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# National Agricultural Innovation Project

The National Agricultural Innovation Project (NAIP), jointly funded by the World Bank (WB) and Government of India (GoI), was implemented by the Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education (DARE), Ministry of Agriculture, GoI. The Project outlay was USD 250 million (USD 200 million by the WB credit and USD 50 million from GoI). Besides, a grant of USD 7.34 million was approved by the Global Environmental Facility (GEF) under the Sustainable Land and Ecosystem Management Country Partnership Programme (SLEM CPP). The NAIP became operational on September 18, 2006 and with an extension of 18 months, it concluded on June 30, 2014.

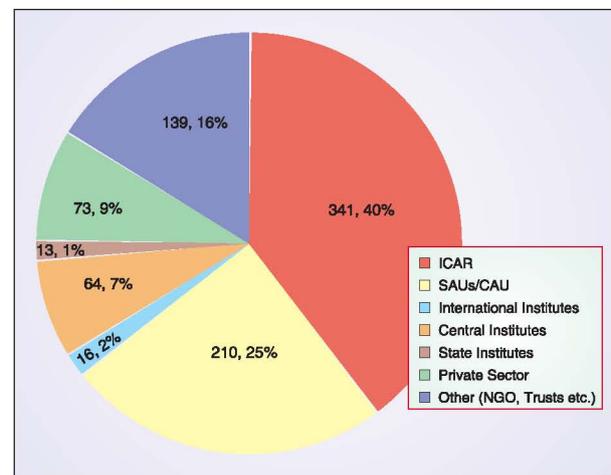
The overall objective of the Project was to facilitate an accelerated and sustainable transformation of Indian agriculture so to support poverty alleviation and income generation through collaborative development and application of agricultural innovations by public organizations in partnership with farmers' groups, private sector and other stakeholders. The Project was implemented through four components—ICAR as a catalyst in management of change in Indian NARES (Component-1), research on production to consumption system through value-chains approach (Component-2); research on sustainable rural livelihood security including sustainable land and ecosystem management (Component-3); and basic and strategic research in frontier areas of agricultural sciences (Component-4).

The ICAR has successfully established pluralism in agricultural research through the NAIP with stronger bonds among unconventional research partners. This was considered necessary to harness complementary synergies and strengths in agricultural research and first-line extension. Under the NAIP, many new changes were successfully introduced, and the ICAR has considered many new initiatives to internalize, sustain and promote successful innovations.

**Innovations ushered:** The important innovations NAIP ushered into the system are: (i) scenario planning with full involvement of clients, (ii) consortia mode to promote pluralism in the design and implementation of research projects, (iii) public–private partnership in research, (iv) competitive selection of subprojects, (v) delegation of powers to consortia, (vi) human capacity development in critical areas of science and cutting-edge research, (vii) business planning and development through incubation and technology commercialization, (viii) ICT applications in agricultural research and education, (ix) multilevel support and monitoring, (x) development and application of value-chain models in agriculture, (xi) integrated farming

systems approach for livelihood improvement in disadvantaged regions of the country, (xii) social inclusion and participatory approach, (xiii) upscaling competitive research capacity in frontier areas of agricultural science, (xiv) inculcating fiduciary experience in research management through specialized finance, procurement, administrative, monitoring and evaluation systems, (xv) emphasis on post-project sustainability and (xvi) cross learnings.

The Project was implemented through 203 subprojects, and 856 consortia partners from the ICAR Institutes (40.89%), State Agricultural Universities (24.53%), Central Universities and Organizations (9.11%), State Universities and Organizations (4.44%), CGIAR Centres (1.87%), Private Industries (8.53%) and Non-Government Organizations (10.63%). This is for the first time in the history of Indian agriculture that such diversified groups of partners have worked together under one project. The non-NARES private sector and NGO partners were mostly involved in value-chain development and rural livelihood security enhancement in disadvantaged districts. They facilitated social mobilization, technology dissemination and market linkages.



Partners under the NAIP

Thus, in partnership with industries and entrepreneurs, the Project supported private sector led growth and poverty reduction by strengthening innovative agricultural research and development. The Project provided a market orientation by innovatively engaging entrepreneurs and private sector to transfer technologies to farmers and by increasing employment opportunities in agricultural production and processing. The three Global Environment Facility (GEF) funded subprojects were also relevant in promoting sustainable agricultural development by addressing to climate change adaptation.



### Synergizing NAIP technologies with traditional art of Kalamkari Handblock Printing

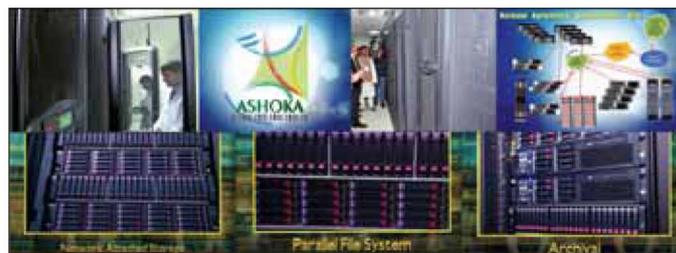
Business Planning and Development (BPD) Project at the National Academy of Agricultural Research Management (NAARM), Hyderabad, took an initiative in scouting suitable technologies to develop traditional art of Kalamkari. The “Geographical Indication” grant from GI registry received on July 24, 2013 by the Vegetable Hand Block Kalamkari Printers Welfare Association for “Machilipatnam Kalamkari Art” at GI awareness event at the NAARM paved the way for request by the Association for the support for the new technologies with natural dyes towards value addition. Modern phyto-based dyeing technologies, generated from the National Agricultural Innovation Project (NAIP) – Value Chain in Natural Dyes (VCND) project at the Department of Home Science, Acharya N G Ranga Agricultural University (ANGRAU), Hyderabad, were identified for transfer. The work under BPD project facilitated the customization of these technologies to the specific needs suiting to local ecosystem of this traditional art of Kalamkari. Technologies for five new colours, their extraction techniques, and the entire methodology were enabled to five master art craftsmen in the Kalamkari group. The trained artisans along with 30 more workers were part of an on-site training. An *end-to-end transfer* of modern technologies was facilitated to solve a long felt gap by the artisans. In the process, technology from a developer from the NARES could reach the targeted technology seeker like Vegetable Hand Block Kalamkari Printers Welfare Association (artisan’s association).

The feedback from technology seeker indicated that this technology transfer has enhanced opportunities for better visibility of Kalamkari art with new dyeing and printing techniques. Skill Development Programme facilitated through the project gave a new approach to the process; by adopting new techniques that save time and money. Thus, enhancement of value addition to the product and enhanced marketability on a par with the present trendy designs were facilitated under the project. It is expected that this linkage will go a long way for fostering innovation and entrepreneurship for this 15th century traditional art in rural Andhra Pradesh and lead them to business avenues like FAB India and National Textile Programme.

### Research capacity build-up

The NAIP supported huge infrastructural development towards advanced research in frontier areas as well as on-farm facility. Some of the major facilities developed, that would go a long way in boosting basic and strategic research are as follows.

- ASHOKA, the first advanced super computing hub for OMICS Knowledge in Agriculture for biotechnological research, at the IASRI, New Delhi.
- A state-of-the-art infrastructure facility for conducting examination of ARS/NET at 23 nodal centres across the country with a question bank of 72,000 questions, covering 55 disciplines, has transformed on-site paper examination to online



ASHOKA — the first advanced super computing hub for OMICS knowledge in Agriculture

examination at the ASRB, resulting in quick declaration of results.

- Central Data Centre (CDC), based on the latest cutting-edge technology, with high speed internet connectivity for ICT based knowledge management and strengthening of communication outreach at the IASRI, New Delhi.
- Establishment of 15 pilot plants under value-chain for selected commodities.
- A state-of-the-art international biosafety compliant national referral laboratory for analysis of milk and milk products; established at the NDRI, Karnal.



Clean Room Facility at the NDRI, Karnal (*left*); insect-proof climate control bio-safe chambers (*middle*) and study on white-fly populations (*right*) at the IARI, New Delhi

- A huge genotyping and phenotyping facility for plant transgenics research at the NRCPB, New Delhi, along with a number of rain-shelters for phenotyping work at a number of partner locations.
- A pilot plant for production of biopesticides at the NBAIL, Bengaluru.
- A laboratory to investigate viral diseases of citrus and to train scientists and technical staff in plant virology, renovated at the NRCC, Nagpur.
- An insect-proof, controlled climate facility for research on white-fly at the IARI, New Delhi.
- A robust and flexible enterprise resource planning system for financial management, project management, material management, payroll & pension and human resource management is in the advance stage of implementation at the ICAR. The ERP system integrates organization’s all functions by allowing the modules to share and transfer information freely. The entire process provides real-time data from anywhere and anytime.
- The Priority setting, Monitoring and Evaluation (PME) has become an essential element of every project in the system. The PME Cells with guidelines regarding the constitution, functioning, financing and activities of the Cells have been internalized in every institute of the ICAR. The PME Cells under the Project have completed the assessment of 40 proven technologies for impact.



### Impact Assessment of International Trainings under L&CB Project

- A total of 487 scientists were deputed for international trainings under the NAIP programme.
- A three-dimensional framework was developed for integrating 'training impact assessment' into the training ecosystem for achieving training transfer and effectiveness. A sample survey of scientists trained abroad under the 'international training' revealed perceptible positive changes of the participants in terms of most of the impact and behavioural indicators.

These results were found to corroborate some of the findings from broader review undertaken by an external review committee from the PWC and IFPRI of the entire component of international training executed under the L&CB subproject of the NAIP.

- More than 1,900 NARES scientists benefitted from advanced technical trainings in frontier science such as genetic marker assisted selection, fermentation technology, nanotechnology, genome resource conservation, carbon trading, nutraceuticals and allele mining.

A total of 904 scientists participated in the international trainings, 21% of them were from SAUs. The impact assessment revealed a significant increase in the number of project proposals, technologies developed, patent applications, and publication of research papers in high-rating journals from among the participants.

### Commercialization of technologies

Beyond research partnerships through consortia, the Project actively engaged private partners in commercializing technologies developed under the NARES. A new system of technology incubation and commercialization under the business planning and development was established at 23 locations across the country. Its main aim was to promote agribusiness in the country through technology commercialization



Network of BPO Units under the NARES

and by nurturing innovations in the agriculture sector by providing incubation environment to start-ups. In a short span of four years, these BPD Units have played a significant role in making sustainable and lasting change in the way agricultural research is being conducted in the NARES. During Project implementation, BPD Units emerged as a vehicle to foster market orientation in the agriculture sector by giving incentives to supply-side of technologies and innovations.

These Units filed 331 licenses for commercial technologies and more than 186 patent applications. During four years, BPD Units provided consultancy by supporting 1,218 entrepreneurs in business incubation, 91 of them have initiated new agri-businesses. It is estimated that these agri-businesses with their products and services, have created almost 220,000 jobs, benefitting over 140,000 farmers. Four entrepreneurs won national awards for best incubators by the Network of Indian Agri-Business Incubators. Technologies generated under the NAIP were showcased at the national level through Agri-Tech Investors Meet in July 2013. More than 400 private entities and scientists participated in the Meet, where 58 technologies were commercialized to 80 licensees, which was worth ₹ 316.0 lakh. In less than five years, BPDUs generated a total of ₹ 2,468.84 lakh.

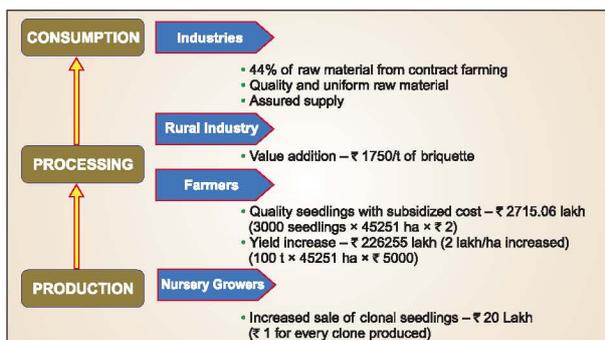
### Market sustainable value-chains

The NAIP aimed to help enhance potential value of agri-products, mobilize partnerships, contribute to optimum utilization of limited resources and enhance synergies among participating institutions. A total of 51 value-chains in nine thematic areas were conceptualized to strengthen weaker links in the chain to enhance productivity and profitability and to contribute to optimum utilization of limited resources. In all, 99 production and 173 processing technologies were developed and adopted, 70 public-private partnerships were formed, and 48 new rural industries were piloted. This Component focussed to develop market-sustainable agricultural value-chains. Private partnership was tried in a big way for the first time in the NAIP. Nineteen NGOs and one KVK and 51 private industries participated in these subprojects.

Over 30 value-chains developed are economically viable. There is immense scope and potential in scaling up of such value-chains, strengthening other value-chains for economic viability and extending the concept to other commodities.

In value-chains, covering agro-forestry, cereals, fruits, vegetables, flowers, natural fibres, dairy foods, livestock and fisheries, innovative approaches were used and interventions were made at the production stage, leading to improved yield and quality. Interventions made at post-harvest stage (flowers, saffron, ginger, linseed, pork, fishes) resulted in improved packaging resulting in longer shelf-life and reduced post-harvest losses, and interventions made in marketing increased returns to growers, processors, exporters and marketers.





Agro-forestry value-chain

Agro-forestry value-chain resulted in a horizontal expansion of 44,724 ha; millet foods backstopped more than 200 processing industries; campaigning on sorghum value-added foods and nutrition covered over 12,000 farmers horizontally; dry flower export increased to ₹ 95 million from ₹ 43 million; and contract farming system in marigold enabled about 13,000 farmers to get a steady price. The saffron value-chain with a new production technology revived its cultivation in the Kashmir valley by increasing yield and posting an economic gain of ₹ 937.5 million to the society. Value-chain on guava and mango brought in a farmer producer company with an assured export market. The interventions under linseed value-chain, increased crop area by 55,000 ha, productivity by 585 kg/ha, income by ₹ 22,000/ha and production and branding of a range of products rich in Omega 3. The yield of coconut was enhanced by 50 nuts/palm, and a protocol for cost-effective production of Virgin Coconut Oil was developed besides another technology for pollution-free activated charcoal preparation from coconut shells.

Export of jasmine to Dubai and the USA, guava to Middle East countries, cryogenic ground spices and Gingerol from ginger are the major successes through value-chain research. Flower value-chains brought down post-harvest losses in jasmine from 40% to 10% by enhancing shelf-life. Extraction of fibre from banana pseudostem to be used in fabrics, preparation of handicraft items such as decorative lamps, fruit baskets and doormats; making organic manure (vermi-compost, fish feed) from scutcher are other success stories.

**Online knowledge resources and e-courses**

- The NAIP made online knowledge resources available to the entire NARES on an unprecedented scale by providing access to over 3,000 professional and scientific journals under the consortium for e-resource in agriculture, a database of 7,627 Ph.D. theses, a group catalogue of 38 libraries (Agricat), and an institutional repository of knowledge in agriculture and allied sciences called Krishikosh with 16 million digitized pages in 50,000 digital items like old books, reports, journals. Additionally, made available 425 user-friendly and multimedia-based online e-courses (<http://ecourses.iasri.res.in>), comprising 15,820 lessons for the under-graduate students in seven disciplines, viz. Agriculture,



e-resources in agriculture

Dairy Science, Veterinary Science and Animal Husbandry, Fisheries Science, Horticulture, Home Science, and Agricultural Engineering.

- The Project introduced e-publishing for ICAR research journals by making the entire publishing process efficient, transparent and paperless. Twenty scientific journals are being published online, and even back volumes of many of them have been digitized and made available in open access. Due to the open access, ICAR research



e-publishing of ICAR Research Journals – Homepage

journals have been accessed internationally from over 200 countries, and their readership is increasing continuously.

**Reaching the unreached farmers in disadvantaged region of the country**

The Project also strived for sustained improvement in the income and well-being of farm families in the





disadvantaged areas through 36 subprojects implemented in 97 disadvantaged districts including 20 districts with more than 50% tribal population. Under the programme, 80,562 ha was brought under improved crop cultivation, 10,160 ha under vegetable cultivation and 6,211 ha under additional irrigation. More than 1.5 lakh farmers, other than direct beneficiaries, have adopted various interventions demonstrated under such subprojects. The project could develop successful producer companies and farmers owned marketing centres having linkages with established markets. The scheme addressed 194,221 direct beneficiaries, leading to enhanced household income to ₹ 77,532 vis-à-vis the baseline income of ₹ 29,298. Interventions in pashmina production in traditional (Leh and Kargil) and non-traditional (Himachal Pradesh) areas led to increased income and ensured sustainable livelihood of poor farmers. The average pashmina yield (g) in Kargil ranged from 128 (Boodhkhharbu) to 182 (Drass) with an overall mean of 160. As a result of refinement of saffron cultivation practices, productivity increased from 2.5 kg to 5 kg/ha and total saffron production increased from 6.5 tonnes to 28.0 tonnes, leading to increase in farm income. The productivity of ginger increased by 32% in the project area, i.e. from 6.5 tonnes/ha to 8.635 tonnes/ha. Development of sustainability fund concept, revolving fund approach, village level seed and feed banks, etc. were undertaken to sustain these activities.

### Integrated Farming System (IFS) models for enhanced livelihood

To enhance livelihood of rural people living in disadvantaged areas, integrating farming system based models were promoted. In all, 107 IFS models covering the bouquet of technologies from crop, livestock and poultry, aquaculture, natural resource management, agro-forestry, farm mechanization, value addition and other income-generating activities such as mushroom cultivation were developed for different categories of farmers. Three typical successful models are given below.

**Integrated rice–fish–poultry model:** In Tamil Nadu, integrated rice–fish–poultry farming system was successfully demonstrated on 430 farm holdings in 12 villages of Cuddalore, Villupuram, Nagapattinam and Thiruvannamalai districts. The intervention included transplanted rice in 200 m<sup>2</sup>, 20 poultry birds kept in



Integrated rice–poultry–fish model

cages of size 6 m × 4 m of floor space having height of 3 m and 100 fingerlings (Rohu, Mrigal, Catla, Common Carp) in trenches of 20m<sup>2</sup>. The results indicated an annual increase in net returns per household by ₹ 33,000 to ₹ 50,500 per ha, respectively, for two and three crops taken annually. Poultry manure addition due to poultry dropping was 11.4 to 19.6 tonnes/ha, and pest suppression ranged from 17 to 27%.

**Integrated rice–fish–vegetable model:** Integrated rice–fish farming in the main field, followed by vegetable crops, viz. Frenchbean, chilli and knolkhol, was promoted in a total area of 160 ha in Asom. A unit area of 2,800 m<sup>2</sup> was under this module for each selected beneficiary. Total of 600 beneficiaries were selected from 6 clusters per year. Net economic benefit per household per annum was ₹ 29,000, due to increased rice production from 2.97 tonnes/ha (baseline value) to 4.6 tonnes/ha, plus additional production of fish and vegetables (average of 41 kg fish and 1.7 tonnes vegetables from 2,800 m<sup>2</sup> rice fields).

**Integrated poultry/pig–fish–vegetable model:** Pig rearing is one of the livelihood options for most of the people in backward districts of Asom. Farmers, however, mostly reared local breed in the backyard with poor productivity and low income. Integrated



Integrated pig–fish–vegetable model

farming system with cross breed of poultry/pigs, fish and horticulture as well as improved method of rearing were demonstrated in Lakhimpur, Kokrajhar and Karbi Anglong and Dhemaji (Asom) and Dhalai (Tripura). The results of demonstrations in Asom indicated that on an average a farmer earned ₹ 54,500 and ₹ 90,000 from poultry–fish–vegetable and pig–fish–vegetable system, respectively.

### Communication and knowledge dissemination to farmers

For farmers, NAIP developed four agricultural knowledge management systems, which provided web-based knowledge platform and mobile-based information delivery (SMS or voice alerts) and one-on-one advisory services. Among these systems, vKVK directly linked 191 KVKs with more than 35,000 farmers.

### Agri-Innovation Conclave

The Conclave was organized to encourage more active participation of public and private sector through



a series of events like the Agri Biz Idol Camp and Kisan Parivartan Yatra, held at different places from Hyderabad to New Delhi, culminating at New Delhi into the Agri-Innovation Conclave.

Establishment and networking of agricultural market intelligence centres in India was implemented to provide short-term price forecast advisory to farmers. The Centres conducted 169 capacity-building programmes for 27,202 farmers and officials.

### Potential Fishing Zone (PFZ) Advisories

In climatically challenged districts, marine fishers were likely to lose livelihoods due to distribution shift of pelagic fishes, submergence of their low-lying fish drying platforms and unseasonal and extreme rains where dried fish on bamboo platforms were spoiled, therefore technological interventions were necessary to prepare them to look for alternative, eco-friendly and remunerative technology. PFZ forecasting was one such technology and it was extended to 1,430 craft owners and 8,580 fishermen through cooperative societies of Raigarh district. It is estimated to have saved 94,000 litres of diesel per year, and was also instrumental in reducing CO<sub>2</sub> emission by 251,920 kg per year. Fishermen could cover their netting activities in the sea beyond 5–8 km, and up to 30 km from the sea-shore.

### Basic and strategic research achievements

**Biotechnology:** This includes whole genome sequencing of 16 stress tolerant and other specific microbial strains. Novel microbes discovered include a *Bacillus thuringensis* strain harbouring multiple insecticidal genes.

Eleven genes responsible for cotton fibre strength, including one gene for abiotic stress tolerance and seven genes for rice-blast resistance have been discovered and validated. Among these, rice-blast resistant genes have been extensively used in breeding programmes of basmati and non-basmati rice through marker-aided selection. A prediction tool shRNAPred-1.0 to predict shRNA from nucleotide sequence data has been developed and successfully employed to study distribution of shRNA on rice genome. Nematode root-specific promoters in model crop (*Arabidopsis*) as well as promoters in cotton and rice, and primers in lac species (*Kerria lacca*) have been reported. Functional genomics of fibre development and fibre strength of cotton has been published

Animal stem cell lines were developed for long-term investigations in animal breeding. The buffalo, 'Garima-II', was produced by hand-guided cloning technique from embryonic stem cells, which attained puberty and successfully gave birth to a female kid 'Mahima' through artificial insemination. Four embryonic stem cell lines produced are for long-term studies in animal production, physiology and health. In addition, one mammary epithelial cell line in buffalo, and one myoblast cell line in goat have been developed and sustained. Six parentage verification kits and a

### CSR-BIO – A boon for commercial crops in sodic soils

Endophytes from the rhizosphere of grasses at pH 9.8–10.4 were isolated and evaluated for their salt tolerance, nutrient uptake and resistance against soil-borne diseases. Large-scale validation and interventions on various crops, viz. paddy, wheat, banana, okra, tomato, capsicum, gladiolus etc, showed 10–24% higher yield, no wilting noticed, and interestingly, also controlled false smut in paddy. Crops like wheat, banana etc. can be taken up to pH 9.0.

A very low cost, patented common medium, using commonly available waste by-products not only supported growth of *Bacillus* and *Trichoderma* simultaneously, but the career used also served as a rich source of nutrients for foliar spray. The technology has been commercialized as CSR-BIO, and is reaching all parts of the country.

traceability software (confirm paternity) for application in different animal species have been produced.

**Advances in research and innovation management:** Temperature and chemical tolerant bio-pesticides identified for sugarcane, vegetable and cotton ecosystems can save farmers ₹ 4,400 per hectare. Temperature and pesticide tolerant biopesticides have been developed and validated, and widely demonstrated in 13 states and licensed to 9 licensees in 4 states. A production unit has been established at Bengaluru.

Four blast-resistant basmati rice lines with resistance to multiple strains of blast pathogen are ready for commercial release. Two accessions of sesame with high sesamin content have been identified for commercial use. Exploration of off-season production of mangoes and augmentation of genetic resource of lac insects proved promising. An imaging agent for tracking nano-pesticide has been developed.

A whole cell vaccine against virulent sheep foot-rot developed has been demonstrated for its effectiveness in Kashmir region.

**Nanotechnology:** Pilot-scale production of a nano-sulphur product has been standardized, and is available for R&D. Nano-phosphate fertilizer, and nano- Zn, Fe, Mg (micronutrients) products are also ready for commercial release. Biosynthesis of metal nano-particles process was standardized, and licensed for commercial use. Similarly, nano-cellulose product and process of preparation, ready for R&D and commerce, were licensed, and pilot-scale production of nano-cellulose has been established.

**Development of infertility control technology:** Infertility/aneustrousis is a major problem, severely affecting profitability of dairy ventures. It results in prolonged inter-calving period and thus lesser number of lactations in the productive life of cattle. Two formulations based on new concept and research findings under the subproject were developed. The total cost of oestrous induction in 3 subsequent pregnancies, averaged around ₹ 80 per animal per pregnancy.





### Snapshot of financial and economic benefits estimated from the NAIP

Total budget allocated (in crore ₹)	Financial benefit accrued (in crore ₹)	Economic benefit accrued (in crore ₹)	Financial benefit: cost ratio	Economic benefit: cost ratio
1,329.11	2,380.88	2,299.66	1.79	1.73

#### Monitoring and Evaluation

Data were collected from 5,557 respondents/stakeholders with equal or two-third control, of which more than 90% were farmers. The analytical tools included both quantitative and qualitative analysis – partial budgeting, multi-criteria analysis, benefit: cost ratio, internal rate of return and NPV. The results,

impact analysis through the stakeholders' survey indicated that the NAIP subprojects had an overall financial and economic benefit: cost ratio of 1.79 and 1.73 respectively, based on the extrapolation of the sample subprojects to whole NAIP project, and its IRR was ~40%.

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