Success Story No. 1

Sundarban Mangrove-Rice System Technological Intervention and Capacity Building for Climate Change Adaptation and Mitigation

A Success Story of Youth Participation

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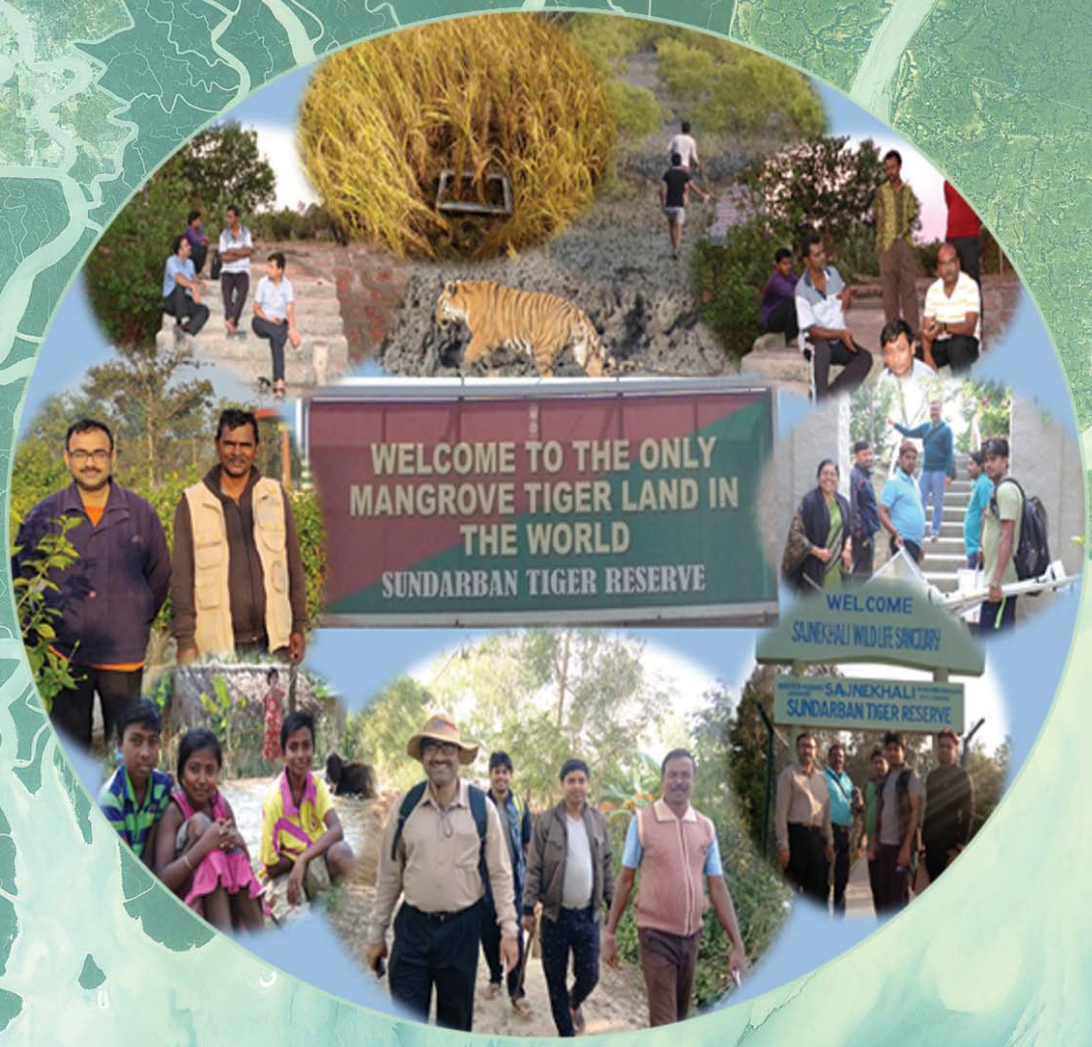

ICAR-National Fellow Project
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The Sundarbans (21°322 to 22°402 N and 88°052 to 89°512 E) covers an area of 10,000 km^2, out of which 62% lies in Bangladesh and 38% in India (Spalding et al., 2010). Mangrove-rice system is a distinct ecosystem that evolved in Sundarban, India in the last century due to anthropogenic activities and climate change consequences. Degraded mangrove and rice exist side by side, having their specific challenges and opportunities. In this region, agriculture and aquaculture are the major occupations of the inhabitants. Agriculture is the backbone of the Sundarbans economy. However, several problems i.e., small landholdings, poor irrigation facilities, extreme events, less use of organic manure, the scanty adaptation of saline tolerant and high yield rice cultivars still exists. Rice is cultivated in around 98% of the total arable land and the rest is primarily used for vegetables. Major cropping systems in this region are rice-rice, rice-vegetables, rice-fallow, and with less area of other crops like oilseeds and pulses. However, in the dry (*rabi*) season maximum area remain fallow due to a poor irrigation system. Therefore, technological intervention and capacity building at for the farmers of Sundarban are necessary for better livelihood.

Sundarban mangroves sustain bio-diversities and provide significant ecosystem services such as supply forestry products (firewood, charcoal, timber, honey *etc*.), fishery products (fish, prawn, crab, *etc*.), shelter of animals (tiger, deer, monkey, birds, etc.), protecting the coast from fury of cyclones, floods, sea level rise, wave action and coastal erosion (Figure 1). It also acts as an effective carbon sink, thereby sequester a higher amount of carbon as compared to other forest. Mangrove wetlands act as a source of methane and nitrous oxide emission, however considering the higher productivity, this ecosystem represents a significant sink for CO_2. About 40% of tropical mangrove has been lost during the last century due to climate change induced sea-level rise and anthropogenic activities. Sundarban-India, the largest contiguous mangrove of the world, lost 10.5% of its green during 1930-2013. Loss of mangrove forests could lead to serious consequences such as loss in biodiversity, ecosystem stability, ecosystem services, and carbon sequestration. So, the restoration and regeneration of mangrove is an important concern in the coastal region that needs increasing awareness on climate change consequences, technological interventions and capacity building of the farmers and particularly the village youth.

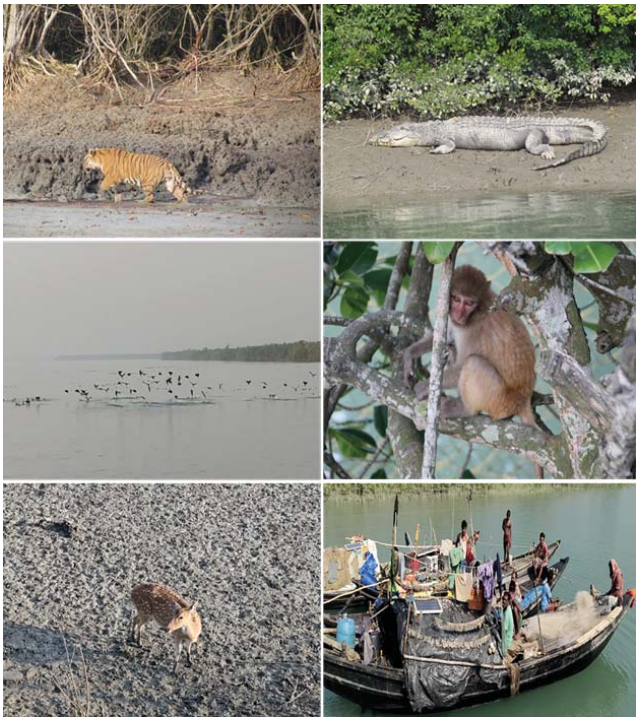

Figure 1: Significant ecological services by mangrove forest in Sundarban-India.
[*Photo credit: Dr. M. J. Baig*]

Research and Development Gaps of mangrove-rice system, Sundarban

- Lack of proper network of drainage and irrigation system and rainwater harvesting structure.
- Majority of pond/ rainwater harvesting structures are silted up.
- Poor adaptation of climate stress (salinity, submergence) tolerant rice cultivars.
- Lack of awareness in integrated nutrient and pest management in rice
- Limited ideas about climate resilient rice production technologies.
- Lack of awareness of sea level rise and negative consequences of climate change
- Poor climate literacy.
- Poor community-based approach for mangrove protection and tackling climate vagaries on rice production.
- Lack of skill on soil, water and crop management using modern tools.
- Reluctance of village youths for mangrove conservation, lack of implement to address climate change issues.

Specific Needs of mangrove-rice systems in Sundarban

Technological Needs

- Renovation of rainwater harvesting structures (ponds).
- Proper layout of drainage and irrigation networks.
- Community involvement in preparation of rice-nursery, mechanization, pest control and marketing.
- Introduction and promotion of climate resilient high yield rice varieties.
- Following the approach of double transplanting and staggered nursery in rice to cope up with the climate change vagaries.
- Proper adaptation of site-specific integrated nutrient and pest management.
- Promotion of legume based cropping systems in rice at suitable ecologies.
- Continuous and systematic seeding and plantation of mangroves and subsequent protection for their establishment.
- Reduction of unnecessary anthropogenic activities in coastal bank; protection of existing mangrove; checking of soil erosion in coastal bank; putting barriers to pollution including plastic use in Sundarban.

Need for Human Resource Development and Capacity Building

- Training programme on climate resilient rice production technologies.
- Training on climate literacy and increased awareness regarding climate change vagaries on coastal livelihoods.
- Awareness and training on site specific integrated nutrient management and pest management.
- Specific training of mangrove, soil and water conservation.

- Training on development of farmers society, cooperatives, self-help groups.
- Specific training, awareness campaign and motivation is necessary for village youth on skill development, climate literacy, alternative avenues of employment, protection needs of mangroves for survival of coastal people and climate change mitigation.
- Proper coordination and confidence-building among ICAR, State agencies, NGOs, Forest and line departments with Farmers/ Villagers are essential prerequisites for sustainable livelihood security and climate change mitigation in Sundarban.

Technological Intervention

Renovation of Rainwater Harvesting Structures (Ponds)

In Sundarban, two rainwater harvesting structures (ponds) were renovated during 2019-2020 at Dayapur and Bali of Gosaba block, South 24 Parganas, district, West Bengal (Table 1, Figure 2). These two ponds were silted up, side slopes were damaged, and rainwater stored capacity had been reduced to more than 60%. The ponds were desilted, side slopes were restored, storage capacity increased and proper runoff collection drainage networks were established with effective participation of farmers. The renovated ponds and drainage networks help in the (i) irrigation to the agricultural fields, (ii) fish cultivation, (iii) checking of soil erosion, (iv) daily use of school children and (v) domestic works of few beneficiaries.

Table 1: Details of the renovated ponds at Sundarban

Pond No	Location	Year of Renovation	Storage capacity		Number of beneficiaries
			Initial (Before renovation)	Final (After renovation)	
I	Dayapur	2019	0.073 acre-ft	0.324 acre-ft	19
II	Bali	2019	2.11 acre-ft	7.13 acre-ft	80

Figure 2: Renovation of ponds at Dayapur and Bali Village, Gosaba block, Sundarban.

Introduction and Promotion Climatic Stress Tolerant High Yielding Rice varieties

The submergence tolerant high yielding rice cultivar Swarna Sub1 was introduced and promoted in three villages. With the availability of irrigation water and introduction of improved rice varieties, there was a 15-30% increase in crop yields in both *kharif* and *rabi* seasons. The average crop yield was increased by 22%, in kharif and 18% in rabi season (Table 2).

Table 2: Rice yield before and after the renovation ponds both during *kharif* and *rabi* season.

Crop	Rice varieties		Rice yield (t ha^{-1})	
	Before pond renovation	After pond renovation	Before	After
Rice (*Kharif*)	CR Dhan, Masuri; Gobindobhog	Swarna Sub1 (submergence tolerance)	5.3	6.8
		Pratiksha	4.8	5.4
		Gobindobhog	4.2	4.8
Rice (*Rabi*)	Satabdi, Hybrid	Satabdi (short duration)	4.5	5.5
		Hybrid	4.8	7.0

Figure 3. Interaction of National Fellow and Scientists of ICAR-NRRI, Cuttack with farmers regarding cropping system and integrated nutrient and pest management.

Double Transplanting and Staggered Nursery

The farmers of Sundarban region face the severe problem of rice nursery damage due untimely rainfall at the beginning of monsoon season and damage to young seedlings (just transplanted) because of heavy downpour during end of July to middle of August. Therefore, availability of a second batch of seedlings is necessary as a contingent plan to get desirable yield during the kharif season. So, the awareness regarding the staggered community nursery was suggested/ demonstrated at the village level to combat the problem of both deficit and excess rainfall situations. The technology of double transplanting was well taken by the farmers along with raising of staggered nursery in the village at an interval of two weeks. First nursery was raised with the long duration rice varieties (>145 days) whereas, the second batch of nursery was raised with medium duration varieties (120-130 days).

Capacity Building

Training programme on Climate Resilient Crop Production Technologies at ICAR-NRRI, Cuttack

A training programme on the topic 'Rice Seed Production Technologies' was organized by ICAR-National fellow Project and NICRA on 18-24th September 2018 in ICAR-National Rice Research Institute, Cuttack (Figure 5).

Training on Climate Resilient Agriculture at Bali Island, Sundarban

A farmers training on the topic 'Training on climate resilient rice technologies' was organized by ICAR-National fellow Project and NICRA with the collaboration of Wildlife Protection Society, India (WPSI) on 4th June 2018 in the Bali Island, Gosaba block, Sundarban, 24 Parganas (S), West Bengal (Figure 6). Details of the training programme are given in Table 3.

Figure 4: Technology demonstration and discussion and awareness campaign regarding the double transplanting and staggered nursery in Sundarban.

Figure 5: Training programme on Rice Seed Production Technologies was organized at ICAR-National Rice Research Institute, Cuttack.

Awareness on Nutrient Management

In Sundarban, still many farmers apply imbalanced chemical fertilizers in both the seasons. Organic manures like green manuring, vermicomposting, compost, etc. used rarely by farmers. They are mostly using chemical fertilizers like urea, di-ammonium phosphate (DAP), Gromer (only nitrogen (N) -phosphorus (P) based), Muriate of Potash (MOP), etc. Fertilization of secondary and micronutrients is mostly missing. Although the nitrogenous fertilizer is used in two/three splits, whereas potassium is only one at basal dose. Hence, unbalanced chemical fertilization could trigger GHGs emissions. In this aspect awareness campaign through 'one to one' discussion mode with farmers and farmers were trained on have been given on integrated nutrient management, Customized LCC based nitrogen management, and inclusion of sulphur and micronutrients (particularly zinc) in fertilizer scheduling. Physical mixing of organic manures with fertilizers also demonstrated and executed in participatory mode (Figure 7) at Sundarban.

Awareness regarding Social Fencing

Social fencing refers to virtual mode fencing where no physical barrier is given to protect the animal grazing of agricultural crops. In this approach the farmers are made aware of the importance of protection of crops, plantation, and mangrove seedlings from animal grazing. And also trained them to manage their cows, buffalos and goats through stall feeding and allow them to graze in designated places on a rotational basis. The approach of social

Table 3: On-site training on climate resilient rice technologies, at Bali Island, Sundarban

Sl. No.	Topic	Resource Person	Activities	No. of Farmers Participated
1.	Climate literacy and awareness of resilient agriculture	Dr MJ Baig Principal Scientist ICAR-NRRI, Cuttack	-	50
2.	About National Fellow and NICRA research activities	Dr P Bhattacharyya ICAR-National Fellow, ICAR-NRRI, Cuttack	Leaflet distribution	50
3.	Nitrogen management through customized leaf colour chart (LCC)	Dr P Bhattacharyya ICAR-National Fellow, ICAR-NRRI, Cuttack	CLCC distribution and demonstration in field	50
4.	Conservation need of mangrove and wildlife in Sundarban	Mr. Anil Mistri Director, WPSI, NGO	-	50
5.	Forest conservation and livelihood secuirty	Mr. Biswajit Das Ranger Officer, Sajnekhali, Sundarban	-	50
6.	Pest management in rice	Dr Totan Adak Scientist, ICAR-NRRI, Cuttack	Demonstration of pesticide application and traps	50
7.	Distribution of climate resilient rice varieties developed by ICAR-NRRI	Dr P Bhattacharyya Dr MJ Baig Dr T Adak	CR Dhan 501 Swarna Sub-1 CR Dhan 401 (2 kg/each)	50

Figure 6: Training on climate resilient rice technologies organised by ICAR-National fellow and NICRA project with collaboration with WPSI at Bali Island, Gosaba block, Sundarban, West Bengal, India.

fencing was followed in Sundarban with the effective participation of farmers, villagers and WPSI, NGO workers. The project staff of ICAR-National fellow project played a crucial role in those endeavours and achieved success at a considerable level. Once majority of seedlings on mangrove (regenerated either by natural means or plantation by project workers, state government interventions, forest departments or villagers) were grazed by animals,

Figure 7: Awareness regarding fertilizer management demonstration of mixed fertilizer use.

Figure 8: Concept of social fencing.

particularly by goats. However, a drastic change in behaviour of villagers was noticed and social fencing became a successful model in those villages of Sundarban (figure 8). This is a clear cut indication of people's participation in protecting mangrove which has a significant contribution to coastal bank protection and climate change mitigation.

Specific Training to Village Youth regarding Soil and Gas sample collection

Three persons were trained in three locations of Sundarban (Dayapur, Bali and Sagar, respectively) to collect soil and gas samples (for GHGs analysis) from mangrove and rice systems. Details of hands-on training of depth wise soil sample collection and of gas sample collection by "manual close chamber" method were given to the educated youth of Sundarban (Figure 9). The gas samples were then subsequently brought to ICAR-NRRI, for further analysis of GHGs in gas chromatography under the ICAR-National Fellow project. This training not only increased the skill and income of youth but also enhanced the awareness for protection of mangrove, necessity to reduce GHGs emission and climate change mitigation. The details of a village of three village youth trained on specific skills GHGs sampling and soil sampling are presented in Table 4.

Figure 9: On-site training of gas sample collection to farmers for research purpose.

Table 4: Details of the trained persons

Sl. No	Name	Gender	Age	Qualification	Address
1	Chitta Ranjan Roy	Male	36	Graduation	Dayapur
2	Anupan Mondal	Male	22	Graduation	Bijoynagar
3	Shyamali Mondal	Female	24	Graduation	Sumatinagar

Success of Ensuring Youth Participation in Climate Change Mitigation

The major success of intervention ICAR-National Fellow Project at Sundarban is to ensure people's participation in climate change mitigation. Particularly village youths including girls were motivated and participated enthusiastically in mangrove plantation; protection of the coastal bank; restricting animal grazing ('social fencing' approach); renovation of silted ponds and drainage systems; putting of the staggered nursery and double transplanting of rice; providing lifesaving irrigation to crops from harvested rainwater; practising integrated nutrient and pest management practices; and taking part in climate awareness campaign. The effective participation of youth in climate change mitigation cum adaptation works are presented in the coming section.

Village Youth Participation in Mangrove Sowing/Plantation

Mangrove seed collection

Mangrove seeds were collected by village youth themselves during the months of July-August 2021 at Bali II, village, Gosaba block, Sundarban. The seeds were accumulated within a specific place in an estuarine-bank near the village with netting (by net and bamboo sticks) by indigenous techniques (Figure 10). Seeds of six different mangrove species were collected and naturally preserved in the specific location. Six different seeds of mangrove species include *Ceriops decandra* (local name: Goran), *Avicennia officinalis* (local name: Baen), *Bruguiera gymnorrhiza* (local name: Kankra), *Xylocarpus granatum* (local name: Dhundul), *Heritiera fomes* (local name: Sundari) and *Rhizophora apiculata* (local name: Garjan) were collected (Figure 11).

Figure 10: Temporary seed storage and collection of seeds for mangrove sowing/ plantation.

Figure 11: Six different types of seeds of mangrove collected for mangrove sowing/ plantation.

[Note: (A): *Ceriops decandra* (local name: Goran); (B): *Avicennia officinalis* (local name: Baen); (C): *Bruguiera gymnorrhiza* (local name: Kankra); (D): *Xylocarpus granatum* (local name: Dhundul); (E): *Heritiera fomes* (local name: Sundari); (F): *Rhizophora apiculata* (local name: Garjan).]

Mangrove sowing/Plantation

Mangrove sowing/plantation was done in four-hectare area on 22nd August 2021, with complete participation of village people (95% of them were youth) (Table 6) of Bali Island along with the staffs of ICAR-National fellow project at the Bali-II area, Gosaba block, Sundarban, India. In the seed collection, sowing and transplantation of mangrove, staff of ICAR-NRRI, WPSI and the local people (30 members) participated. Details of the participants in mangrove plantation are given in Table 5.

Table 5: Details of the participants in mangrove plantation

Sl. No.	Name	Gender	Age	Qualification/Designation	Address
1	Dr. Pratap Bhattacharyya	Male	48	ICAR-National Fellow & Pr. Scientist	ICAR-NRRI
2	Anil Mistri	Male		Director, WPSI	Bali
3	Pradeep Kumar Dash	Male	35	RA, National Fellow Project	ICAR-NRRI
4	Soumya Ranjan Padhy	Male	30	SRF, National Fellow Project	ICAR-NRRI
5	Gouri Shapui	Female	10	5th Standard	Bali
6	Susila Mandal	Female	10	5th Standard	Bali
7	Tuktuki Gayan	Female	08	3rd Standard	Bali
8	Pijush Kanti Das	Male	14	9th Standard	Bali
9	Sourav Gayan	Male	10	5th Standard	Bali
10	Dipu Mistri	Male	13	8th Standard	Bali
11	Ranbir Mistri	Male	12	7th Standard	Bali
12	Dipu Mandal	Male	13	8th Standard	Bali
13	Animesh Mandal	Male	13	8th Standard	Bali
14	Tuhin Mondal	Male	12	7th Standard	Bali
15	Palash Biswas	Male	12	7th Standard	Bali
16	Souvik Sarkar	Male	17	12th Standard	Bali
17	Mihir Mandal	Male	22	8th Standard	Bali
18	Suranjan Biswas	Male	16	12th Standard	Bali
19	Nimai Mandal	Male	23	8th Standard	Bali
20	Bapi Sarkar	Male	40	10th Standard	Bali
21	Kamalakanta Mandal	Male	25	7th Standard	Bali
22	Sona Gharomi	Female	17	9th Standard	Bali
23	Rahul Biswas	Male	08	3rd Standard	Bali
24	Sujit Mandal	Male	10	3rd Standard	Bali
25	Sujaya Mandal	Male	11	3rd Standard	Bali
26	Biduyt Sarkar	Male	11	3rd Standard	Bali
27	Deepa Mondal	Female	15	10th Standard	Bali
28	Deepika Sarkar	Female	16	10th Standard	Bali
29	Anuj Gharami	Male	56	10th Standard	Bali
30	Lalita Biswas	Female	32	10th Standard	Bali
31	Jayamala Mandal	Female	33	10th Standard	Bali
32	Riya Biswas	Female	14	9th Standard	Bali
33	Laboni Biswas	Female	16	12th Standard	Bali
34	Tanmaya Sarkar	Male	22	10th Standard	Bali

Key points of success story

a. *Village youth are motivated to protect their land.*

b. *Youth (age between 8-35; around 30 in no.) participated spontaneously in mangrove seed collection and planting.*

c. *Both girls, boys, men, and women are spontaneously participated in mangrove plantation (more than 35% girls participated)*

d. *People awareness created (more than 100 villagers/farmers in 4 villages, Sundarban) on mangrove protection and villagers protect the mangrove seedlings from grazing through social fencing.*

e. *Climate-literacy of school children and youth (both boys and girls; about 100 in numbers) were provided and accepted.*

f. *Special training on soil, plant, and gas sampling (including GHGs sample collection) were given to selected youth. Presently three farmers/ youth (Sh. Chitta Ranjan Roy; Sh. Anupam Mondal and Miss. Shyamoli Mondal) can do the sampling independently.*

g. *Village people protect their own village land and build faith on ICAR-NRRI scientists, NGOs, state and forest department-staffs in Sundarban-India.*

h. *Direct collaboration established among ICAR-NRRI with NGOs (WPSI) and village society/ peoples in climate vulnerable region, Sundarban, India.*

Figure 12: Farmer's participation in double transplanting

Figure 13: Farmer's participation in INM, IPM

Figure 14: People participation in diversified cropping system (rice-potato) with harvested rainwater

Figure 15: Trained Village Youth are collecting the GHGs samples of their own.

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Participation of villagers' including girls in Mangrove plantation on Bali Island

Mangrove regeneration after plantation on Bali Island

People participation of desilting and digging of ponds and creation of drainage network

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