

Compensatory Afforestation in Rajasthan

An Evaluation



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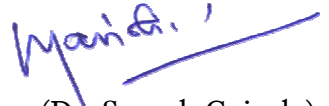
FOREWORD

It gives me immense pleasure to write about the CAMPA evaluation work carried out by Arid Forest Research Institute, Jodhpur. State Forest Department, Government of Rajasthan, Jaipur has carried out large scale afforestation and reforestation works since long. So far 1079 plantation and asset sites have been developed during 2010-14 under CAMPA Fund. The evaluation work carried out by AFRI was based on random selection of 242 sites. These 242 sites were assessed for the effective implementation of the activities, adherence to the guidelines provided in the project document and the field performance. Present document provides suggestions, based on the observations, the areas of improvement and action to be taken for future programmes.

The huge task of evaluating 242 sites involves 156 assets and 86 plantation sites covering 3800.7 ha area under different plantation models. This work encompasses a wide range of countenances like soil and water conservation measures, protections, people participation, survival and growth of plantation adopting effective methods of monitoring and evaluation. The outcome of the assessment on survival and growth of the planted seedlings, seed sowing and naturally occurring species based on their performance (due to years of plantation/seed sowing, models adopted under plantations and field sites) appears very useful for reaching to a logical conclusion on factors responsible for success or failure of a plantation. Likewise, geo-tagging of the assets and plantation sites, boundary delineation of planted area and offering

qualitative scoring of the plantation as well as the assets created would help the field practitioners to access the sites to ascertain the quality for future remediation, if any.

This publication '**Compensatory Afforestation in Rajasthan**' provides list of most adapted species of trees and shrubs suitable for plantation in dry climates and suggestive course of actions for further improvements and remedial measures. I hope this evaluation work would be useful in more effective planning and implementations of future programmes on afforestation/reforestation for increasing green cover, sequestering carbon and addressing societal benefits.



(Dr. Suresh Gairola)
Director General

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PREFACE

Afforestation projects in general have positive impact on both biophysical and socioeconomic environment and contribute to the sustainability in the region. However, non-achieving of the desired results despite of implementation of several afforestation programmes in India and abroad are matter of concerns on effective implementation and adherence to the guidelines provided in a project document. There is growing recognition among the field practitioners and researchers that good project management is integrally linked to a well-designed monitoring and evaluation (M & E) system. M & E is a process that helps improve performance and achieve better results and is thought that good management goes beyond implementation. Monitoring and evaluation not only answers questions related to how well a project or strategy is working and identifies the conditions under which an action is likely to succeed but also serve as an early warning system for potential problems and lead to ideas for potential remedial actions. This helps in distilling some important lessons and improves decision making process.

Under CAMPA fund afforestation/ reforestation and asset developments works have been carried by the State Forest Department (SFD), Rajasthan at 1079 sites. A total of 18373 ha area were planted during 2011-14 following Non-Forest Lands, Degraded Forest Lands and Assisted Natural Regeneration plantation models. Monitoring and evaluation division of Rajasthan State Forest Department, Rajasthan funded a project **‘Evaluation of forest protection, management and developmental activities under Compensatory Afforestation and Management Authority in Rajasthan’** to *Arid Forest Research Institute, Jodhpur (AFRI)* to evaluate and present an assessment evaluation report on the CAMPA work carried out in Rajasthan. Evaluation of randomly selected 156 assets and 86 plantation sites throughout Rajasthan were done during November 2016 to June 2017. Care was also taken regarding proper representation of types of assets and plantations (3800.7 ha area). This work is divided into 6 chapters. First chapter describes general physiography, climatic conditions and socio-economic profiles including land uses in Rajasthan. Second chapter discusses the methods of data collection, analysis, interpretation and limitations. Results and finding on the overall assessment of record keeping and maintenance, types of protection measures and people involvement, various types of soil and water conservation measures adopted and

different types of assets created are provided in chapter 3, whereas survival and growth performance of different species used under plantation and seed sowing as well as natural vegetation growing either inside or outside of the plantation area under ANR model are presented in Chapter 4. The fifth and sixth chapters cover conclusion and recommendations and bibliography.

This publication has only been possible with financial support of Rajasthan Forest Department, Government of Rajasthan, for this we are grateful. We would also like to thank staff of forest department for their field supports in successful completion of field evaluation work. For field data recording, compilation and report preparation all staff of AFRI and division of Forest Ecology and Climate Change Division in particular are gratefully acknowledged. We shall not justify, if not mentioned the name of Sh. C.S. Ratnalaxmi, PCCF, Sh. A.K. Goyal, Ex PCCF, Rajasthan, Sh. Indraj Singh, Addl. PCCF (M & E), Sh. R.K. Tyagi and Dr. O.P. Singh, Ex Addl PCCF (M & E), Dr. D.N. Pandey, Addl. PCCF (CAMPA), Sh. T.C. Verma, CF (M & E) and Sh. P.S. Shekhawat, DCF (M & E), Department of Forest, Government of Rajasthan for their dynamical supports in completing this huge task. Last but not the least, we would also like to thank Sh. N.K. Vasu, Ex Director, AFRI for his keen interest and involvement since inception of this project leading to its successful execution and completion, and Dr. I.D. Arya, Director, AFRI for his support of varying forms.

This study report will help in effective planning for soil and water conservation measures, use of quality seedlings of best fitting species for enhanced plantation survival and growth. Proper maintenance of the plantation related records for learning from the past will assist in conserving and enriching the degraded forest with effective participation of village communities and promoting their ecological value with rural livelihood benefits.

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Acronyms

ACZ	:	Agro-Climatic Zone
Addl. PCCF	:	Additional Principal Chief Conservator of forests
AFRI	:	Arid Forest Research Institute
ANR	:	Assisted Natural Regeneration
BSI	:	Botanical Survey of India
BCM	:	Billion Cubic Meter
cm	:	Centimeter
CAMPA	:	Compensatory Afforestation Fund Management and Planning Authority
CA	:	Compensatory Afforestation
CAF	:	Compensatory Afforestation Fund
CO ₂	:	Carbon dioxide
CD	:	Collar Diameter
°C	:	Degree Centigrade
%	:	Per cent
DCF	:	Deputy Conservator of Forests
DFL	:	Degraded Forest Lands
DFO	:	Divisional Forest Officer
EDC's	:	Eco-Development Unit
FRE	:	Forest Research Expenditure
FAO	:	Food and Agriculture Organization
FGC	:	Forest Guard Chowki
FSI	:	Forest Survey of India
Fig	:	Figure
FC	:	Forest Conservation
g	:	gram
GIS	:	Geographic Information System
GOI	:	Government of India
GoR	:	Government of Rajasthan
GPS	:	Global Positioning System
ha	:	Hectare
HDI	:	Human Development Index

H. Q.	:	Head Quarter
ICAR	:	Indian Council of Agriculture Research
INR	:	Indian Rupee
IPCC	:	Intergovernmental Panel on Climate Change
IUCN	:	International Union for Conservation of Nature
JFM	:	Joint Forest Management
km	:	Kilometer
mm	:	Milimeter
MoA	:	Ministry of Agriculture
MOU	:	Memorandum of Understanding
msl	:	Mean Sea Level
LSD	:	Loose Stone Checkdams
LSW	:	Loose Stone Wall
MB	:	Measurement Book
MoEF	:	Ministry of Environment and Forests
NFL	:	Non-forest land
NGO	:	Non Governmental organization
R.O.	:	Research Officer
RMT	:	Running Meter
NTFP	:	Non Timber Forest Produces
PET	:	Potential Evapo-Transpiration
PF	:	Protected forest
POL	:	Petrol Oil and Lubricant
Pop	:	Population
RFS	:	Rajasthan Forest Statistics
RFO	:	Range Forest Officer/Office
RF	:	Reserve Forest
RMT	:	Running Meter
SD	:	Standard Deviation
SFD	:	State Forest Department
SMC	:	Soil Moisture Conservation
Sq	:	Square
SOC	:	Soil organic carbon
SFR	:	State of Forest Reports
TGA	:	Total geographical area
VFPMC	:	Village Forest Protection & Management Committee

Executive Summary

Compensatory Afforestation Fund Management and Planning Authority (CAMPA) or Compensatory Afforestation is promotion of afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses. The prime task of State's CAMPA is regenerating natural forests and building up of the institution engaged in this task focusing on to promote (i) Conservation, protection, regeneration and management of existing natural forests; (ii) Conservation, protection and management of wildlife and its habitat within and outside protected areas including the consolidation of the protected areas; (iii) Compensatory afforestation; (iv) Environmental services. Rajasthan Forest Department have implemented CAMPA programme by carrying out wide range of activities for this purpose. For evaluation of effectiveness and impacts of different activities and the works under CAMPA programme and the impact of these works activities carried out during 2010-14, a project "Evaluation of forest protection, management and developmental activities under Compensatory Afforestation and Management Authority in Rajasthan" was funded to Arid Forest Research Institute, Jodhpur. This was (i) to evaluate the performance of different plantation models in different locations; (ii) to record and valuate percent survival and growth of the planted species; (iii) to verify documents, records and assets created under the programme; (iv) to verify and validate water conservation structures and eco- restoration closures and their impacts; and (v) to suggest areas of improvement and action to be taken.

Various activities carried out under CAMPA of Rajasthan Forest Department were evaluated during November 2016 to June 2017, wherein 86 plantation sites and 156 assets were measured and verified. Evaluation sites were randomly selected from 385 plantation sites in 28 districts and 705 assets distributed in 31 districts of Rajasthan. Each site was geo-tagged, whereas the boundaries of the evaluated plantations sites were demarcated for easy access and verification whenever required. Total 3800.7 ha area planted during 2011-12, 2012-13 and 2013-14 under non-forest land (NFL), degraded forest land (DFL) and Assisted Natural Regeneration (ANR) models and distributed in 86 plantation sites were evaluated and assessed. Among the assets, 19 Anicut type II, 18 Anicut type III, 5 Arboretums, 25 sites of boundary pillars, 39 sites of boundary walls (one 12' height, twenty five 4' height and thirteen 6' height), 29 forest Chowki, 14 Range Forest Office and 7 Rescue Centres were verified. Different activities at plantation sites included plantation and seed sowing of different species of trees, shrubs and grasses, fencing of the area, entry gate, temporary hut for watch and ward and water tank etc, site signage like board, and soil and water conservation measures like contour trench, V-ditch, Gradonie ditch, Contour dykes, loose stone check dams etc., for

reducing run-off losses and improving soil moisture regime for improved seedling growth and plantation establishment.

Out of eighty six plantation sites, Bhir in Talara Range of Sawaimadhopur and Tarunda area in Sariska Range of Alwar forest division had no sign of plantation activities. Samlipathar site in Chittorgarh has been converted to DFL model in place of ANR model. Temporary hut, entry gate, signboard and water storage tanks were observed only at 5.8%, 39.5%, 59.3% and 5.8% of the evaluated site respectively. Micro-plans, site map and Estimates and Treatment note were verified for about 91% sites. Likewise, plantation journal, VFPMC Records and Measurement book were available and verified for about 98% sites. Measured plantation areas for most of the sites were observed larger in size as compared to the reported ones.

A total 1651974 seedlings of 57 plus species were monitored and verified. Most commonly used species under plantations were *Acacia tortilis* (18.90%), *A. catechu* (11.55%), *Z. mauritiana* (10.84%), *A. leucophloea* (9.60%), *A. nilotica* (8.49%), *Dendrocalamus strictus* (8.24%), *A. senegal* (6.02%), *A. indica* (2.94%), *Albizia lebbeck*, *Gmelina arborea*, *P. pinnata*, *P. cineraria*, *C. wightii*, *H. integrifolia*, *Bombax ceiba*, *T. indica*, *S. oleoides*, *E. officinalis*, *B. monosperma*, *Ficus religiosa*, *D. sissoo*, *Cassia fistula* etc. Contributions of *P. cineraria* and *T. undulata* seedlings in total plantations were only 0.33% and 0.46%, respectively. About 28%, 50% and 22% seedlings were used in NFL, DFL and ANR plantation models. Most frequently used species was *Z. mauritiana* followed by *H. integrifolia*, *A. leucophloea* and *A. indica*. There were 16 species planted at >10 sites, 12 species at 5-10 sites, 11 species at 2-4 sites and 18 species at one site. *Prosopis cineraria* and *T. undulata* have been used at 7 and 6 sites, respectively. Under seed sowing, 26 species of trees and shrub have been used along contour trenches, V-ditches, ditch fencing etc., wherein *Acacia senegal*, *A. leucophloea* and *A. catechu* were used at 69.8% sites, 33.7% sites and 30.2% sites, respectively.

Most of the assets developed at different locations are good to very good in quality of construction and place of establishment sites except some boundary walls and arboretums. Most of the structures are useful and are being utilised effectively, though some structures are not at all up to the expectations and unfinished. For example conditions of arboretum appeared poor for most of the sites and some boundary walls have been observed in damaged condition and are not effective in protecting the area. Though most of the water harvesting or storage structures constructed have been found suitable, but constructions in name of Anicut type II and III appears confusing as they vary from place to place. About 14% structures have been observed in poor condition.

Barbed wire (8.1% site), loose stone wall (64.0% site), ditch (62.8% site), masonry wall (1.2% site) fencing and their combinations have been used in protecting the plantation area depending upon the terrain conditions and availability of the fencing materials. Quality of protection measures have been observed poor in about 14% site and good in rest sites. Social fencing has not been observed at any site and people participation has been observed limited

to labour works. Most of the plantation sites showed biotic interference. However, protection measures adopted to protect the plantation had facilitated regeneration of many other indigenous species too hence helped conserve biodiversity at many sites.

Overall survival of plantation under CAMPA is 49.37% in Rajasthan. There were <10%, 10-20% and 20-30% survival at 5 site each and 30-40% survival at 12 sites. About 46% sites are in the category of <50% survival, whereas 35.8% and 17.9% sites are in 50-70% and 70-95% survival range, respectively. ANR, NFL and DFL plantation models showed 45.47%, 60.37% and 49.2% survival. Jodhpur, Jaisalmer and Bikaner –the desert districts, showed better survival than other areas under NFL. *Bauhinia variegata*, *M. azedarach*, *Neolamarkiana kadamba* and *Sterculia urens* did not survive. Only 16 species showed >49.27% survival. *T. arjuna*, *S. cumini*, *Mitragyna parvifolia*, *B. ceiba*, *Madhuca indica* etc., showed poor survival; whereas species showing >49.4% survival were *A. catechu*, *A. senegal*, *A. tortilis*, *Ailanthus excelsa*, *Azadirachta indica*, *Anogeissus pendula*, *B. monosperma*, *Commiphora wightii*, *Cordia gharaf*, *D. strictus*, *F. benghalensis*, *Manilkara hexandra*, *Moringa oleifera*, *W. tinctoria* and *Z. mauritiana*. Plantation of 2011 showed 42.01% survival, whereas the plantations of 2012 and 2013 showed 25.2% and 55.53% survival, respectively. Species with lesser numbers of planted seedlings performed better.

Height and collar diameter were highest for 2011 (199.2 cm and 2.2 cm) and lowest in 2013 (179.0 cm and 1.7 cm respectively) and showed very high inter - and intra species as well as site variations. Respective variables among the species varied from 22.3 cm for *S. oleoides* to 445.0 cm for *A. marmelos*, and from 0.8 cm for *S. oleoides* to 5.7 cm for *Acacia nilotica*. *Acacia catechu*, *A. nilotica*, *A. tortilis*, *Annona squamosa*, *Azadirachta indica*, *Cassia fistula*, *Embllica officinalis*, *G. arborea*, *H. integrifolia*, *Pongamia pinnata*, *Tamarindus indica*, *Terminalia bellirica*, *Wrightia tinctoria* and *Ziziphus mauritiana* are the best performing species in these plantations.

Average height and collar diameter of the plantation were 179.1 cm (22.3 cm for *S. oleoides* to 380.0 for *Tamarindus indica*) and 2.3 cm (0.70 cm for *P. cineraria* to 8.4 cm for *Ailanthus excelsa*) under ANR, 195.8 cm (41.3 cm for *T. undulata* to 359 cm for *Cassia fistula*) and 1.9 cm (0.60 cm for *T. undulata* to 3.6 cm for *Tectona grandis*) under DFL, and 171.1 cm (21.2 cm for *E. officinalis* and 422.0 cm for *Dalbergia sissoo*) and 2.6 cm (0.80 cm for *Mitragyna parviflora* to 5.20 cm for *Acacia nilotica*) under NFL plantation model. Relatively better performing species are *A. nilotica*, *A. leucophloea*, *A. tortilis*, *Ailanthus excelsa*, *Annona squamosa*, *Azadirachta indica*, *B. monosperma*, *C. fistula*, *G. arborea*, *N. arbore-tristis*, *P. dulce*, *T. indica*, *T. bellirica* and *W. tinctoria* under ANR model; *A. catechu*, *Aegle marmelos*, *A. excelsa*, *A. lebbeck*, *A. squamosa*, *A. indica*, *B. ceiba*, *C. fistula*, *G. arborea*, *M. indica*, *M. oleifera*, *P. pinnata*, *S. cumini*, *T. indica*, *T. grandis*, *T. bellirica*, *W. tinctoria* and *Z. mauritiana* under DFL model; and *A. catechu*, *A. nilotica*, *A. tortilis*, *A. excelsa*, *A. procera*, *A. indica*, *C. fistula*, *D. sissoo*, *H. integrifolia*, *P. pinnata* and *Z. mauritiana* under NFL plantation model.

Twenty six species have been used under seed sowing and *A. senegal* was most frequently used species followed by *A. leucophloea*, *A. catechu*, *Jatropha curcas*, *Z. mauritiana*, *Azadirachta indica*, *Acacia nilotica* etc. Average population was 100.4 plants per ha (379.0 plant per ha at Manakchowk in Baran to 6.0 plants per ha at Pooranabhursidh in Alwar division). About 44.6% site indicated above average population. *Acacia senegal* showed highest population. Average height and collar diameter were 79.3 cm and 1.77 cm respectively. Population was 27.2 plants per ha under NFL, 24.6 plants per ha under DFL and 21.6 plants per ha under ANR models. Plants were tallest under NFL (113.3 cm) and shortest under ANR plantation (89.5 cm) model, whereas collar diameter was in the order: ANR<DFL<NFL plantation. Average population of seed germinated plants varied between 20.2 plants per ha for 2011 and 25.8 plants per ha for 2013. Height and collar diameter were greater for the plants germinated from 2013 and 2011 seed sowing, respectively, whereas the least growths were observed for the plants of 2012. *A. senegal*, *Acacia catechu*, *A. nilotica*, *A. tortilis*, *Aegle marmelos*, *Butea monosperma*, *J. curcas* and *Z. mauritiana* are the best performing species under seed sowing

Various soil and water conservation measures included contour trench, V-ditch, Gradonie ditch, earthen Checkdams, Loose Stone Check dams etc., but most of these measures have been filled up with the transported soils. Earthen checkdams or LSDs constructed under drainage line treatment were observed damaged or have been washed out under excess run-off. However, plantations coupled with soil moisture conservation work helped improve soil water and conserve some indigenous species growing in the area as indicated by higher population of trees and shrubs species inside plantation area. Species richness ranged between 2 to 14 numbers of species at different ANR sites. There were 20 trees and 23 species of shrubs were recorded at 39 ANR sites. Most frequent species was *A. leucophloea* (54.1% sites) followed by *B. monosperma*, *A. pendula*, *Z. nummularia*, *A. senegal*, *P. juliflora* (32.4% site), *A. nilotica*, *A. tortilis*, *B. aegyptiaca*, *A. indica*, *H. integrifolia*, *D. melanoxylon*, *Prosopis cineraria*, *M. emarginata* (13.5% site) etc. However, Rohal Undvela site in Banswara, Dadhimata site in Bhilwara, Tiliwara (Ghata) site in Dausa, Ratapani C.No.19 site in Dungarpur, Beriganga site in Jodhpur, Sawan-Bhado I site in Kota and Bhir site in Sawai Madhpur division indicated greater species richness outside of the plantation than the plantation area. Height and collar diameter of shrubs and trees growing inside plantation area were 122.4 cm and 4.13 cm, and 221.4 cm and 6.02 cm, respectively. For unplanted area, average height and collar diameter for shrubs and trees were 125.1 cm and 4.02 cm, and 286.6 cm and 7.20 cm respectively.

Despite of many associated problems like invasion by *Prosopis juliflora* or *Lantana camara*, increased biotic pressures and intrusion of animals in plantation area, problems in species selection, unawareness of the staff about plantation activities and environmental and soil conditions affecting growth and survival, overall performance of the plantation under CAMPA appears good by scoring 5.82 values out of 10. Alwar, Banswara, Bharatpur, Baran, Bikaner, Dausa, Dholpur, Dungarpur, Jaipur, Jhunjhunu, Jhalawar, Pratapgarh,

Rajsamand, Sikar, Sirohi, Mt Abu, Tonk and Udaipur showed above average plantation performance.

Considering the observation some suggestion and recommendations include: needs of capacity building of the local staff about record keeping and maintenance; maximization of forest block numbers under boundary wall mostly under 6 feet height and pillars erection; promotion of natural fencing (bio-fencing). Making provision of additional 20% fund under maintenance of walls or RWH structures; control of invasive species by effective protection of free roaming livestock dispersing seeds of *Prosopis juliflora*; adoption of soil and water conservation measures after assessing maximum and minimum quantity of run-off at the site; putting emphasis on selecting suitable species under plantation and seed sowing and use of quality planting materials; strengthening of VFPMC's in protecting and conserving the forest areas; effective management of above-and below ground resources under ANR/DFL models; promotions of grass seed sowing in dry areas or degraded hills areas to enhance fodder availability and thus reducing livestock pressures on the other vegetations.

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