later inducted as per the official rules and scale

Year- wise proposed budget

S. No.	First & Second year(In Rs)	Third year	Fourth year	Fifth Year
1	2,26,00,000.00	23,10,000	12,90,000*	12,90,000

* Excluding the amount after the completion of research project on monitoring of rhinos

Quantification of vegetation of proposed Rhino area in Bhadhi – Churella Taal Area of Dudhwa NP

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Naim Akhtar and Mohit Kalra, Field Biologist
Project funded under Rhino and Tiger Conservation Fund,
US Fish & Wildlife Services, USA

METHODOLOGY

The present existing forest cover and grassland along with the water body in the Bhadhi Taal – Churella area forms an ideal habitat for the rhinos in the current situation in Dudhwa NP. The following methodology has been followed for the quantification of vegetation in proposed rhino area in Dudhwa NP which is as follows:

Line transect sampling (Burnham *et al.*, 1990) for vegetation quantification was found infeasible due to small size of patches, hence sampling was done covering many random points in each patch of corridors. Sampling for trees was done in circular plot of 20 m radius at various points, picked randomly in each existing forest cover in the both identified corridor. Optimum size of vegetation sampling plot was followed as described by Sharma *et al.* (1983). From the same sampling point, data were also collected for shrub and herb using circular plot of 5 and 1 m respectively. Woody species exceeding 20 cm GBH (Girth sizes) were considered as trees whereas less than 20 cm in GBH were counted as shrub.

At each sampling plot, plant species and their number, GBH, tree height, terrain, vegetation type and canopy cover was measured. Importance Value Index generated to assess the ecological value of a species with respect to the community structure (Muller Dombois and Ellenberg, 1974 and Roy *et al.*, 1993). The purpose of measuring community diversity was to judge its relationship with either to community properties or to the environmental conditions to which the community was exposed. Krebs (1989) has illustrated the importance and measurement of vegetation diversity indices. Canopy cover was measured with the help of GRS densiometer. Both twinspan i.e. two-way indicator species analysis (Hill, 1979) or cluster analysis (Norussis, 1994) are used to classify the vegetation community of study area of North Kheri forest division. Numbers of other techniques are in practice for the quantification of vegetation especially for the measurement for diversity indices in the various part of the world. (Pielou, 1975., Pielou, 1988., McIntosh, 1967., Magurran, 1988., Hill, 1973 and Inouye, 1998). Vegetation analysis of woody species was done for Chakrata Himalayas by Singhal *et al.*, (1986). Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India was studied by Swamy *et al.* (2000).

Similarly for shrubs quantification, shrubs numbers, height and cover were recorded. Since grasses are highly significant for rhino, hence grasses were quantified using a cross of 5 m length from the centre. Grass species and their height were recorded at distance of 20 cm interval of the 5 m rope of cross in all four directions. In total 100 points were taken in a quadrat for grass abundance.

Clustering of tree using Ward method revealed that *Shorea robusta*, *Tectona grandis*, *Mallotus philipensis*, *Tectona grandis*, *Bombax ceiba* and *Buchanania lanzan* showed close association to each other (Figure 5)

Results

Most abundant tree species in proposed rhino area was *Tectona grandis* (26) followed by *Shorea robusta* (14.4), *Bombax ceiba* (8) and *Mallotus philipensis* (5.36). Whereas density of tree per hectare was estimated highest for *Shorea robusta* (95.54) followed by *Mallotus philipensis* (33.17), *Tectona grandis* (23.0), *Millusa tomentosa* (15.92) (Table 11).

Shrub abundance:

Most abundant species of shrub, *Clerodendron viscosum*, estimated with 5357.81 plants per hectare. Species with high density were *Glycosmis pentaphylla*, *Tamarix dioica* and *Shorea robusta* with 547.02, 224.8, 1483.7 per hectare and *Tiliacora acuminata* (a climber), 5245.41 per hectare respectively (Table 12). *Tiliacora* has encroached most of the woodland areas and becomes a weed in the forest and a very strong physical barrier in the free movement of wild animals.

Herb/grasses abundance:

Altogether 11 species of grasses were recorded from proposed area of Dudhwa NP. Most abundant species was *Desmostachya bipinnata* (18.8%), followed by *Themeda arundinacea* (15.1%), *Saccharum bengalense* (12.9), and *Saccharum fuscum* (12.2%). About 13.3 percent land was bare without any herb or grasses (Table 13).

Height profile of grasses varies between 3-620 cm. Grass species like *Saccharum bengalense* have the maximum height (280.29 cm) followed by *Themeda arundinacea* (254.54), *Saccharum fuscum* (252.9) and *Saccharum spontaneum* (197.7). Reason behind the great height was that grasses were at the maturation and flowering stage where grasses already achieved its maximum growth as height is concerned. Mean height of grass was 184.6 ± 91.04 cm (SD) (Table 14). One of the major reasons in gaining the maximum height of grasses is because of the location of the area and restricted to any type of removal as well as any type of anthropogenic pressure like regular grazing by large number of livestock and irregular burning of grassland.

Only 6 species of herb/grass were recorded in the woodland of proposed area. *Imperata cylindrica* was most abundant followed by *Desmostachya bipinnata*, *Ageratum conizoides* and *Capillipedian assimile* grass species (Table 15).

The mean height of herb/grass ranges between 5-150 cm. *Bothriochloa intermedia* with a maximum mean height (95 cm) followed by *Desmostachya bipinnata* (90), *Imperata cylindrica* (80 cm), and *Capillipedian assimile* (80) (Table 16). Mean height of grass was 55.8 ± 47.11 cm.

Figure 1. Hierarchical cluster analysis of tree vegetation of proposed area of rhino translocation in Dudhwa NP

Dendrogram using Ward Method

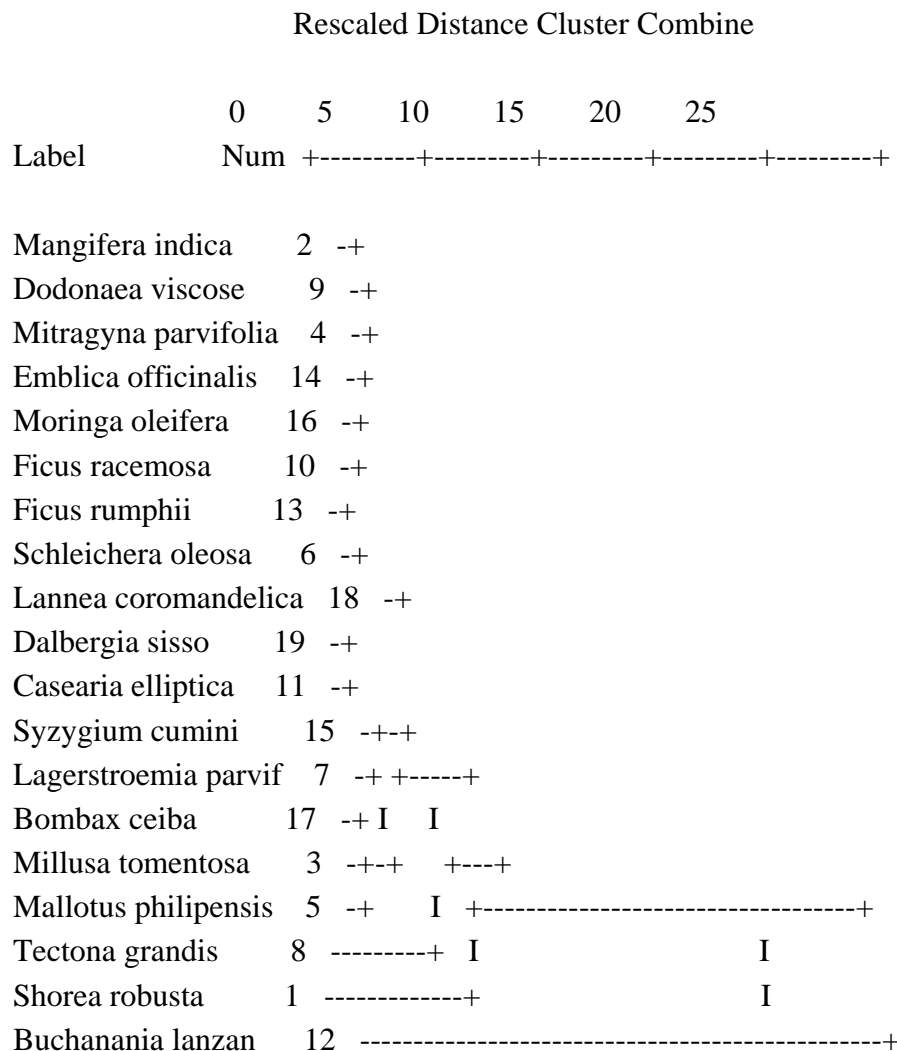


Table 1. Tree density in the proposed Rhino area in Dudhwa NP

Species	Frequency	No. Of plant	Abundance	Mean	SD	Density/ha
<i>Shorea robusta</i>	15	216	14.40	12.71	8.32	95.54
<i>Mangifera indica</i>	1	1	1.00	0.06	0.24	0.44
<i>Millusa tomentosa</i>	7	36	5.14	2.12	5.11	15.92
<i>Mitragyna parvifolia</i>	1	2	2.00	0.12	0.49	0.88
<i>Mallotus philipensis</i>	14	75	5.36	4.41	3.48	33.17
<i>Schleichera oleosa</i>	5	7	1.40	0.41	0.80	3.10
<i>Lagerstroemia parviflora</i>	7	14	2.00	0.82	1.33	6.19
<i>Tectona grandis</i>	2	52	26.00	3.06	12.36	23.00
<i>Dodonaea viscosa</i>	1	1	1.00	0.06	0.24	0.44
<i>Ficus racemosa</i>	1	1	1.00	0.06	0.24	0.44
<i>Casearia elliptica</i>	3	4	1.33	0.24	0.56	1.77
<i>Buchanania lanzan</i>	5	17	3.40	1.00	2.89	7.52
<i>Ficus rumphii</i>	1	1	1.00	0.06	0.24	0.44
<i>Emblica officinalis</i>	1	1	1.00	0.06	0.24	0.44
<i>Syzygium cumini</i>	2	6	3.00	0.35	1.06	2.65
<i>Moringa oleifera</i>	1	1	1.00	0.06	0.24	0.44
<i>Bombax ceiba</i>	1	8	8.00	0.47	1.94	3.54
<i>Lannea coromandelica</i>	1	2	2.00	0.12	0.49	0.88
<i>Dalbergia sisso</i>	1	3	3.00	0.18	0.73	1.33

Table .2. Shrub density in the proposed Rhino area in Dudhwa NP

Species	Frequency	No of plant	Abundance	SD	Density/ha
<i>Lagerstroemia parviflora</i>	8	16	2.00	1.93	119.90
<i>aegle marmelos</i>	1	7	7.00	.	52.45
<i>Glycosmis pentaphylla</i>	8	73	9.13	5.44	547.02
<i>Grewia sp.</i>	1	8	8.00	.	59.95
<i>Clerodendron viscosum</i>	16	715	44.69	52.03	5357.81
<i>Nyctanthes arbortristis</i>	1	3	3.00	.	22.48
<i>Casearia elliptica</i>	9	27	3.00	1.58	202.32
<i>Desmodiumppulchellum</i>	2	7	3.50	2.12	52.45
<i>Bridelia verrucosa</i>	3	30	10.00	3.61	224.80
<i>Syzygium cumini</i>	3	8	2.67	1.53	59.95
<i>Millusa tomentosa</i>	5	26	5.20	3.70	194.83
<i>Schleichera oleosa</i>	1	1	1.00	.	7.49
<i>Mangifera indica</i>	1	18	18.00	.	134.88
<i>Litsea sp.</i>	1	2	2.00	.	14.99
<i>Murraya koenigii</i>	1	3	3.00	.	22.48
<i>Flacourtia indica</i>	1	2	2.00	.	14.99

<i>Tiliacora acuminata</i>	15	700	46.67	31.87	5245.41
<i>Mallotus philipensis</i>	5	30	6.00	1.87	224.80
<i>Shorea robusta</i>	13	198	15.23	15.22	1483.70
<i>Rauvolfia serpentina</i>	1	1	1.00	.	7.49
Total	96	1875	19.53	30.93	14050.21

Table .3. Herb density in the proposed Rhino area in Dudhwa NP

SPECIES	Frequency	No. of plants	Abundance	Density /ha	Mini	Maxi	SD
<i>Capillipedian assimile</i>	1	4	4	749.34	4	4	.
<i>Ageratum conizoides</i>	1	14	14	2622.71	14	14	.
<i>Desmostachya bipinata</i>	7	152	21.714	28475.08	5	48	18.00
<i>Imperata cylindrica</i>	6	270	45	50580.74	5	88	35.09
<i>Aiserna scadia</i>	1	1	1	187.34	1	1	.
<i>Bothriochloa intermedia</i>	2	6	3	1124.02	2	4	1.41
Total	25	447	17.88	83739.23	0	88	25.65

Table.4. Height profile in the proposed Rhino area in Dudhwa NP

SPECIES	Frequency	No. of plants	Mean height (cm)	Minimum height (cm)	Maximum height (cm)	SD
<i>Capillipedian assimile</i>	1	80	80	80	80	.
<i>Ageratum conizoides</i>	1	5	5	5	5	.
<i>Desmostachya bipinata</i>	7	630	90	50	150	33.66
<i>Imperata cylindrica</i>	6	480	80	30	110	30.33
<i>Aiserna scadia</i>	1	10	10	10	10	.
<i>Bothriochloa intermedia</i>	2	190	95	90	100	7.071
Total	25	1395	55.8	0	150	47.11

Table .5. Grass abundance in the proposed Rhino area in Dudhwa NP

Species	Frequency	Percent
Bare land		
106	13.3	13.3
<i>Vicia sativa</i>		
2	.3	13.6
<i>Cyperus sp.</i>		
1	.1	13.7
<i>Capillipedianassimile</i>		
68	8.5	22.2
<i>Saccharum spontaneum</i>		
53	6.6	28.9
<i>Vetiveria zizanioides</i>		
47	5.9	34.8
<i>Desmostachya bipinnata</i>		
150	18.8	53.6
<i>Imperata cylindrica</i>		
24	3.0	56.6
<i>Saccharum fuscum</i>		
97	12.2	68.8
<i>Bothriochloa intermedia</i>		
21	2.6	71.4
<i>Saccharum bengalense</i>		
103	12.9	84.3
<i>Trifolium indicum</i>		
5	.6	84.9
<i>Themeda arundinacea</i>		
120	15.1	100.0
Total		
797	100.0	

Table .6. Height profile of grasses proposed Rhino area in Dudhwa NP

Species	Frequency	Mean height (cm)	Minimum height (cm)	Maximum height (cm)	SD
Bare land	106	0	0	0	0
<i>Vicia sativa</i>	2	67.5	65	70	3.54
<i>Cyperus sp.</i>	1	190	190	190	.
<i>Capillipedianassimile</i>	68	164.04	40	320	71.2
<i>Saccharum spontaneum</i>	53	197.74	100	320	52.61
<i>Vetiveria zizanioides</i>	47	166.6	75	320	58.03
<i>Desmostachya bipinnata</i>	150	181.27	0	320	47.59
<i>Imperata cylindrica</i>	24	83.75	20	240	56.78
<i>Saccharum fuscum</i>	97	252.99	120	410	57.06
<i>Bothriochloa intermedia</i>	21	198.57	140	270	36.92
<i>Saccharum bengalense</i>	103	280.29	40	620	125.99
<i>Trifolium indicum</i>	5	4.2	3	5	1.1
<i>Themeda arundinacea</i>	120	254.54	110	610	102.7
Total	797	184.61	0	620	114.05

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