World Agroforestry Centre

THE FRUITS OF A DECADE

ICRAF in South Asia

CGIAR

World Agroforestry Centre is a member of the CGIAR Consortium

World Agroforestry Centre, United Nations Avenue, Gigiri,
P. O. Box 30677-00100, Nairobi, Kenya.
Phone + (254) 20 722 4000, Fax + (254) 20 722 4001,
Via USA phone (1-650) 833-6645,
Via USA fax (1-650) 833-6646,
Email: worldagroforestry@cgiar.org
Website: www.worldagroforestry.org

The Fruits of a Decade: ICRAF in South Asia

South Asia Regional Programme
World Agroforestry Centre (ICRAF)

About the World Agroforestry Centre and the CGIAR Consortium

The World Agroforestry Centre (ICRAF) is one of the 15 Centers of the CGIAR (Consultative Group on International Agricultural Research) Consortium. ICRAF's headquarters are based in Nairobi, Kenya, with eight regional and subregional offices located across Africa, Asia, and Latin America.

Vision

A rural transformation in the developing world where smallholder households strategically increase their use of trees in agricultural landscapes to improve their food security, nutrition, income, health, shelter, energy resources, and environmental sustainability.

Mission

To generate science-based knowledge about the diverse roles that trees play in agricultural landscapes, and use the Centre's research to advance policies and practices that benefit the poor and the environment.

The CGIAR Consortium integrates and coordinates the research of its 15 member-Centers to increase the effectiveness and relevance of their work, and enhance the impact of the research by setting common objectives and planning concerted action.

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World Agroforestry Centre (ICRAF)
1st Floor, Block C, National Agricultural Science Complex (NASC)
Dev Prakash Shastri Marg
Pusa Campus, New Delhi, India 110012
Tel: +91 11 25609800/25847885/6
Fax: +91 11 25847884
Email: j.rizvi@cgiar.org

This publication is printed on paper manufactured entirely from renewable resources.

Cover: Agroforestry landscapes involve mosaics of multiple components, including trees, shrubs, crops, livestock, and people.

Whatever I dig from thee, O Earth,
May that have quick growth again.
O purifier, may we not injure thy vitals or thy heart.

– Atharva Veda, 12.1.35
(c. 1200-1000 BCE)

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Foreword

When the World Agroforestry Centre (ICRAF) decided in 2003 to expand its research-for-development activities to South Asia, it was aware of two contrasting realities. Firstly, South Asia is a region with a rich history of agroforestry; and, Secondly, South Asia is also a region where the majority of the world's poor live. However, ICRAF saw opportunities to tap into the potential of the diverse agroforestry systems in the region to reduce poverty and improve the food and nutritional security of the poor.

Searching for a home for ICRAF's South Asia Regional Programme (SARP) was easy. India kindly offered to host the Program in New Delhi. ICRAF is grateful to the Government of India for its continued whole-hearted support to SARP in every possible way.

Soon after its establishment, SARP moved quickly in forging partnerships and identifying gaps in agroforestry research that needed to be filled through collaborative research. A programme of work was developed with partners encompassing such critical areas as diversifying agroforestry products, designing environment- and location-specific agroforestry systems, efficient use of the scarce water resources, reversing land degradation, mitigating the effects of climate change, producing clean energy at village level, empowering women, and helping develop local capacity. SARP is now meaningfully involved in several Consortium Research Programmes and other important projects in India and in the region.

The achievements of SARP in transforming lives in South Asia with agroforestry in a short period of 10 years are truly commendable. Other than developing both improved and new pro-poor technologies, SARP also contributed substantially to the development and launch of the National Agroforestry Policy of India, a historic development. I am particularly impressed by SARP's efforts in bringing about a change in farmers' perception of agroforestry from a casual activity to a full program with potential to generate additional income, employment opportunities, and protect the health of both humans and the environment. Gaining farmers' trust has played a very important role in the success of SARP activities. The number of farmers participating in SARP projects has been constantly increasing. SARP has also been successful in forging strategically important partnerships beyond the region. The South Asia-Africa Bridge and the South Asia-Southeast Asia Bridge are good examples. A selection of success stories is presented in this publication.

I would like to take this opportunity to thank the national programs in the region, as well as all other stakeholders, for their collaboration and support to SARP. I would also like to thank the donors who have been supporting SARP's research-for-development agenda. And from an individual point of view it is clear such progress would not have been possible without the energetic and innovative approaches of our founder SARP staff member, Dr V.P. (Pal) Singh.

I hope all those who are working to make this world a better place would find the information in this publication both inspiring and useful.

I congratulate the entire SARP team for their dedication and determination to pursue their objectives and goals. "The Fruits of a Decade" reveals progress; the journey, however, is long and must continue.

Tony Simons
Director General
ICRAF

Preface

Passing the baton: Dr V.P. Singh (left) handed over the reins of ICRAF's South Asia Regional Programme to Dr Javed Rizvi in May 2014.

After a decade since the South Asia Regional Programme (SARP) came into being in 2003, it was time to both look back and look forward. This publication was conceived to help share with our collaborators, donors and other stakeholders, what we have achieved and the lessons we learned during the past decade, and how we propose to respond to agroforestry farmers' future needs and expectations driven by climate change and the ongoing reorientation of the global action programmes. Clearly, we need to set new milestones and new goalposts.

At the outset, I would like to tell the readers that "I am the new kid on the block." I joined ICRAF's South Asia Regional Programme in May 2014, and feel proud in presenting the great work and achievements of the Programme in this publication. Given that SARP had already developed into a mature Programme, with major achievements and a vast array of collaborative activities with partners, I faced the challenge of how I could contribute to the further development of the Programme when I took office. I identified two priorities, in addition to carrying forward the ongoing work: making advanced research techniques accessible to colleagues in national programmes, where needed, and expanding the Programme's network of partnerships by forging new ones and strengthening the existing ones. The progress made in these two key areas is reported as well in this publication.

The source material for this publication was provided by the SARP team members, and was also drawn from ICRAF documents, several websites, scientific articles and reports, and personal discussions. It is an attempt to appreciate the contributions and support of those we have been working with.

I feel short of words to acknowledge those scientists from the national programmes in South Asia, and colleagues both in international and regional organizations, whose collaborative work during the past 12 years is reported in this publication, and the farmers who have been enthusiastically participating in our research projects. The administrative and support staff at SARP deserve a special mention for their strong and dedicated support to the scientific team. I would like to say "Thank You" to all of them.

I am very thankful to Dr V.P. Singh who identified the material to use in this publication and worked closely with the editor. My special thanks are due to Ms Devashree Nayak who painstakingly assisted in collecting much of the source material, and for her 'people skills' in the overall coordination of the project.

I am very grateful to Dr Tony Simons, Director General of ICRAF, for his deep interest in, and continued support to the South Asia Regional Programme. I thank Dr Ravi Prabhu, Deputy Director General-Research, ICRAF, for his encouragement and support, without which this publication would not have been possible.

I thank the donors who have been supporting SARP's work.

I would like to thank Dr S. Varma, ex-Head of Communication, ICARDA (International Center for Agricultural Research in the Dry Areas), who worked as a Consultant with SARP and wrote/edited the text for this publication and worked closely with designers and printers. My thanks are also due to Mr Paul Stapleton, Head of Communication, ICRAF, and his team members for their support, especially Ms Tabitha Obara and Ms Daisy Ouya who worked on the design and layout of this publication.

I hope this publication will meet its intended objectives.

Javed Rizvi
Regional Director
South Asia Regional Programme
ICRAF

Introduction

The term 'agroforestry' was coined by a visionary study in the mid-1970s led by forester John Bene of Canada's International Development Centre (IDRC). The study highlighted the role that trees play on farms. In response to the study, ICRAF (the International Council for Research in Agroforestry) was established in 1978 to promote agroforestry in developing countries. ICRAF has continued to grow and evolve, joined the CGIAR in 1991, and changed 'Council' in its name to 'Centre.'

In 2002, ICRAF adopted 'World Agroforestry Centre' as its brand name but retained 'International Centre for Research in Agroforestry' as its legal name.

This publication focuses on the activities and achievements of the World Agroforestry Centre (ICRAF) in South Asia, over a period of 10 years, working with and for the welfare of the farmers in the region.

What is Agroforestry?

Defined simply, agroforestry is the art and science of integrating trees and shrubs into various crop and crop-livestock production systems. It should not be confused with natural and man-made forests. Introducing trees in conventional agricultural landscapes helps to achieve increased land productivity, diversity of products, better nutrition, increased income and employment generation, and protection of the environment. Thus, while agriculture is widely recognized as the engine of growth and poverty reduction, agroforestry makes the engine even more efficient. Carefully designed agroforestry systems can even help to mitigate the threats of climate change.

Farmers in South Asia have used trees and shrubs in their agricultural landscapes for centuries (now redefined as agroforestry). South Asia is, therefore, often referred to as the "cradle of agroforestry" in recognition of its diverse agroecological environments, agroforestry systems, and agroforestry products and services. The indigenous knowledge of agroforestry farmers is very valuable for researchers in developing new, improved technologies.

Agroforestry is now emerging as an important discipline to address the complex issues, hitherto not fully understood, to complement agriculture, for sustainable use of natural resources and to improve livelihoods and the quality of life of the poor, particularly in developing countries.

Archaeological excavations corroborate early tree domestication around the settlements in South Asia. The earliest evidence of this dates back to the Mesolithic period (10,000–4,000 BCE) when fruits of 63 plant species were reportedly eaten raw, ripe or roasted, or pickled by the inhabitants of central India. *

*Randhawa, M.S. 1980. A history of Indian Agriculture: eight to eighteen century, vol 2. ICAR, New Delhi

Agroforestry Products and Services

Agroforestry provides a wide range of products and services which support livelihoods of farmers, improve sustainability of production systems, and protect the environment.

Products: Food: fruits, nuts, edible leaves, pods, tubers, roots, honey, etc.; Commodities: confectionery, beverages, oils, paper, and other industrial products; Energy: liquid biofuels, fuelwood, and charcoal; Timber; Fodder; Herbal medicines and spices; Fertilizer. A wide range of value-added processed products of agroforestry are popular in both domestic and international markets.

Services: Ground cover and ecosystem integrity; Better water management; Biodiversity conservation; Soil regeneration; Carbon sequestration; Micro-climate modification; Nutrient cycling; Pollination by attracting insect pollinators; Spiritual and ritual values.

Some value-added processed products from agroforestry
© V.P. Singh

South Asia Programme Inception

As part of its global mandate, ICRAF established the South Asia Regional Programme (SARP) in 2003, with its headquarters in New Delhi, India. SARP covers Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka (Fig. 1). Its activities focus on all four agroecological environments found in South Asia: (1)the mountainous regions of Afghanistan, Bangladesh, Bhutan, northeast India and Nepal, (2) the Indo-Gangetic Plains of Bangladesh, India, Nepal and Pakistan, (3) humid coastal areas of Bangladesh, India, Maldives and Sri Lanka, and (4) semi-arid lands of India, Pakistan and Sri Lanka.

Fig. 1. Countries in South Asia

Agroforestry Systems in South Asia

A paddy-based agroforestry system
© DKNG Pushpakumara

A diversity-guided agroforestry system
© V.P. Singh

A coconut-based coastal agroforestry system
© DKNG Pushpakumara

A tea-based forestry system with two levels of shade from trees
© DKNG Pushpakumara

Emperor Ashoka , a great Indian ruler (273–232 BCE), encouraged a system of arbori-horticulture of plantains, mango, jackfruit, and grape. According to the second of the 14 *Rock Edicts* of *Ashoka* (257 BCE), planting of medicinal herbs and trees besides shade trees along the roads and fruit plants on the wastelands was an accepted norm in those days—analogous to social forestry and agroforestry programmes of today.*

South Asia is unique not only in its cultural diversity but also in the diversity of its agroforestry systems. The key South Asian agroforestry systems include parkland systems (with trees, usually of the same species, widely scattered over a large agricultural farm or pasture); agrisilviculture involving poplar and eucalyptus; plantation agriculture involving coffee, tea, cacao, and spices in association with a wide variety of trees; intercropping systems with coconut, para rubber and other trees; commercial crop production under the shade of trees in natural habitats; and homestead farming systems (integrated production of trees, food crops, horticultural crops and livestock around a farmer's home).

Within these main systems, farmers also practice several other location-specific sub-systems, such as fish culture, apiculture, sericulture, and lac insect rearing. On the other hand, tribal communities in South Asia, guided by their indigenous knowledge, design their own systems using the various components of agroforestry in multiple combinations, compatible with the diverse environments where they live, and to meet their needs for food, shelter, and firewood.

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*Kumar, B.M., Singh, A.K. and Dhyanai, S.K. 2012. South Asian Agroforestry: Traditions, Transformations, and Prospects. *In* P.K.R. Nair and D. Garrity (eds). Agroforestry-the Future of Land Use. *Advances in Agroforestry* 9. DOI 10.1007/978-94-007-4676-13_19.

Agroforestry Area vs People and Environments

Over-grazed and wind-eroded land in Bhilwara, Rajasthan, India
© V.P. Singh

Reliable data on area under agroforestry globally and in various regions is not available. ICRAF places a cautious global estimate of agricultural land involving agroforestry at 17 percent where tree cover is more than 30 percent. But, if the area with only about 10 percent tree cover is considered, the estimated global agroforestry area is estimated to be 46 percent. Using the 10 percent figure, ICRAF estimates that an area of over 10 million km^2 is under agroforestry globally.

For South Asia, ICRAF's estimates are: 389,056 km^2 (21 percent) with more than 10 percent trees; 161,463 km^2 (9 percent) with more than 20 percent trees; and 97,160 km^2 (5 percent) with more than 30 percent trees. A non-ICRAF report in literature claims that there are more trees in agroforestry systems than in forests in South Asia.

ICRAF researchers have also studied the distribution of global and regional populations living in agroforestry landscapes. Using the more than 10 percent tree cover as the reference point, they estimate that there are at least 100 million people living in agroforestry landscapes in South Asia. They also found a strong association between the extent of tree cover and agroecological environments. Generally speaking, the level of tree cover is higher in more humid environments, but there are exceptions. The researchers found no clear relationship between population and tree cover.

Development Challenges

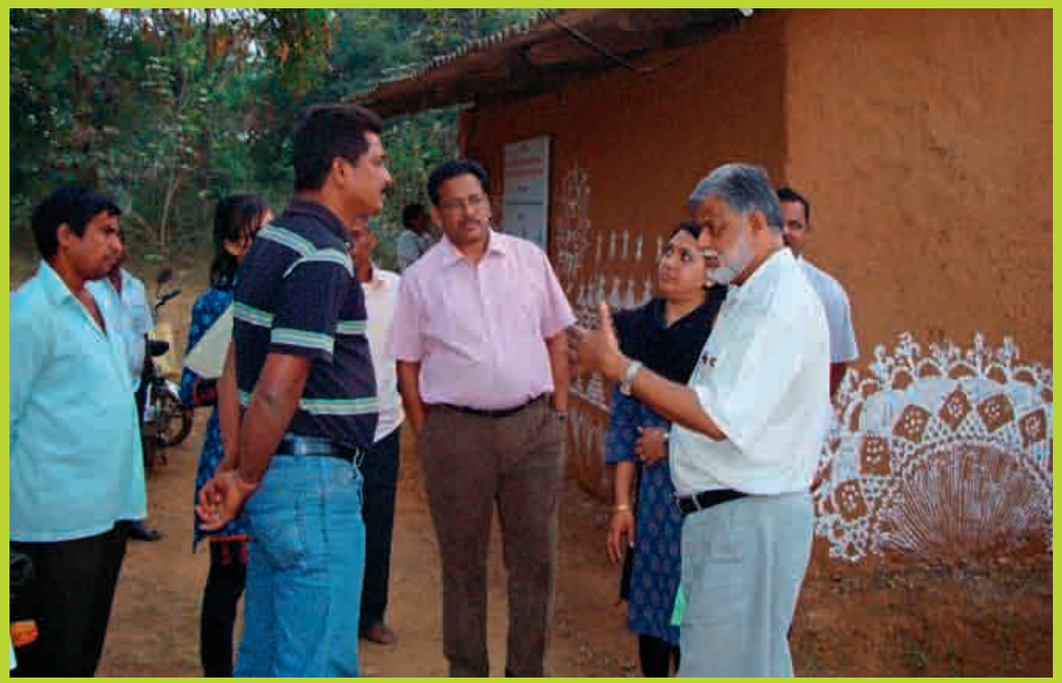
The development challenges in South Asia are no different from those in other regions of the developing world. The key challenges include the following:

1. Poverty (low and unstable income)
2. Hunger (poor nutrition and health)
3. Social disparity and inequality (rights, gender, access to resources, etc.)
4. Energy scarcity
5. Land degradation
6. Climate change
7. Deforestation and habitat loss
8. Biodiversity loss
9. Lack of reward for ecosystem services

Poverty ranks No. 1 among the development challenges, and South Asia is home to most of the world's poor. Of about 1.6 billion people (i.e., nearly one-quarter of the world population), about 688 million (nearly 43 percent) live on a dollar a day in the region. This figure is higher than those for Sub-Saharan Africa, East Asia, the Middle East, Latin America, the Caribbean and the Pacific region, including China. The poor are trapped in a vicious cycle of land degradation, biodiversity loss, water scarcity and vagaries of climate change, where one component drives the other.

South Asia is home to most of the world's poor. Above, poverty-stricken, malnourished children in a village in Rajasthan, India.
© V. P. Singh

Smart Research Approaches and Strategic Goals



Dr V.P. Singh (right), then Regional Coordinator of ICRAF's South Asia Programme, interacting with progressive farmers at Athagarh, Odisha, India. Standing to his right is Ms Devashree Nayak, a member of the Programme's research team.
© Anuj Parihar

ICRAF uses an innovative approach, emerging from a new school of thought: the landscape approach. This approach is built on the concept of resilience, adaptive management and participatory research, and forms the most important thread in the tapestry of ICRAF's South Asia Regional Programme's research-for-development activities.

Agroforestry, as a well-defined discipline, is still young and at early stages of its growth, although famers have been incorporating trees into their agricultural landscapes for centuries. The new definition of agroforestry recognizes that it is much more complex than conventional agriculture. Agroforestry landscapes involve mosaics of multiple components, including trees, shrubs, crops, livestock, and people. Assessing and improving the overall performance of a given mosaic in such complex combinations demands a transdisciplinary effort, using new methodologies in harmony with economic, social, and environmental factors. The traditional ecosystem approach used for conventional agriculture does not seem to work well for agroforestry as it misses to take into account the human activity and how it affects landscape transitions, the interaction of trees with other components in a given mosaic and with the physical environment involving the natural resources management conflicts, tradeoffs, and hidden threats. ICRAF uses an innovative approach, emerging from a new school of thought: the landscape approach.

This approach is built on the concept of resilience, adaptive management and participatory research, and forms the most important thread in the tapestry of ICRAF's South Asia Regional Programme's research-for-development activities. Within the framework of the landscape approach, SARP places great emphasis on the concept of payment/reward to farmers in cash or kind, who manage and maintain ecosystems and their services. Application of this concept makes farmers feel the 'custodians' of natural resources, and ignites their enthusiasm to take better care, and help maintain the sustainability of natural resources. SARP, therefore, ensures that farmers and communities are fully integrated into research teams as equal partners.

A paradigm change is needed in transforming the women farmers' role from being dependent and passive recipients of assistance to being acknowledged as key players in agroforestry research and development, and as promoters of social transformation.

SARP recognizes the important role that women play in agroforestry, and the need to empower them through major policy changes, although their roles vary in different countries. India stands out as one country in South Asia where women farmers (average 55 -65 percent) play diverse dominant roles in the production, processing, and sale of agroforestry products. Yet, they do not enjoy the decision-making power, land rights, or access to resources. The rate of female illiteracy, poor health, and pregnancy deaths is still high in rural South Asia. A paradigm change is needed in transforming the women farmers' role from being dependent and passive recipients of assistance to being acknowledged as key players in agroforestry research and development, and as promoters of social transformation.

Working directly with farmers helps researchers to design gender- and culture-responsive interventions, identify loopholes in policy, institutions and infrastructure that affect farmers' lives, and bring them to the attention of national governments.

The outputs of SARP's smart research approaches (reported here under "Major Achievements") to address the development challenges in South Asia are paving the way for the poor to come out of the vicious cycle created by the degradation of natural resources. Overall, the outputs of SARP's research contribute to ICRAF's strategic goals, set out in its new Strategy for 2013-2022, as follows:

Strategic Goal 1: Build livelihoods by generating knowledge, choice, and opportunities

Strategic Goal 2: Improve landscapes and their sustainability by better managing their complexity

Strategic Goal 3: Transform agroforestry impacts to large scale through policy, innovation, and partnerships

How the South Asia Programme Works

Work plans are jointly developed with the ultimate objective of research-for-development, within the framework of national and regional priorities against the backdrop of ICRAF's global mandate, and implemented with farmers and communities, and national programmes.

SARP works through partnerships and networking. While the national research and extension organizations in the region (including the institutes in the ministries of agriculture, environment, natural resources, planning and education; and universities) are key partners and provide laboratory and field research facilities, SARP acts as a platform for a wide range of other partners with common interest to join in. These include CGIAR and non-CGIAR Centers, advanced research institutes, civil society organizations including non-governmental organizations (NGOs), sub-regional organizations, UN organizations, and donors.

SARP has no laboratory or field research facilities of its own. It only plays a catalytic role, and acts as a facilitator, in implementing the research agendas of its partner countries. Using an integrated approach, the projects are geared to make the most efficient use of the available national expertise and resources and to benefit from the comparative advantages of the partners involved, with backup support from ICRAF headquarters, where necessary, and to promote the development and adoption of new technologies. Joint expert teams conduct studies on impact assessment and constraints to adoption of new technologies, and develop recommendations for improvements in policy, institutions and infrastructure, including post-harvest storage technologies, access to markets, and other areas that affect the lives of poor farmers.

SARP is also actively involved in capacity building of national partners in strategic areas, who, in turn, help improve the quality and pace of research. The Programme both organizes and participates in national, regional, and international scholarly meetings to promote interaction and exchange of knowledge and experience.

Working directly with national partners provides first-hand information on the problems and possible solutions; and about any new, emerging changes taking place in agroforestry systems. Feedback of this information to ICRAF headquarters helps the Centre to realign its dynamic global research agenda for its relevance and impact, and refine its strategic plan. The feedback also helps ICRAF identify technologies and systems that could be replicated in other regions to avoid duplication of efforts.

Programme Priorities

SARP activities are built around the following priorities:

- Development of efficient supply systems for improved germplasm and high-quality planting material
- Intensification and diversification of agroforestry
- Assessment of the current and future demand for agroforestry products, and market and value chain analysis
- Assessment and rehabilitation of degraded land
- Climate change mitigation and adaptation
- Carbon finance
- Bioenergy and biofuel production
- Payment/reward for environmental services
- Impact assessment
- Policy improvement
- Capacity building
- Inter-regional and international collaboration

Programme Networks

SARP implements its activities through four principal networks, each designed to address the needs of a specific agroecological environment and operated by teams involving multiple partners (Table 1).

Table 1. Principal Networks of the South Asia Regional Programme

Agroecological Environment				
Network	**Hilly and Mountainous Areas**	**Indo-Gangetic Plains**	**Semi-Arid Areas**	**Coastal Humid Areas**
Timber/other Wood Products	Afghanistan, Bangladesh, Bhutan, India, Nepal, Sri Lanka	Bangladesh, India, Nepal, Pakistan	Afghanistan, India, Pakistan	Bangladesh, India, Maldives
Climate Change	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan	Bangladesh, India, Nepal, Pakistan	Afghanistan, India, Pakistan	Bangladesh, India, Maldives, Sri Lanka
Medicinal Products	Bangladesh, Bhutan, India, Nepal	Bangladesh, India, Nepal, Pakistan	India, Pakistan	India, Maldives, Sri Lanka
Fruits and Nuts	Afghanistan, Bhutan, India, Nepal, Sri Lanka	Bangladesh, India, Nepal, Pakistan	India, Pakistan	Bangladesh, India, Maldives

South Asian Network on Evergreen Agriculture

Over-arching the ecosystem-specific networks, the South Asian Network on Evergreen Agriculture (SANEA) was launched by Dr Dennis P. Garrity, then Director General of ICRAF, and Dr V. Pal Singh, then Regional Coordinator for the South Asia Regional Programme, at the M.S. Swaminathan Research Foundation in Chennai, India in 2011. Professor M.S. Swaminathan, the father of the Green Revolution in India and a strong supporter of agroforestry, joined the ICRAF team to launch the network.

Evergreen agriculture is a farming system where trees are intercropped with annual food crops, thus providing a green cover throughout the year. The network will promote the use of indigenous trees and farming practices that encourage natural regeneration. It has a comprehensive research agenda, including the use of practices that protect the environment, and promote transfer of technology. All countries belonging to the South Asian Association for Regional Cooperation (SAARC) are partners in the network, which is coordinated by ICRAF's South Asia Regional Programme.

Bangladesh, India, and Sri Lanka have already pledged resources for the network, and initiated SANEA activities.

Over time, the network intends to reach out to other regions beyond South Asia and establish linkages for collaborative work.

"Evergreen Agriculture allows us to glimpse a future of more environmentally sound farming where much of our annual food crop production occurs under a full canopy of trees."
--Dr Dennis P. Garrity, Former Director General, World Agroforestry Centre

SANEA
Launching of the South Asian Network on Evergreen Agriculture. Left ro right:V. P. Singh, then Regional Coordinator, ICRAF's South Asia Programme; Edwin Price; M.S. Swaminathan, Chairman, MS Swaminathan Foundation; Dennis Garity, then Director General of ICRAF; Ajay Maken, then Union Minister for Youth Affairs and Sports; and Ajay Parida, Executive Director, MS Swaminathan Foundation.
© ICRAF/South Asia

Our Investors

SARP receives a modest amount of core funding from ICRAF headquarters to meet the operational costs of its regional and country offices. ICAR has also contributed to the core funding. But much of the funding for specific research projects is provided by national, regional, and international donors, and the CGIAR Research Programmes (CRPs). For example, the project on Livelihoods and Carbon Finance was funded by NAIP/World Bank, India with USD 1.5 million; on Enabling Smallholder Vulnerable Communities to Secure Sustainable Livelihoods under Changing Climate in India, by NICRA with USD 160 K; and the global Programme for the Development of Alternative Biofuel Crops, by IFAD with USD 2.5 million.

MAJOR ACHIEVEMENTS

A key achievement of the South Asia Programme was the change it was able to bring about in farmers' perception of agroforestry—from a casual activity alongside their agricultural activities to earn some 'pocket money', to a full programme that could generate a substantial income, often as much as, if not more than, the income from agriculture—the main component in their landscapes.

Given the long-term nature of agroforestry, quick breakthroughs are not possible. Yet, SARP has made giant strides in a short period of 10 years since it was established, and a small selection of the achievements presented here is only intended to serve as an 'appetizer' for the reader. More, detailed, information is available in research reports and journal articles published by SARP.

A key achievement of SARP, that permeates through all the research achievements presented here, was the change it was able to bring about in farmers' perception of agroforestry--from a casual activity alongside their agricultural activities to earn some 'pocket money', to a full programme, involving scientifically designed agroforestry systems, that could generate a substantial income, often as much as, if not more than, the income from agriculture--the main component in their landscapes. By implementing appropriate agroforestry systems and demonstrating their potential to generate income and employment, SARP has been successful in inspiring farmers and promoting their enthusiasm and interest in agroforestry, gaining their trust, sharing knowledge, creating awareness about protection of the environment, and kicking off a multiplier effect reflected in the increasing number of farmers participating in SARP's activities.

A Tree-based Package for Better Livelihoods and a Healthier Environment in India

In a five-year project (2009-2014) entitled "Enabling smallholders to improve their livelihoods and benefit from carbon finance," SARP, using a Consortium approach (Fig. 2), established mini, location-specific networks of farmers, both smallholder and landless, including women, from a group of villages ("grids"), in four agroecological environments in India: semi-arid in Andhra Pradesh (now Telangana), humid in Odisha, semi-arid and arid in Rajasthan, and sub-temperate in Uttarakhand.

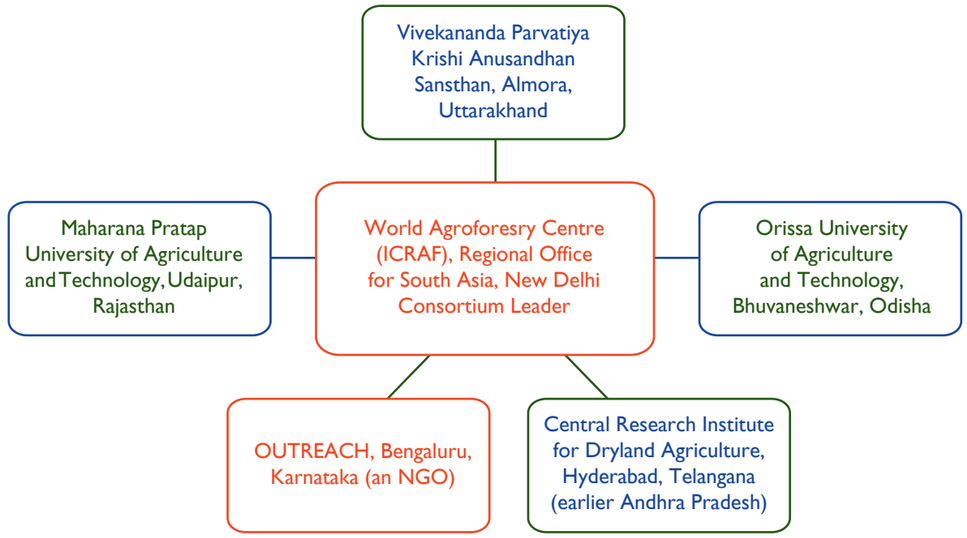


Fig. 2. Consortium partners

A participating farmer with papaya and pomegranate trees introduced in his field at Mavli Block, Rajasthan.
© Charlie Pye-Smith

Citrus trees introduced in a farmer's field at Mavli Block, Rajasthan.
© Charlie Pye-Smith

Women farmers planting Eucalyptus seedlings at Athagarh, Odisha.
© Ashok Sahoo

A participating farmer who planted teak trees on the bunds of his rice field at Jaffergudem Block, Telangana.
© Charlie Pye-Smith

In each grid there were over 1000 households and 2000 hectares of agricultural fields and community land. A facilitation unit called Gramya Sampada Kendra (Village Assets Center) was created at each grid, with its own office bearers, and registered under the Indian National/State Societies Act, which provided a legal status to it.

The stage was thus set for implementing the project activities, geared to usher in a transformation from conventional agriculture to agroforestry, and participating farmers were offered the following package:

- **Planting trees:** Tree species appropriate for each environment were selected for the participating farmers to plant. High-value trees were planted on field bunds; horticultural crops, fodder and fertilizer trees, timber and fuel trees, and shrubs were planted in the fields and common lands. To reduce emissions, farmers were advised to plow back crop residues, instead of burning it, follow minimum and zero tillage, row planting, and rotational irrigation practices, and use compost and manures. Across the grids, over 371,000 trees were planted. Not counting the income from the products of these trees, and the value of carbon units sequestered by them, the value of these trees itself will grow exponentially to about Rs 10 crores (100 million), with a conservative estimate of only Rs 1,000 per tree, say, after 10 years.
- **Using energy-efficient cooking stoves**: Participating farmers were provided with efficient energy-efficient cooking stoves at a subsidized price to replace their traditional open-flame chulhas which use fuelwood, to reduce carbon emissions, and save energy. This led to a reduction in fuelwood consumption by 50 percent, and saved the hard labor involved in its collection from community lands/forests.

A participating farmer with his solar lantern at Almorah block, Uttarakhand.
© Dibakar Mahanta

The project continues to have a multiplier effect. Over 5,000 farmers have already adopted the project recommendations, convinced that the future holds a promise for them for better livelihoods and a healthier environment.

- **Using Compact Fluorescent Lamps (CFLs) and solar lanterns in place of Edison bulbs:** Energy-saving CFLs and solar lanterns were provided to participating farmers at a subsidized price to replace the Edison and incandescent bulbs. This intervention provided a saving of Rs 840 in electricity bills and 18 liters of kerosene (where used) per household per year.
- Training, workshops, TV and radio programmes, and printed information material in local languages were provided to help improve skills of the participating farmers and maintain the momentum of activities.

Payments received from farmers were placed in an interest-earning bank account in the name of Gramya Sampada Kendra for community use.

Certified Emission Reductions (CERs) estimated across all grids worked out to 57,755 units, of which 46,445 resulted from tree-based and 11,310 from energy-based interventions. Baseline studies of carbon stocks followed the methodologies accepted by the Kyoto Protocol's Clean Development Mechanism (CDM). To translate these CERs into money, in Andhra Pradesh alone, where farmers were able to save 11,500 CERs per year, the households could receive over Rs 33,00,000 (USD 55,000, assuming 1USD=60 Rupees) per year, at a modest value of USD 5 per CER. A number of companies have expressed an interest in buying carbon credits from the project.

The project continues to have a multiplier effect. Over 5,000 farmers have already adopted the project activities, convinced that the future holds a promise for them for better livelihoods and a healthier environment.

The project was financed by ICAR under the umbrella of its National Agricultural Innovation Project (NAIP), and followed the "SMART-CDM" (Specific, Measurable, Achievable, Realistic, and Tangible–Clean Development Mechanism) protocol developed by ICRAF scientists.

Restoring the Health of Degraded Lands with Agroforestry in India

According to a recent report from the Indian Space Research Organization (ISRO), nearly 32 percent of India's land area is undergoing processes of land degradation. Water erosion, vegetal degradation, and wind erosion are the three most serious of those processes. Rajasthan, Jammu & Kashmir, Gujarat, and Maharashtra have high proportions of land undergoing degradation.

As a result, shortage of food and fodder is forcing farmers and other villagers to migrate to urban areas, leaving their land to degrade even more, and to add pressure on the urban-area resources which are already in short supply (electricity, water, housing, etc.).

Recent research has demonstrated that community-driven restoration schemes can be instrumental in halting and even reversing land degradation across India and dissuading the farmers from migrating to urban areas. SARP, in collaboration with one of its partners in Rajasthan-- the Foundation for Ecological Security (FES)--launched such a scheme at two pilot sites in Bhilwara district of the State: Amartia and Kekadia villages. A range of relatively simple land rehabilitation measures were introduced in both villages. The communities constructed contour trenches, gully plugs, soil-filled cages, loose boulder check dams and earth bunds, and a series of stone-wall enclosures to capture rainwater. Social grazing lands (about 45 hectares in each village) were fenced for controlled grazing. Selected tree species, which included bamboo, sissoo, acacia, and amla were planted; and some areas were seeded with fodder legumes (stylo) and grasses (*Cenchrus* sp.).

In a short period of just six years, rainwater runoff reduced from 80% to 45–50% in the areas where bunds were constructed. The water level in the wells rose by 1.5 m, and there has been a significant increase in forest cover. Before the conservation measures were introduced, farmers in the two villages grew crops on just 73 hectares of arable land. Now, with increased availability of water and nutrients, they are farming on 135 hectares, and crop productivity has risen by 24 percent. Before the project began, farmers were buying livestock fodder for at least six months every year. Now they have a surplus, and in 2010, they raised over 1.4 million rupees from fodder sales.

A project site in a village in Bhilwara with a stone wall constructed by the community to capture rainwater and prevent runoff and soil erosion in 1998 (left), and regeneration of vegetation in the stone wall enclosed area in 2007 (right).
© V.P. Singh

Fodder Trees for Better Livelihoods of Livestock Farmers in India

Livestock-based livelihood system (dependent on fodder tree, Khejri) in Churu District, Rajasthan.
© V.P. Singh

Livestock are a major source of income for the small and marginal farmers in India, and account for about 32 percent of the total agricultural output in the country. India has the distinction of having the largest number of livestock in the world, but the shortage of fodder in all three of its forms—green (60 percent), dry (20 percent), and concentrates (60 percent)—does not allow farmers to exploit the full potential of their livestock. Nutritional quality of fodder is also important. Performance of not only indigenous but also improved breeds of livestock remains low if they are not fed nutrition-rich fodder. Allocating more arable land for fodder production is not an option. Production increases must be achieved from improved, high-yielding varieties and innovative agroforestry practices. The Government of India is well aware of the fodder crisis and has been making aggressive attempts to address it. SARP joined the National Initiative on Climate Resilient Agriculture (NICRA) of India in one such attempt to deal with the problem in Rajasthan and Uttar Pradesh.

The project was implemented in Udaipur, Bhilwara, Chittorgarh, Churu and Fatehpur- Shekhawati districts of Rajasthan, and the Allahabad district of Uttar Pradesh. Participating farmers were grouped into "grids" of 30-50 hectares of land area. The project employed the following interventions:

- Promoting natural regeneration of fodder trees and grasses on common lands through social fencing to avoid overgrazing, seeding grazing lands with fodder grasses and legumes, and controlled harvesting and sharing of fodder from these lands
- Using appropriate management practices, such as the linear tree planting geometry, and keeping proper intervals in fodder tree lopping

Among fodder trees, *Prosopis cineraria* (Khejri) was the most popular; its density varied from 20-30 trees per hectare. The land in grids was also seeded with *Cenchrus ciliaris*, a fodder grass, and *Stylosanthes scabra*, a fodder legume. This was supplemented with planting fodder maize and bajra, and berseem, where irrigation was available.

Farmers were able to regenerate fodder vegetation from almost rootstock and stubbles in common property pasture lands to fully grown trees in two to three years. Field grasses also grew during this period to add to fodder production.

All farmers in the project grids were able to produce more than enough fodder for the entire year. Some communities, after saving the fodder for their livestock, sold the rest. There was a significant increase in livestock population and milk production at the Uttar Pradesh site: 6000 liters of milk was being sold daily. Forced sale/slaughter of livestock due to fodder shortage in Rajasthan came to an end.

Tree-based fodder system for livestock in Rajasthan: Prosopis cineraria (Khejri), a fodder tree, grown with mustard and chickpea.
© V.P. Singh

Alternative Biofuel Crops for Clean Energy and Better Livelihoods

Mixed plantation for evaluation of different biofuel tree species: Azadirachta indica, Simarouba glauca, Pongamia pinnata, Aphanamyxis polystachya and Calophyllum inophyllum.
© ICRAF/Biofuels Programme

Biofuels, if produced sustainably, have the potential to provide the much needed clean energy for enhancing agricultural production in developing countries.

Biofuels have generated much attention globally because of their projected ability to provide alternative sources of clean energy and reduce greenhouse gases that contribute to climate change. Initially, biofuel production involved the use of food crops, such as maize, wheat, sorghum and sugarcane, but these efforts are facing severe criticism in "food vs fuel debates" globally. Use of food crops for biofuels threatens food security, particularly of the poor in developing countries, and can trigger deforestation to bring new lands under cultivation. In spite of the controversy that surrounds biofuels, their demand has been rising rapidly both in developed and developing countries, driven mostly by their mandates and subsidies. Biofuels, if produced sustainably, have the potential to provide the much needed clean energy for enhancing agricultural production in developing countries.

Biofuel sources are renewable; fossil fuel sources are not. New technologies are needed for sustainable production of biofuels, without compromising food and energy security. To respond to this challenge, a paradigm shift has been underway in recent years to exploring alternative biofuel crops that are not used for food and do not involve any land-use change. For this shift to be successful, there are social, economic, environmental, and technical issues that need to be addressed. These include: profitability of feedstocks both to growers and biofuel producers; poverty reduction potential; sustainable use of natural resources (particularly impact on water resources and biodiversity); the tradeoff between carbon and nitrous oxide (where fertilizer is used) emissions in producing feedstocks and carbon emissions reduced by using biofuels; empowering women; generating employment opportunities; and rural social inclusion.

To address these complex issues, ICRAF, in 2013, with financial support from IFAD, launched a "Programme for the Development of Alternative Biofuel Crops in South Asia, Latin America, and Africa". The Programme will run for four years and has three interrelated components: (i) conduct coordinated action research along the entire value chain of non-food or multiple-use biofuel crops that can be grown on degraded lands as well as under saline conditions, (ii) support local energy provision and offer policy recommendations to governments on biofuel production that does not compromise food security or health of the environment, and (iii) disseminate knowledge and organize awareness campaigns to use biofuels as an instrument of rural development. The Programme plays a catalytic role in strengthening public-private sector partnerships and promoting cooperation between international research and development organizations and foundations.

The Programme uses a landscape approach, with small farmers as its target beneficiaries. The overall goal is to develop 'energy-smart' integrated food and energy agroforestry systems that would ensure higher yield of feedstocks per unit of land area, food security, local energy provision, and additional income to improve the livelihoods of smallholder farmers and increase their resilience to climate change.

Through partnerships with multiple stakeholders, the Programme is exploring the use of local, multi-functional oil-bearing 'crop trees' such as macaúba (*Acrocomia aculeata*), pongamia (*Millettia pinnata*), simarouba (*Simarouba glauca*), mahua (*Madhuca longifolia*), and neem (*Azadirachta indica*), as alternative candidates. These species have high potential for biofuel production. In well-designed agroforestry models, they can even improve the productivity of food crops and livestock.

In South Asia, the Programme's emphasis is on improving and scaling-up the successful biofuel production initiatives taken in the State of Karnataka, India during the past decade. In partnership with the University of Agricultural Sciences, Bengaluru and the Karnataka State Biofuel Development Board, the Programme is improving rural livelihoods by supporting family farming of biofuel species along with food, fodder, and other crops.

Local species of pongamia, simarouba, mahua, and neem are being integrated into traditional agricultural systems, by growing them on bunds and along borders of fields; they are also being established on marginal lands. These trees contribute to local energy provision, and generate additional income and employment opportunities throughout the year. The oil extracted from their seed is cleaner than diesel, and can be processed into biodiesel, or used directly for fueling generators, tractors, and irrigation pumps. The leftover seed cake is also valuable: it is used as animal feed, biofertilizer, or for the production of biogas. On top of these benefits, this energy-smart agroforestry model reduces soil erosion and even the use of pesticides.

Rejuvenating Old Mango Trees in India

Mango, the "King of Fruits", is native to South and Southeast Asia. It is the national fruit of India, Pakistan and the Philippines, and the national tree of Bangladesh.

Mango, the "King of Fruits", is native to South and Southeast Asia. It is the national fruit of India, Pakistan and the Philippines, and the national tree of Bangladesh. Other than the popularity of its juicy, delicious fruit, its leaves are used in religious rituals, weddings, and public celebrations in some cultures.

India accounts for about 40 percent of the world mango production. Demand for the fruit is rising both at home and elsewhere in the world, but mango farmers are not able to capitalize on the export potential of the fruit. The reason: at least half the country's mango orchards are over 40 years old. Challenged by age, productivity of mango trees in those orchards has declined drastically, and maintaining them (protection against disease and insect pests, cost of labor and inputs) is no longer an economically viable option for farmers.

One option for the farmers could be to remove the old trees and plant new ones in their place. But this option would not only be expensive, time consuming and legally complicated, the farmers would have to wait for 6 to 10 years before seeing any fruit.

Researchers from the Indian Agricultural Research Institute (IARI) and SARP explored the option of rejuvenating the old mango trees. At the horticulture research farms of IARI, they first identified the old trees that were still healthy enough (not damaged by disease or insect pests or lack of nutrition) and fit for the rejuvenation procedure.

Canopies of the trees selected were inspected for the passage of light and to determine whether the canopy opening should be total, partial, central, or peripheral. Differential pruning was employed, in which trees were either pollarded or headed. Copper oxychloride paint was applied to the cut surfaces for protection against insect pests and disease. Adequate nutrients and water were provided, and the inter-tree spaces were mulched.

It takes about three years for the rejuvenated trees to start producing fruit: new shoots develop in the first year; a good canopy develops with mature buds and some fruit in the second year; and a bumper yield of 8-10 ton/ha starts in the third year (more than double the average yield). The life of rejuvenated trees can span about 15-20 years.

There are other advantages, too. With canopies reduced, farmers can plant high-yielding crop varieties in the spaces between the rejuvenating trees. And the timber harvested from pruning the trees selected for rejuvenation, could fetch a revenue equivalent to four or five crops of fruit (Rs 2400-7500 per tree, depending on the volume of pruning). It is a win-win situation for farmers: no loss of income while the trees are rejuvenating, and a prolonged and more productive life for their orchards.

Pollarded/headed mango trees
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Rejuvenated mango trees with rich first fruiting
© A. K. Singh.

It is a win-win situation for farmers: no loss of income while the trees are rejuvenating, and a prolonged and more productive life for their orchards.

Sentinel Landscapes

A sentinel landscape is a large site, or a network of contiguous sites--bounded by common ecogeographic features, and anthropogenic activities driven by local cultures and traditions--where a broad range of biophysical, social, economic and political data are monitored and collected, using standard methods, and interpreted over the long term. It is a common observation ground where the trail of biophysical processes, and the changes they cause, and how the communities have been responding to them over time, could be followed to understand the pattern of changes. The information thus obtained is used to educate the society, inform policymakers, and engage the government, public and private sectors, and the media for safeguarding the welfare of the communities and protection of the landscapes and their physical environment.

The concept of identifying a set of sentinel landscapes is an initiative of the CGIAR Research Programme on "Forests, Trees and Agroforestry", led by the Center for International Forestry Research (CIFOR), in partnership with ICRAF, Bioversity International, and the International Center for Tropical Agriculture (CIAT).

The Programme is integrating comparative, site-based research, conducted through a network of partners, in the context of publicly available datasets. Building on the integration of high-value datasets already assembled, such as the extensive land degradation database of ICRAF, the Poverty and Environment Network of CIFOR, and the large-scale data networks of IFPRI (International Food Policy Research Institute), long-term monitoring of plots is underway.

Of the seven priority sentinel landscapes identified by the CGIAR Programme, the Western Ghats in India is one. The Western Ghats are a mountain range in India that runs almost parallel to the western coast of the great Indian Peninsula, covering about 160,000 km^2, and is home to about 242 million people. The range is a UNESCO World Heritage Site, and one of the "hottest hotspots" of biological diversity in the world. It has over 4,780 plant species (46 percent endemic), 58 protected areas, 14 national parks, and 44 wildlife sanctuaries. Infrastructure development and agroforestry are the main drivers of change. Landscapes are dominated by agroforestry systems, with forest fragments, and large tracts of state-controlled forests.

Four sites in the Western Ghats Sentinel Landscape have been identified for data collection and research: Kodagu, BRT Hills (Biligiri Rangana Temple Tiger Reserve), Wayanad, and the Nilgiris. SARP has initiated data collection activities in Kogadu and BRT Hills.

Kogadu is characterized by forests, agroforestry and rice cultivation; and complex shade- grown coffee agroforestry systems. Small landholdings (less than two hectares) represent about 58 percent of the total, and 22 percent of the coffee area.

In BRT Hills, 52 percent of the area is protected (including Tiger Reserves). The site is characterized by Soliga tribal settlements. The tribal population accounts for about 11 percent.

Socioeconomic data has been collected from 250 households in the BRT Hills, and 240 in Kodagu. Adopting the Land Degradation and Surveillance Framework (LDSF), developed by ICRAF, biophysical data has been collected from 160 plots each in Kodagu and BRT Hills. Socioeconomic and biophysical data collection in Wayanad and the Nilgiris will start soon.

ICRAF has conducted training for national partners on LDSF and the role of Geoinformatics in agroforestry.

A complex agroforestry mosaic in Kodagu, Western Ghats. Coconut and areca nut (Areca catechu) trees (right); paddy (foreground); unused land with livestock grazing on natural vegetation (background); an evergreen forest (around the landscape), involving Dalbergia latifolia, Acrocarpus fraxinifolius, Artocarpus hirsutus, Termanalia sp. and Dipterocarpus sp. trees. On fringes of the forest are banana trees.
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Tapping into the Agroforestry Potential in Karnataka

Intercropping of Napier grass in coconut-based agroforestry system in Tumkur, Karnataka.
© S.K. Dalal

SARP has initiated a scoping study to explore the potential of agroforestry in four districts of Karnataka: Tumkur, Chikamagalur, Bijapur, and Raichur. The SARP team, with its partners in Karnataka, conducted intensive surveys of the pilot sites in these districts, held discussions with farmers, researchers and local authorities, and designed a set of agroforestry interventions for each site.

In Tumkur district, the model with staggered trenches was found suitable in the dry belt where little moisture is available for agroforestry.

Tamarind was the most suitable and popular tree, but fodder trees would need to be added to meet the growing demand for feed for cattle, goat, and sheep. In the field, dryland crops, such as groundnut, could be grown profitably.

In Chikamagalur, coffee plantation dominates. The district has two distinct terrains: a hilly terrain with high rainfall, and a lower altitude, transitional terrain with low and erratic rainfall. In the hilly terrain, where coffee plantation is most popular, planting silver oak and jackfruit on boundaries would be the best option.

In the lower altitude terrain, with sloping lands and low rainfall, the staggered trenches agroforestry model would be useful in conserving moisture and recharging groundwater. Coconut plantation is widely practiced in the area, mixed with grain crops, and in some fields, with forage crops, such as Napier grass and sorghum.

In Raichur, the average rainfall is low and summers are harsh. A lot of water in reservoirs and ponds is lost to evaporation.

Fruit-tree-based agroforestry system in Bijapur, Karnataka.
© S.K. Dalal

Multi-tier coffee agroforestry system in Chikamagalur, Karnataka.
© S.K. Dalal

Therefore, crops such as honge (Indian beech) and bevu, which can grow in low-moisture conditions, would be appropriate, in combination with drumstick for quick cash, and fodder trees to support livestock. Raised bunds were found useful in conserving water and for planting trees.

In the Manvi *taluka* of Raichur district, however, a sizeable area is under irrigation. In such areas, teak on boundaries mixed with plants like Indian gooseberry and custard apple would be a good option.

In Bijapur, bunds around the fields helped conserve moisture and check soil erosion. On drainage lines, small check dams could help conserve soil and water, and agroforestry plantations in the adjoining areas could protect the check dams against soil erosion. Another activity found useful was planting oil-borne trees in combination with fodder trees and drumstick. Of horticultural crops, dryland species, such as Indian gooseberry, drumstick, and lemon, would be good options.

The leads emerging from this scoping study will be used for developing more efficient agroforestry systems for the entire State.

Prize-winning Trees

In 2007, the Utthan Centre for Sustainable Development and Poverty Alleviation, one of ICRAF's key partners in India, was awarded the prestigious Alcan Prize for Sustainability, worth USD1 million, to recognize the Centre's outstanding achievements.

Rio Tinto Alcan and the International Business Leaders Forum, managing partners of the Alcan Prize, when announcing the prize, cited two of Utthan's agroforestry projects among its major achievements. One has involved the widespread planting of Jatropha curcas, whose seeds are used to make carbon-neutral biofuels; the other has helped to reclaim large areas of degraded land. These projects have benefited at least 100,000 people, many of them being among the poorest inhabitants of degraded tribal areas in North India.

SARP researchers provided technical advice and helped identify and source the superior varieties of trees for both projects. In one of these, some 750 hectares of degraded land, belonging to 735 socially and economically disadvantaged families, was reclaimed using superior varieties of Jatropha with early fruiting and higher nut and oil yield. The initial investment amounted to around USD 650 per family. By the third year, the beneficiaries were earning USD 1,200 each from the sale of Jatropha seed.

As a result of this project, Jatropha has received widespread attention and Utthan believes that its cultivation on the 30 million hectares of wasteland in India could produce 60 million tons of biofuel a year, thus saving USD20 billion in oil imports.

The second project benefited 90,000 families who reclaimed over 85,000 hectares by planting bamboo, babool, Jatropha, and medicinal plants. The tree cover in the project area has increased, and soil fertility and crop yields have remarkably improved.

Utthan has also been involved in health and education. Its health programmes have led to the immunization of 600,000 children against six preventable diseases, and its literacy and adult education work has benefited around a million people in Uttar Pradesh, Chhattisgarh, and Madhya Pradesh.

Jatropha has received widespread attention and Utthan believes that its cultivation on the 30 million hectares of wasteland in India could produce 60 million tons of biofuel a year, thus saving USD20 billion in oil imports.

Wasteland reclaimed with Jatropha in India.
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Mapping Trees Outside the Forests

Information generated by mapping trees outside the forests should be useful for the Greening India Programme, which has a target of 33 percent tree cover in all States by 2020

SARP, in collaboration with its partners in India, used the satellite imagery analysis carried out by the Forest Survey of India to map trees outside the forests. Detailed analysis was conducted for Yamuna Nagar district in Haryana, a number of villages in the Lucknow district of Uttar Pradesh, and for Punjab. Researchers used different methods of sampling on remotely sensed data to analyze the nature and extent of linear plantations, such as avenues along canals and roads, block plantations and scattered trees, at different levels.

Countrywide, mango was found to be the most important agroforestry tree, followed by neem and coconut. Not surprisingly, there was considerable variation between States, with just 0.3 percent tree cover on farmland in Sikkim to 13 percent in the Lakshadweep. In Punjab, almost half the trees on farms are eucalypts and poplars. In Kerala, mango, coconut, and other fruit trees predominate.

This information should be useful for the Greening India Programme, which has a target of 33 percent tree cover in all States by 2020. Some States could meet this target by planting more trees on state-owned forest land, but others, lacking forest land, will have to turn to agroforestry and plant trees on agricultural land.

Time series images (2001-2014) from Google Earth showing farm fields with Block Mango Plantations at Jaffergudem Grid, Warangal District, Andhra Pradesh, India (under supervision of ICRAF's project partner, Central Research Institute for Dryland Agriculture (CRIDA).
© Devashree Nayak

Fighting Coconut Disease in Sri Lanka

There is no energy drink that can compete with coconut water in its nutritional value and price.

In Sri Lanka, coconut trees cover more area than any other trees or crops: 394,386 hectares, of which 2,543 hectares lie in Galle, 14,398 in Matara, and 20,733 in Hambantota districts. According to FAO, the country is the world's fifth largest producer of coconuts. For hundreds of thousands of resource-poor farming families, coconut, the fruit, itself is a key source of income.

Street vendors selling green coconuts for coconut water is a common sight in Sri Lanka and other coconut-producing countries in South Asia. Going by medical literature, there is no energy drink that can compete with coconut water in its nutritional value and price. Some people even refer to coconut water as an "elixir of life". Packaged coconut water is flooding the international market, and can be an excellent source of income for coconut farmers, but this opportunity has not yet been fully exploited. Other than coconut water, a coconut tree provides food, cosmetics, wood, choir, and pharmaceuticals for famers to improve their income and livelihoods.

Given the importance of coconut tree farming, the outbreak of the Weligama coconut wilt leaf disease in 2007 in Sri Lanka was understandably a cause of serious concern for the Government of Sri Lanka. This phytoplasma disease, transmitted by insects and fatal to the infected trees, affected over 320,000 trees in the three districts named above. Since this disease was first observed some 20 years ago in Kerala, India, and a lot of research had been carried out

Symptoms of Weligama wilt leaf disease on infected coconut trees in Sri Lanka.
© HPM Gunasena

to deal with it, SARP lost no time to connect Sri Lanka's Coconut Research Institute (CRI) to the Central Plantation Crops Research Institute (CPCRI) in Kerala. Researchers and policymakers from Sri Lanka visited CPCRI to develop strategies to contain an control the disease, including the creation of a 3-km-wide barrier around the three worst affected districts. Diseased trees were felled, and CRI began a programme to breed disease-resistant coconut trees.

ICRAF's contribution to tackling the disease through technical support to maintain the health of coconut-based agroforestry systems in Sri Lanka was acknowledged on the World Coconut Day, 12 October 2012, when the Sri Lankan Ministry of Coconut Development and Janatha Estate Development presented a special award and a certificate of appreciation to Dr Ravi Prabhu, ICRAF's Deputy Director General for Research, and Dr V.P. Singh, then Regional Coordinator of ICRAF's South Asia Programme.

Dr Ravi Prabhu (left), ICRAF's Deputy Director General for Research, and Dr V.P. Singh (right), then Regional Coordinator of ICRAF's South Asia Programme, receiving awards and certificates of appreciation from (left to right), Honorable Basil Rajapaksa, Minister of Economic Development, Honorable Jagath Pushpakumara, Minister of Coconut Development and Janatha Estate Development, and Mr Nihal Somaweera, Secretary, Ministry of Coconut Development and Janatha Estate Development, Sri Lanka.
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Raising Food Production in the Maldives

With a small area of arable land with poor soil, agriculture in the Maldives contributes only 6 percent of the GDP, and is limited to a few subsistence crops, such as coconut, banana, papaya, and mango. To feed its population in its scattered islands, the Maldives depends on food imports. Tourism, fishing, and small-scale industry are the main sources of income.

Agriculture not being an important sector, agricultural research and education in the Maldives has not received a high priority. There is, therefore, a shortage of trained personnel, who could help farmers to manage their crops better.

In 2010, the Government of the Maldives and IFAD (International Fund for Agricultural Development), with SARP as a partner, launched a project geared to improve home-grown food production by developing a cadre of trained agricultural experts who could guide local communities to improve the production of high-value crops.

The project team hired consultant teachers who taught a basic course in agriculture to a group of high school students for six months. Eleven most promising students were then selected to undergo a specially designed diploma course at the G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. The students had opportunities for field visits and to interact with teachers and researchers at the University to enrich their knowledge and skills. They then returned to the Maldives where they spent a year to gain practical experience in the field under the supervision of the University professors.

Mahatma Gandhi's slogan "each one, teach one" worked in the Maldives, too. The project-groomed 'graduates' are now imparting training to agricultural technicians, as well as advising farmers, throughout the Maldives. These efforts are enabling the farming communities to produce and market a range of vegetables, unlike before. A recent government report acknowledges that agriculture is now becoming increasingly popular among farmers, and is even competing with fisheries in its contribution to GDP.

A farmer's field with eggplant (foreground) and papaya (background) in Hanimaadhoo Island, the Maldives.
© V. P. Singh

Innovative Agroforestry Systems in Bangladesh

A three-tier agroforestry system (jack fruit, papaya, brinjal) in Narsingdi village, Bangladesh.
© Md. Giashuddin Miah

Participating farmers' income increased by 280 percent in Narsingdi, 550 percent in Kapasia, and 300 percent in Paikgacha villages, in Bangladesh.

Agroforestry took root in Bangladesh in the 1980s, and has seen much progress since then. With increasing support from the Government of Bangladesh, and partnerships with regional and international research and development organizations, NGOs, and other players, agroforestry in the country is witnessing fast advancements. One example of such partnerships was a recent three-year (2011-2014) project entitled "Improvement of Agroforestry Practices for Better Livelihoods and Environment," in which the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) and SARP were partners. The project was funded by the Sponsored Public Goods Research (SPGR) Programme of Bangladesh Agricultural Research Council (BARC).

The joint research teams conducted both formal and informal surveys to identify the traditional agroforestry systems and practices, as well as constraints, in two ecosystems: Terraces (at Narsingdi and Kapasia sites), and Coastal Zone (at Paikgacha site). The survey, which covered 60 respondents at each location, revealed that farmers were practicing jackfruit-based agroforestry systems in Narsingdi, guava-based in Kapasia, and mango-based in Paikgacha. But they were not happy because the yields were low and the income much below their expectation. The major constraints included a lack of appropriate technologies, high cost of production, and high incidence of insect pests and disease. Shortage of water for irrigation during dry seasons was a major problem in Narsingdi and Kapasia; and salinity in Paikgacha.

To ensure that project interventions would be successfully implemented, 50 farmers drawn from the three sites were first given training in key areas of agroforestry systems. Following the training, 5, 11, and 16 farmers were then selected, based on their enthusiasm and skills, from Narsingdi, Kapasia and Paikgacha, respectively, to participate in on-farm experimentation with the team of project researchers.

The jackfruit-based system in Narsingdi was transformed into a three-tier agroforestry system, with jackfruit in the upper tier; papaya, lemon, and sweet orange in the middle tier; and seasonal vegetables such as brinjal, bottle gourd, ash gourd, and turmeric in the lower tier. Jackfruit yield increased remarkably (about 33 percent) because of the 'spillover' benefits from fertilizer and irrigation applied to the m iddle and lower tiers. Papaya gave acceptable yields, and helped to make the system economically more profitable. The crops in the lower tier produced reasonable yields, although lower than those from control plots, due to inter-crop competition for resources. Overall, the three-tier systems in Narsingdi produced higher profits, reaching about 280 percent in one of the participating farmer's fields.

In Kapasia, where farmers had guava, jackfruit, and banana plantations, yields and income levels were low. These fields were transformed into litchi- and guava-based agroforestry systems, in combination with several common vegetables. Papaya seedlings were transplanted between litchi plants, and Indian spinach was grown in the spaces between litchi and papaya. Although yields of the vegetables tested were slightly lower than expected, the introduction of papaya significantly contributed to the profitability of the system. In the litchi-based system, brinjal was most profitable, followed by Indian spinach and tomato. Sweet gourd was found to be suitable in the guava-based system. The profitability levels varied among the different combinations, the litchi-based system ranked highest providing an increase of 550 percent in income to one of the participating farmers.

In Paikgacha, rice, turmeric, pulses, and seasonal vegetables were incorporated in different combinations into the mango- and ber-based systems. New mango orchards were also established. In mango-based systems, turmeric varieties, BARI halud 3, rice variety BRRI dhan 54, and Indian spinach, followed by okra and yard long bean were found to be most suitable. In ber-based systems, adding sponge gourd, okra, and mukhi kachu (*Colocasia esculenta*) were found to be both most suitable and profitable. The mango-turmeric system increased the income of one of the participating farmers by 300 percent.

Selection and screening of salinity-tolerant fruit trees is underway in the south-west coastal zone of Bangladesh. A mango cultivar, locally known as Lata Bombay, has been found to be very promising. It can also withstand inundated conditions. It produces fruit in 6-8 years, and has a productive life span of 15-17 years. Rice, vegetables, spices, and oil crops are under evaluation for use in this system.

Research continues on the improvement of yield, nutritional value, and quality of minor fruits also by using efficient management practices. Burmese grape and lemon are under trial.

Custard apple can be protected against damage if stacked as pyramids (background), as opposed to leaving it in heaps (foreground).
© V.P. Singh

Helping Farmers Understand How Markets Work

Smallholder agroforestry farmers in India derive a significant proportion of their income from fruits, nuts, medicines, dyes, raisins, and other tree products. Some of these products are sold at the farm gate, but most through middlemen. Are the middlemen facilitators, linking the poor producers to markets; or exploiters, buying cheap and selling at a much higher price? The answer is: both. Many farmers do not have adequate storage and transport facilities, are often under pressure to repay loans, and are not knowledgeable about how markets work, so they take the shortcut to sell their produce to middlemen for on-the-spot cash. But this is not an ideal situation for farmers to gain the income they deserve.

SARP is working to assess the value chain and market demand, and find ways how the profits made by the middlemen and other players in the marketing channels could be diverted to farmers themselves. The Programme is providing training to farmers on how to collect, sort, grade, package, and transport their produce; and to set up cooperatives and federations to increase their bargaining power, and understand how the market systems work.

Influencing the Development of Agroforestry Policies

National Agroforestry Policy of India: A Historic Development

At the 3rd World Agroforestry Congress (see below for details), the President of India, Honorable Shri Pranab Mukherjee, announced the launch of the National Agroforestry Policy of India. The policy development process went through a series of intensive consultations with all the stakeholders. Dr Rita Sharma, a member of ICRAF's Board of Trustees and Secretary to the Government of India's National Advisory Council (NAC), played an instrumental role in the process. ICRAF's South Asia Regional Programme team was actively involved at all stages of the process. It first launched an Agroforestry Policy Initiative in June 2011. This was followed by a series of workshops in 2012 and 2013. NAC then established a working group in 2013, with ICRAF as a partner, to develop a framework and recommendations to formulate the policy. The group organized nine national-level consultations, which came up with 10 major policy recommendations. A draft policy document was developed at a 10th national-level consultation meeting, and submitted to the Government of India. After its approval at the Cabinet level, the document was placed before both Houses of Parliament, and was approved as India's National Agroforestry Policy. ICRAF's South Asia Programme continues to play an active role in policy implementation also, by working with the policymakers and research institutions involved. The policy spells out the following objectives (verbatim):

- Encourage and expand tree plantation in complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the smallholder farmers.
- Protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- Meet the raw material requirements of wood-based industries and reduce import of wood and wood products to save foreign exchange.
- Supplement the availability of agroforestry products, such as the fuelwood, fodder, non-timber forest produce and small timber of the rural and tribal populations, thereby reducing the pressure on existing forests.
- Complement achieving the target of increasing forest/tree cover to promote ecological stability, especially in the vulnerable regions.
- Develop capacity and strengthen research in agroforestry and create a massive people's movement for achieving these objectives and to minimize pressure on existing forests

President Mukherjee stressed, "2014 should be a defining moment for evolving tree-based production systems to fight the debilitating impact of climate change in agriculture".

With a well-defined agroforestry policy, India has earned the distinction of being the first nation in the world to have such a policy.

"2014 should be a defining moment for evolving tree-based production systems to fight the debilitating impact of climate change in agriculture."

Pranab Mukherjee, President of India

Implementation of India's Agroforestry Policy

To implement India's Agroforestry Policy, the Ministry of Agriculture has already earmarked Rs 200 crores (USD 33 million), and an Agroforestry Mission is expected to be established soon with an estimated budget of Rs 4000 crores (USD 667 million). The government has funded new agroforestry plantations on about 80,000-100,000 hectares. Action has been initiated to de-regularize felling, transport and marketing of selected agroforestry species; and guidelines are in the offing to monitor and ensure availability of quality planting material, and improve the institutional and individual capacities. The Policy has greatly influenced the inclusion of agroforestry as one of the preferred investment areas through the newly introduced Corporate Social Responsibility funding mechanism. The Policy has also catalyzed the elevation of the agroforestry research center of the ministry of agriculture to a national-level Central Agroforestry Research Institute (CAFRI).

Agroforestry Policy for the Indian State of Chattisgarh

Chhattisgarh has taken the lead to become the first State in India to have its own agroforestry policy specific to its ecosystems.

SARP worked with the State researchers, authorities, and officials throughout the process of the policy development.

Over 80 percent of the State's population depends on agriculture for its livelihood. Agroforestry farmers are constrained both by the complex approval procedures and the uncertainty about the timely sale of their produce at a fair price. The new policy envisages simplified procedures to obtain government approval for agroforestry projects, both on private and public land, and a commitment from the government to buy the farmers' produce at a fair price. These provisions will particularly help the tribal communities, for whom agroforestry is the primary source of their survival. Nevertheless, farmers will be free to sell their produce to other buyers in the market. The other elements of the policy relate to simplified regulations for tree felling, transport, and sale of the produce.

The policy, thus, is expected to promote tree planting on farms and help improve the quality of life of the poor.

A Journey through Time: Agroforestry Research in India

Since the inception of organized agroforestry research at global level, India has remained at the forefront, promoting this multiple-benefit land management system. In 1983, the Indian Council of Agricultural Research (ICAR) launched an All India Coordinated Research Project (AICRP) on Agroforestry which was implemented at 20 centers located in 18 provinces across the country. This was followed by the establishment of a National Research Centre on Agroforestry (NRCA) in 1988, in Jhansi, U.P. In the past 26 years, NRCA has excelled in fulfilling its mandate and objectives. It also coordinated and managed one of the largest research network projects, the AICRP on Agroforestry, which currently operates at 39 centers located throughout the country.

ICRAF has also been actively involved in agroforestry research in India in the past decades. It has contributed to capacity building and provided support during the diagnostic and design surveys, conducted under AICRP, in agroforestry. The partnership between NRCAF and ICRAF has continued to grow and, in 2007, they developed and implemented a joint work plan. The two institutions have worked on domestication, utilization and conservation of superior agroforestry germplasm, maximizing on-farm productivity of trees and agroforestry systems, developing the National Agroforestry Policy of India, and organizing the 3rd World Congress on Agroforestry. ICRAF and NRCAF have also worked closely in capacity building of Indian and regional scientists in various strategic aspects of agroforestry.

After 26 years of successful research and development activities in agroforestry, the status of NRCAF was elevated to the Central Agroforestry Research Institute (CAFRI), in India, by ICAR.

ICRAF's Regional Director for South Asia, Dr Javed Rizvi visited the newly created CAFRI to congratulate Dr Dhyanai, Director, and his team, and to assure them of an even stronger collaboration between the two institutions. Dr Dhyani presented a memento to Dr Rizvi to acknowledge the mutually rewarding partnership with ICRAF.

In a congratulatory note to Dr Shiv Kumar Dhyani, Director of CAFRI, ICRAF's Director General, Dr Tony Simons, said: "This is a fantastic and well deserved recognition for all your and others' efforts to raise the profile and impact of agroforestry in India. The World Agroforestry Centre (ICRAF) takes this opportunity to congratulate you and ICAR, and to pledge our support for continued collaboration and engagement."

Dr Shiv Kumar Dhyani (third from right), Dr Javed Rizvi (second from left), Dr V.P. Singh (third from left), along with other senior colleagues, celebrate the formation of CAFRI.
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Rewarding the Unrewarded

ICRAF coordinated an IFAD-funded project entitled "The Rewards for, Use of, and Shared Investment in, Pro-poor Environmental Services (RUPES)" to introduce the concept of rewarding people to protect or enhance the environmental services. The project covered Indonesia, the Philippines, Viet Nam, Nepal, India, and China.

ICRAF published a comprehensive report on the completion of Phase 2 of this IFAD-funded project. Presented below are the highlights of the project's work in India and Nepal, extracted from that report. SARP was not directly involved in these efforts, but is pleased with the achievements of the project in these two countries, which belong to its geographic mandate.

India

In spite of the fact that there exists a good understanding in the Indian National Programme of the role of payments/rewards for environmental services, there has been little progress in launching any robust schemes in this critical area.

RUPES in India focused on an incentive system for Lake Loktak, the largest fresh water lake in Northeast India, located in Moirang in Manipur State, with the objective of promoting sustainable water management for ecological restoration and sustaining livelihoods. The IFAD report on RUPES states: "Lake Loktak and its associated wetlands, are multifunctional systems providing food and water security for the entire region. Sustained provision of ecosystem services derived from the wetlands is critically linked to hydrological regimes. At the core of lake degradation is a lack of integration of ecosystem services into developmental planning processes leading to over-provisioning of tangible ecosystem services while severely undermining relatively intangible regulating, cultural, and supporting services of the wetlands ecosystems."

Lake Loktak is a source of substantial revenue, of which water use for hydropower contributes about 74 percent. Current water management practices are not efficient, and do not take into account the role of payment for environmental services.

Lake Loktak is a source of substantial revenue, of which water use for hydropower contributes about 74 percent.

RUPES supported development of a water allocation policy for Lake Loktak, balancing human needs with ecological requirements. The policy has been endorsed by the Steering Committee of the Loktak Development Authority and modalities are being worked out for its implementation in participation with various stakeholder agencies.

Nepal

The ecosystems in the Hindu-Kush Himalaya (HKH) region are rich in biodiversity and natural beauty, and provide important watersheds and sinks of carbon. Nearly 1.3 billion people benefit from the services provided by these ecosystems. But economic and institutional incentives to the local communities who manage these ecosystems are either too small to make a difference or non-existent.

The RUPE's team, working in partnership with the International Center for Integrated Mountain Development (ICIMOD), and Winrock International, implemented a project in Kulekhani catchment to support the farming communities for their environmental service of reducing siltation in the reservoir of the Kulekhani hydropower plant and increasing dry season flows in streams. Project activities led to useful negotiations with the government for using some of the hydropower royalty money as an incentive for upland communities. An environmental management special fund was established under the Makwanpur District Development Committee that facilitates the allocation of a higher proportion of the royalty budget for the upstream villages. The Makwanpur District Development Committee issued a Hydropower Royalty Distribution and Use Directive in 2005, for allocating 50 percent of royalties it receives from the central government to the Village Development Committee where the hydropower plant is located. A significant proportion of this money is provided to villages in the upstream area for conservation activities. This directive was circulated to all districts in the country to adopt a similar approach of paying a higher proportion of hydropower royalties to upstream communities.

Guided by a socioeconomic survey of the villagers living in Sundarijal catchment of Shivapuri Nagarjun National Park in Kathmandu valley, RUPES developed a framework of potential mechanisms for payments for environmental services from the revenue collected through state-owned companies, private companies, and national park visitors.

Agroforestry Attracts Increased Attention in Sri Lanka

Coconut- and pasture-based agroforestry system in the intermediate zone of Sri Lanka.
© DKNG Pushpakumara

Sri Lanka spends billions of dollars every year to import food. There are three key reasons, among others, for this: (i) agricultural productivity is low, (ii) land availability is limited, and (iii) some of the available land remains unused.

To respond to the challenge of increasing food production and reducing food imports, the Government of Sri Lanka recently launched *Deshiya Ahara Nishpadana Diri Genvime Jathika Meheyuma* (National Campaign to Motivate Domestic Food Production) under the theme *Api Wavamu, Rata Nagamu* (Let us cultivate to uplift the nation) and *Divi Naguma* (Livelihood Development Programme). Promoting and improving agroforestry is one of the key components of these comprehensive programmes. In addition, a number of other agroforestry programmes are being implemented by international and non-governmental organizations. ICRAF is one of them.

Sri Lanka has a long history of agroforestry, with at least 29 agroforestry systems in place, yet the potential of agroforestry has remained under-exploited. Classification and mapping of trees outside forests is being carried out in Nuwara Eliya district of Sri Lanka to understand the importance and contribution of agroforestry landscapes to the country. Both high density and low density systems are being assessed for their contribution to landscape diversity. Based on estimates of the extent of home gardens in Sri Lanka, more than 25 percent of the country's land area is currently under agroforestry.

ICRAF's South Asia Regional Programme has been actively involved, in collaboration with national scientists, in supporting Sri Lanka's systematic efforts to review the agroforestry systems in the country, classify them (tea-based, coconut-based, rubber- based, rice-based, home-garden-based, coastal-based, etc.), determine their extent using the GIS technology, and identify their potential for development through tree domestication. A self-learning guide to agroforestry systems of the country has been published electronically.

Home Gardens in Sri Lanka

A home garden (HG) is a traditional agroforestry system practiced by farmers on land around or close to their dwellings (homesteads). Kandyan home gardens in Sri Lanka are well known around the world for their unique features and existence in the country for ages. The average area of a home garden is often relatively small, but involves multiple combinations of trees, shrubs, vegetable and root crops, grasses and herbs that provide food, spices, medicines and construction materials, and generate income and employment opportunities. Some farmers integrate livestock also into their home gardens, but not frequently. Home gardens also

contribute to enhancing and conserving biodiversity, and providing a range of environmental services, as well as cultural services by being the venues for social activities of the family and communities in an aesthetically pleasant environment.

In Sri Lanka, home gardens have been an integral part of the landscape and culture for centuries and represent one of the oldest forms of land use. HGs are usually designed to conform to the socioeconomic, cultural, and ecological needs of diverse communities and landscapes. Over 14 percent of the land area of the country is under HGs.

Although home gardens hold great potential for economic prosperity and sustainable use of land and other natural resources, they have not received enough attention from either researchers or policymakers in Sri Lanka. A long-term, multidisciplinary research programme is needed that would address the constraints to the productivity and sustainability of home gardens. The key constraints include access to suitable and sufficient land to establish a home garden along with ownership/usage rights; access to capital or credit, labor, water, planting materials and other inputs, and markets; and efficient extension and advisory services.

ICRAF's South Asia Regional Programme has been working in collaboration with national scientists in Sri Lanka to identify critical gaps in knowledge and how to fill them, and develop policy recommendations to optimize the benefits of home gardens.

A typical home garden in Sri Lanka.
© DKNG Pushpakumara

A Kandyan home garden in Sri Lanka.
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Strengthening Partnership with Nepal

Nepal's Minister of Agriculture, Honorable Hari Prasad Parajuli, flanked by senior government officials, presented a memento to Dr Javed Rizvi to express his Government's appreciation for ICRAF's proposals to strengthen partnership.
© ICRAF

Nepal is endowed with an abundance of two key natural resources, forests and fresh water, yet, paradoxically, it is one of the world's least developed nations. At least 35 percent of the country's population lives below the national poverty line. The country has to import food, because domestic food production cannot meet the demand of the growing population. The key reasons for the widespread poverty and food and nutritional insecurity are: low agricultural productivity; a lack of access to inputs (seed, fertilizer, etc.), new technologies, and agricultural credit; inadequate institutional and policy support; poor infrastructure and access to markets; and the absence of social safety nets and welfare schemes. To add to these woes, members of rural households migrate to urban areas in the country, as well as to neighboring countries in search of better livelihoods, causing a shortage of labor. About 70 percent of Nepal's population depends on agriculture for its livelihood.

Agroforestry in Nepal is fragmented and its potential to alleviate poverty and food shortages remains unexploited. This offers opportunities for ICRAF to make a quick impact, as some of its technologies developed and tested, and long experience gained, elsewhere in South Asia could well work in Nepal, too. What is needed is an integrated, carefully designed, and well-coordinated programme to promote agroforestry in Nepal.

Nepal is endowed with an abundance of two key natural resources, forests and fresh water, yet, paradoxically, it is one of the world's least developed nations.

To explore the opportunities and strengthen the ongoing partnership with Nepal, Dr Javed Rizvi, Regional Director of ICRAF's South Asia Programme, met Nepal's Minister of Agriculture, Honorable Hari Parajuli, in Kathmandu, first in November and then in December 2014. Several high-ranking government officials were present at the meeting. The Minister and his team members expressed a strong interest in ICRAF's proposals and assured full support for their implementation.

Subsequently, the group held a consultation workshop on 26-28 March, 2015. Jointly organized by Nepal's Ministry of Agricultural Development, Ministry of Forests and Soil Conservation, ICRAF, and the Asia Network for Sustainable Agriculture and Bio-resources (ANSAB), the workshop brought together more than 150 participants. After considerable deliberations, the workshop developed a Kathmandu Declaration on Agroforestry.

"To ensure that the population of Nepal gets full benefits of agroforestry, we need to develop a national agroforestry policy, and I am pleased that the process has already begun," said Mahesh Acharya, Nepal's Minister of Forests and Soil Conservation, as he opened the meeting. Hari Prasad Parajuli, Minister of Agricultural Development, added that the development of a national agroforestry policy has his "fullest support."

A group of participants of the Consultation Workshop with Honorable Minister of Forests and Soil Conservation, Mr Mahesh Acharya (centre, sporting a cap).
© ICRAF

"In order to have a more focused and coordinated strategy and approach to promote agroforestry among various actors and stakeholders, participants agree to develop a National Agroforestry Policy for Nepal," said the Kathmandu Declaration on Agroforestry (see Box for full text), which was released by Nepal's Minister of Agricultural Development at the close of the workshop.

The Declaration, signed by the Secretaries of Nepal's Ministry of Forests and Soil Conservation as well as the Ministry of Agricultural Development, added that the new policy is expected to help ease regulatory constraints and ultimately strengthen Nepal's food security, environmental security, and soil health. The Declaration recognizes the role ICRAF played in developing and implementing the National Agroforestry Policy of India and identifies ICRAF as a potential partner for Nepal's Agroforestry Policy development.

Kathmandu Declaration on Agroforestry

A consultation workshop was jointly organized by the Ministry of Agricultural Development (MOAD), Ministry of Forests and Soil Conservation (MFSC) of the Government of Nepal, World Agroforestry Centre (ICRAF) and the Asia Network for Sustainable Agriculture and Bio-resources (ANSAB) at Hotel Himalaya, Kathmandu, Nepal from 26-28 March 2015 on "Present Status and Future Prospects of Agroforestry in Nepal".

Participants realize that Nepal needs strengthening agroforestry research and development (R&D) and its application in the areas of classification and documentation of agroforestry practices for various agro-ecological zones, developing new and fine tuning of existing good practices and scaling up of promising agroforestry technologies for enhancing trees, shrubs, crops, livestock and fisheries production and productivity. These areas together with capacity strengthening would contribute to the socio-economic development and food, nutritional, energy and environmental security of the country.

Participants recognize the indigenous practices and traditional knowledge, existing policies and initiatives on agroforestry from various government, non-government, farmers' organizations and private sector. In order to have a more focused and coordinated strategy and approach to promote agroforestry among various actors and stakeholders, participants agree to develop a National Agroforestry Policy for Nepal. It is expected that the policy will encourage the easing of regulatory constraints and will facilitate the development of feed and fodder resources, income generation, food, nutritional and energy security, germplasm conservation and production of quality planting material, arresting of land degradation and restoration of soil health, and the development of appropriate agroforestry models for different agro-ecological zones. Furthermore, the policy will contribute to the environmental security. Appreciating the development of the National Agroforestry Policy of India and ICRAF's contributions to it, securing assistance from the international agencies, such as ICRAF, and the Indian experience could be useful to this initiative.

We further agree to let this document be known as "Kathmandu Declaration on Agroforestry".

The "Kathmandu Declaration on Agroforestry" is released on 28th of March 2015 at Kathmandu, Nepal by Honorable Hari Prasad Parajuli, Minister of Agricultural Development, Government of Nepal.

Mr. Sharad Chandra Paudel, Secretary,
Ministry of Forests and Soil Conservation

Dr. Shyam Kishor Shah, Secretary,
Ministry of Agricultural Development

Fostering Agroforestry in Bhutan

"A good foundation for ICRAF's partnership with Bhutan has been laid. Efforts to strengthen the partnership will continue."
Javed Rizvi, Regional Director ICRAF's South Asia Programme

Bhutan is a small but vibrant country, with the distinction of having achieved remarkable macroeconomic growth using its unique "Gross National Happiness" concept.

Bhutan is situated in the eastern Himalayas, has mountainous landscapes, and a small land area (about 46,500 km2). The country is blessed with a valuable natural resource of forests, which occupy about 64 percent of the land area. The cultivated land accounts for 8.8 percent, and Alpine pastures 6.6 percent.

In spite of the impressive economic growth and overall development, about 12 percent of Bhutan's population, especially in rural areas, still lives in poverty. Food production is falling short of meeting the demand of the country's growing population. Therefore, food import has been rising to fill the gap. While forests are well managed in Bhutan, with community participation, the concept and potential of agroforestry to meet the challenge of producing more food and reducing poverty has remained untapped. There are, therefore, opportunities for ICRAF to promote agroforestry to support the country in dealing with poverty and food insecurity.

Bhutan's Minister of Agriculture and Forestry, Honorable Lyonpo Yeshey Dorji, happened to visit India to participate in a high-level Regional

Consultation Meeting in August 2014. Dr Javed Rizvi, Regional Director of SARP, who was also participating, took the opportunity on sidelines of the meeting to brief the Minister on the potential of agrofoestry in Bhutan and present the highlights of the successes achieved by ICRAF in other countries in South Asia. The Minister appreciated Dr Rizvi's briefing and was enthusiastic to consider his proposals in consultation with his colleagues in the ministry.

Following the meeting with the Minister, Drs Rizvi and Mohammad Ghiasuddin, ICRAF Liaison Scientist in Bangladesh, visited Thimphu, Bhutan and met senior policy makers, scientists and other stakeholders. The group identified rejuvenation and rehabilitation of cardamom-based agroforestry as a priority area for collaboration with ICRAF.

Dr Javed Rizvi, Regional Director of ICRAF's South Asia Programme, with Bhutan's Minister of Agriculture and Forestry, Honorable Lyonpo Yeshey Dorji (right).
© V.P. Singh

Dr M. Ghiasuddin (left) and Dr Javed Rizvi (right) with Dr Ugyen Wangchuk (second from right) , Secretary, National Environment Commission Secretariat, Bhutan.

NEW INITIATIVES

ICRAF's Gender Strategy

ICRAF recently embarked upon developing a Gender Strategy under the umbrella of the CGIAR Programme on "Trees, Forests and Agroforestry", implemented by CIFOR, ICRAF, Bioversity International, and CIAT, in collaboration with international, regional, national, and local partners.

A cross-regional gender research study on "Gender Appreciation for Multifunctional Landscapes" was launched in all five regions in ICRAF's geographic mandate: East and Southern Africa, Southeast Asia, South Asia, Latin America, and the West and Central Africa. The study aims to determine the differences in appreciation of landscape functions by women and men, to better design gender-responsive/sensitive landscape management interventions that benefit both women and men. Based on research findings, the study recognizes the dynamic relationships between men and women, instead of focusing on women only, in the context of gender, and the higher probability of the acceptance for changes in institutions, policies, and practices to address gender inequality, if both men and women are considered together.

A Gender Implementing Team (GIT) of scientists from across the five regions was established in 2012 by ICRAF. The GIT members were trained on gender research at a workshop on "Integrating Gender into the R&D Cycle and the Organization", held on 28 May-3 June, 2012 in Kunming, China. Subsequently, ICRAF's South Asia Regional Programme hosted the first Gender Cross-cutting Annual Planning Meeting and Concept Note Writeshop of GIT in November, 2012. The Writeshop developed five concept notes for gender research, of which one has already succeeded for donor funding.

In 2013, the GIT members, along with ICRAF scientists and participants from 19 countries, got together in Bohol, the Philippines, 13-14 June, to take part in a "Gender Analysis" training, which focused on two methods that were used to analyze gendered land use decision-making: agent-based modeling and role-play games. Dr Grace Villamor, a postdoctoral fellow at ICRAF from Bonn University, Germany conducted the training. This was followed by a workshop to develop project-level gender indicators, 15-16 June, in the Philippines. Facilitated by Dr Maria Elena Javier, Gender Consultant, the workshop aimed to develop gender indicators that could be adopted across projects and research activities to achieve gender equity. On 17-19 June, 12 authors and peer reviewers from ICRAF organized a Writeshop at Bohol in the Philippines, and developed a portfolio of methods used in gender analysis into a publication "In Equal Measure: A User Guide to Gender Analysis in Agroforestry," published by ICRAF. The International Institute for Rural Reconstruction (IIRR) facilitated the Writeshop.

Another workshop to mainstream gender in ICRAF's strategy followed in 2014 in Hanoi, Vietnam. These efforts have led to the development of ICRAF's draft Gender Strategy, which was reviewed at a workshop in Bogor, Indonesia, 2-3 March 2015. The Bogor workshop – whose participants included two regional coordinators, one country coordinator, and one senior chief scientist – helped integrate the different perspectives from the regions and headquarters. It also shed light on the diversity of regional processes and structures related to gender. SARP and other regional programmes of ICRAF have been actively involved in these efforts. The draft Gender Strategy of ICRAF is now ready to be ratified by the Centre's Board of Trustees for implementation.

The Gender Strategy recognizes the dynamic relationships between men and women, and, instead of focusing on women only in the context of gender, considers both men and women together to address the issues related to gender inequality.

Participants of the Gender Focal Points training workshop on gender-responsive methods, Bohol, the Philippines.
© GIT-ICRAF

Mapping the Extents of Agroforestry using Geoinformatics

Said simply, geoinformatics is a newly emerging branch of science which combines several high-end technologies to transform data into new knowledge.

In recent years, there has been a shift in the focus of agroforestry research from the plot or field scale to the landscape scale, which has uncovered the multiple benefits that trees provide in agricultural landscapes. However, the spatial distribution and extent of agroforestry is not well understood at present due to the complexity involved in accurately mapping trees outside the forests in mixed tree/crop/livestock systems. While high-resolution satellite or aerial imagery may be used to detect individual trees and has been applied for estimating the extents of trees outside forests at the local scale, these imageries are very costly and often lack the spatial coverage necessary for assessments at regional to national scales. Also, part of the challenge in mapping agroforestry is that it is not sufficient to be able to detect trees, but one needs integrated methods that capture both the trees and land use systems. In addition, there is generally a lack of systematically collected ground reference information for the development of predictive models of the extents of agroforestry, as well as for validation of these estimates.

SARP aims to narrow this gap by developing new approaches for mapping complex agroforestry systems, building on a wide body of research in agroforestry by ICRAF and its partners in ICAR, combined with recent advances in spatial statistics and remote sensing. The project will systematically collect data on land use, tree densities, biomass and species distribution across a wide range of agroecological zones in India, using and adapting existing biophysical field methodologies. The proposed efforts will build on ongoing ICRAF-coordinated activities as part of, for example, the Sentinel Landscapes initiative, where ICAR is a partner and field surveys are currently ongoing in the Western Ghats. SARP has already initiated this through international training for Indian scientists, including some work at ICRAF's central geospatial laboratories. The main objectives of the initiative are to: build an archive of calibrated imagery for detecting trees on farms for India; estimate and map the extents of agroforestry in India at multiple spatial resolutions (~30m to ~500m); build capacity within ICAR and other Indian partner institutions on the mapping of the distribution of agroforestry in landscapes; and, eventually, use the technology in the South Asia region.

Soil-Plant Spectroscopy

Soil-plant spectroscopy uses the interaction of electromagnetic radiation with matter to characterize the biochemical composition of a soil or plant sample.

ICRAF, through its Soil-Plant Spectral Diagnostics Laboratory, has advanced the use of spectroscopic methods for direct, rapid, and low-cost measurement of soil and plant properties. These techniques could make a major contribution to South Asian agricultural development and environmental management. ICRAF has initiated transfer of these scientific and technological advances to the Indian Institute of Soil Science (IISS) of ICAR. Indian scientists are now calibrating the technology to Indian conditions, with a view to achieving its large-scale application in India, such as developing "Soil Health Card" for farmers.

Soil-plant spectroscopy uses the simplicity of light (including electromagnetic radiation in the x-ray, visible, near infrared, and mid-infrared ranges, and the use of lasers)--the interaction of electromagnetic radiation with matter--to characterize the biochemical composition of a soil or plant sample. Infrared spectral signatures (visible-near-infrared, near infrared, or mid-infrared) detect molecular vibrations that respond to the mineral and organic composition of soil or plant materials. Spectral signatures thus provide both an integrated signal of functional properties as well as ability to predict a number of conventionally measured properties. ICRAF has deployed the infrared spectroscopy at a range of scales in Africa. The Soil-Plant Spectral Diagnostics Laboratory of the Centre supports a network of 30 spectrometers operating globally.

ICRAF has also developed several additional spectral technologies. A protocol for the use of total x-ray fluorescence (XRF) spectroscopy was developed for determination of the total concentrations of total elements in soils, which has now been extended to handheld XRF for soil and plant material. The world's first benchtop X-ray

Installation and demonstration of the MIR Spectrometer at IISS, Bhopal by Elvis Weullow of ICRAF.

diffraction spectrometer has been harnessed to provide semi-quantitative high-throughput soil mineralogical analysis and a fully quantitative method will soon be available. These advances enable the use of x-ray technology in predictive, as opposed to descriptive mode. Spectral technology has shifted the required scientific and technological skill set from traditional solution chemistry methods towards an emphasis on data science.

SARP has taken an initiative to establish such a laboratory at ICAR's Indian Institute of Soil Science (IISS). Necessary equipment has been procured and installed, and scientists from IISS and other partner institutes have been trained in using the new technology. The major objectives of this initiative are to:

Transfer spectral science and technology advances to ICAR's Indian Institute of Soil Science, Bhopal, including capacity building of scientific and technical staff

1. Develop calibrations for infrared and x-ray spectroscopic technologies for India soils and major crops
2. Test the development of spectral methods for improving India's fertilizer recommendations
3. Test the development of spectral methods for providing an integrated soil health index
4. Assist with the scaling up of spectral technology in the public and private sectors
5. Conduct joint research to advance spectral applications in agricultural research and development

Practice session on Statistical Packages to be used with MIR Spectrometer, conducted by Andrew Sila of ICRAF.

Long-term trials of mango-based agroforestry systems at the Indian Institute of Horticulture Research, Bengaluru.
© Javed Rizvi

Dr Javed Rizvi (centre) discussing new collaborative projects with Dr T. Manjunatha Rao (right), and Dr A.N. Ganeshamurhy (left), Director and Head of the Soil Science Division, respectively, of the Indian Institute of Horticulture Science, during his visit to the Institute in Bengaluru.
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New Collaborative Projects in Horticulture-based Agroforestry

ICRAF is gearing up its activities on promotion of fruit trees on crop land in India. Priorities were identified with the Deputy Director General of ICAR (Horticulture), and with the Indian Institute of Horticulture Science (IIHR), based in Bengaluru. IIHR has its main research station at Hessaraghatta, Bengaluru with two regional experiment stations at Bhuvaneshwar in Orissa and Chettalli in Karnataka. The institute is active in research on fruits, vegetables, ornamental plants, post-harvest technology, pathology, entomology and nematology, soil science and agricultural chemistry, plant physiology and biochemistry, plant genetic resources, biotechnology, medicinal and aromatic plants, and seed science and technology.

Through consultations and field visits, the following new projects of mutual interest were identified to be included in the work plan of the ICAR-ICRAF collaborative research programme for 2016-2020.

- Evaluation and dissemination of fruit-based agroforestry systems
- Soil health monitoring through MIR–spectroscopy
- Underutilized fruit crops and genomic studies
- Challenges in quality planting material production, certification, and distribution.

Bolstering Capacity Building Efforts in Collaboration with AICRP

The All India Coordinated Research Project on Agroforestry (AICRP) of the valuates various agroforestry options in different agroclimatic conditions, develops packages of practices, and disseminates these to farming communities through a massive network of partners. The project is coordinated by the Central Agroforestry Research Institute (CAFRI) of India.

The Annual Consultation Workshop of AICRP was held on 25-27 July, 2015 at Shere Kashmir University of Agriculture Science and Technology (SKUAST) at Srinagar, Kashmir. Seventy-one scientists from 37 partner institutions discussed their research work on various aspects of agroforestry across India. Dr Javed

Several quality books were released at the All India Coordinated Research Project on Agroforestry Annual Consultation Workshop, held in Srinagar.
© ICRAF

Dr Javed Rizvi inaugurated the Annual Consultation Workshop of the All India Coordinated Research Project on Agroforestry, in July 2015 in Srinagar.
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Rizvi, Regional Director, SARP, inaugurated the workshop.

CAFRI and AICRP teams expressed to Dr Rizvi a strong interest to enhance their collaboration with ICRAF. One of the major areas of collaboration discussed was to provide increased training and capacity building opportunities to scientists. In recent years, ICRAF has organized three international training events for the scientists of AICRP and CAFRI on the subjects suggested by them. Both ICRAF and CAFRI are now moving towards an enhanced and more impact-oriented collaboration in capacity building.

"Research in agroforestry is expanding and opening new horizons. We need to keep pace with the new developments to mainstream agroforestry for greater impacts. ICRAF will work with you closely to learn from each other's experiences", said Javed Rizvi in his inaugural address.

Collaborative Agreement with the Borlaug Institute for South Asia (BISA)

ICRAF signed a collaborative agreement with the Borlaug Institute for South Asia (BISA), a not-for-profit research institute dedicated to the improvement of food security and reduction of hunger in India. BISA is a collaborative effort between the International Maize and Wheat Improvement Centre (CIMMYT), and the Indian Council for Agricultural Research (ICAR). The Agreement stipulates for BISA and ICRAF to jointly undertake the following activities:

- To develop and implement a detailed work plan for collaborative research and development activities on crop-tree farming and on diversification of cereal-based cropping systems with appropriate organizations and institutions of national programmes, extension agencies, universities, NGOs and private-sector organizations in South Asia in the furtherance of the common goals and objectives of BISA and ICRAF. The scale of collaborative work between BISA and ICRAF will be determined from time to time by mutual consent of both parties.
- To jointly organize training courses, workshops, and seminars in India and in other South Asian countries.
- To exchange information, generate knowledge and disseminate the same though print and electronic means
- To develop joint funding proposals and implement the approved and funded projects in South Asia
- To hire scientific staff as joint appointee(s) under the umbrella of BISA-ICRAF Agreement. While BISA will provide the working space and administrative and managerial support, ICRAF will absorb the related costs of such joint appointment(s).

Dr H. S. Gupta, Director General of BISA, and Dr Javed Rizvi exchanged the signed copies of the Collaborative Agreement at the office of ICRAF at New Delhi. Both BISA and ICRAF have

Dr H.S. Gupta (left), Director General of BISA, and Dr Javed Rizvi, Regional Director of ICRAF's South Asia Regional Programme, exchanging copies of the Collaborative Agreement.
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initiated a scoping study to identify the priority research areas. The collaborative research programme will initially start at the research station of BISA in Jabalpur, Madhya Pradesh. During a visit to Jabalpur, ICRAF South Asia held discussions on the various aspects of the joint projects with Dr Raj, Director of BISA at Jabalpur. Scientists of both centres are now jointly developing research project proposals to be implemented in India, as well as in South Asia.

ICRAF South Asia team visited BISA research station in Jabalpur, Madhya Pradesh, India for site selection and identifying priorities.
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Enhanced cooperation with APAARI

ICRAF and APAARI (Asia-Pacific Association of Agricultural Research Institutions) have been working together to promote and facilitate through novel partnerships among NARS and other related organizations sustainable improvements in the productivity of agricultural systems and the quality of natural resources. ICRAF represents 10 CGIAR centres on the Executive Committee of APAARI. ICRAF and other CGIAR centres collaborate with APAARI in South Asia to support knowledge sharing and capacity development in the region.

ICRAF and APAARI, with ICAR and other partners, will jointly organize a regional consultation meeting on agroforestry sometime in October, 2015. The meeting is expected to bring together more than 100 policy makers, scientists, practitioners, and representatives from international, regional and national organizations, and NGOs from Afghanistan, Bangladesh, Bhutan, India, Indonesia, Malaysia, Maldives, Nepal, Pakistan, Vietnam, and Sri Lanka. Participants will discuss the recent progress made in agroforestry in India and elsewhere in the Asia-Pacific and formulate recommendations for the future work, and the establishment of an Agroforestry Mission. Exchange of ideas among the policy makers and scientists from the region is expected to developing a road map for agroforestry research, education, and development in the Asia-Pacific.

ICRAF represents 10 CG centres on the Executive Committee of APAARI. Dr Javed Rizvi, Regional Director, South Asia Programme of ICRAF, represented Dr Tony Simons, Director General of ICRAF, at the Executive Committee meeting of APAARI, held on 12 May 2015 in Bangkok, Thailand.
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Dr Javed Rizvi delivering his lead presentation at the SAARC Regional Expert Consultation workshop.
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Forging New Partnerships with SAARC

A new partnership has emerged with two SAARC (South Asia Association for Regional Cooperation) institutions: SAARC Forestry Centre, Bhutan and SAARC Agriculture Centre, Bangladesh. Dr Javed Rizvi represented ICRAF at a two-day SAARC Regional Expert Consultation workshop on "Technological Advancement in Agroforestry Systems: Strategy for Climate-Smart Agriculture Technologies in SAARC Countries" held and hosted by Central Agroforestry Research Institute (CAFRI) of ICAR at Jhansi, India. The objective of the workshop was to document the innovative agroforestry practices under the influence of changes (climate, socio-economic, governance) in SAARC Countries; to assess the productivity and environmental services of trees in agriculture landscape and their contribution to food security and poverty alleviation, and to identify emerging issues and propose strategies to develop agroforestry. The workshop was attended by delegates from all SAARC countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Dr Javed Rizvi made a lead presentation on agroforestry for socioeconomic, ecological and environmental sustainability in South Asia. He also shared new initiatives of ICRAF in agroforestry research, policy and advocacy, and in regional capacity building. SAARC institutions, CAFRI and ICRAF are considering to organize a SAARC-oriented capacity building programme; and to initiate a SAARC Coordinated Project on Agroforestry. Dr Tayan of SAARC Forestry Centre, Bhutan is coordinating this initiative with CAFRI and ICRAF.

"A new partnership is in offing leading to further strengthening of regional agroforestry research possibly through a SAARC-coordinated research programme", said Dr Rizvi.

Foundation Laid for Partnership with Public and Private Sectors

Dr Pal Singh, Senior Policy Advisor at South Asia Regional Programme, is leading an initiative on working together with both public and private sectors through India's CSR (Corporate Social Responsibility) Programme. Negotiations are at an advanced stage with Oil and Natural Gas Commission of India (the largest public sector oil extraction company in the country) to fund agroforestry research and upscaling through CSR funding mechanism. CSR-law of India mandatorily encourages the private sector to invest 2 percent of their profits in social and environmental causes, which include agroforestry. Soon, ICRAF will be implementing the first of its projects in India funded through CSR by ONGC. The project will target areas in Rajasthan. "In addition to ONGC, we are also negotiating with other public sector agencies like Coal India Ltd as well", said Pal Singh.

ICRAF South Asia team has also established contacts with international players active in India. Recently, talks have been initiated with L'Oréal, one of the largest cosmetics producers of the world which sources Guar (*Cyamposis tetragonomoloba*) from India. ICRAF and L'Oréal are discussing ways and means to use agroforestry interventions in reducing the carbon foot print of L'Oréal's operations in India.

ICRAF-South Asia team discussing possible collaboration with Charlotte de Tilly, CSR Manager, and Rachel Barre, Biodiversity and Sustainable Sourcing Manager, of L'Oréal, France.
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CAPACITY BUILDING

Capacity building is an integral component of the South Asia Regional Programme. Training courses and workshops in strategic areas are organized to upgrade the skills and expertise of national partners as well as the Programme's own research team members. Farmer-to-farmer interaction is encouraged through awareness workshops and field trips. SARP is actively involved in both organizing and participating in national, regional, and international scholarly meetings to promote interaction and exchange of knowledge and experience. A few examples of the Programme's capacity building efforts are given below.

Farmers' Awareness Workshop on Biofuels

Within the framework of its partnership with the University of Agricultural Sciences, Bengaluru (USAB), ICRAF's "Programme for the Development of Alternative Biofuel Crops" organized a joint Farmers' Awareness Workshop entitled *Sustainable Rural Biofuel Energy Options:A Dialog with Farmers* at the Biofuel Park at Madenur, in Hassan district of Karnataka, India on 3 January 2015. Participating farmers represented the 20 villages where

ICRAF's Biofuels Programme is working collaboratively with USAB to improve rural livelihoods. There were 20 women farmers in the group.

The workshop was opened by the Honorable Minister of Agriculture, Government of Karnataka, Mr Krishna Byre Gowda. Several other high-ranking government officials were also present. Addressing the participants, the Minister emphasized the importance of growing oilseed trees to meet the local energy needs of the rural poor, and highlighted other benefits of agroforestry systems. He then gifted the low-cost oil-extracting machines and awarded certificates of recognition of participation in the Biofuels Programme initiatives to the participating farmers. The smart oil-extracting machines were designed and developed by USAB, with financial contributions from ICRAF.

As part of the workshop programme, the Minister was given a tour of the Biofuel Park where he saw the ongoing trials to evaluate the potential of the different species of biofuel trees. The workshop organizers briefed the Minister on the activities and objectives of the collaborative ICRAF-UASB programme.

During the workshop, capacity building sessions were held with the participating farmers and they were introduced to the operation and maintenance of the oil-extracting machines.

The initiative is expected to boost biofuel production at village level by rural communities to operate their agricultural machinery, and produce oil cake as manure, and thus improve their livelihoods through increased income and employment opportunities.

The initiative is expected to boost biofuel production at village level by rural communities to operate their agricultural machinery.

Honorable Minister of Agriculture, Government of Karnataka, Mr. Krishna Byre Gowda (centre), awarding certificates of appreciation to participating farmers.
© ICRAF-Biofuel Programme

Participating farmers with their oil-extracting machines gifted to them by the Biofuels Programme. Seen on left is Dr Naveen Sharma, Programme Director.
© ICRAF-Biofuel Programme

Training on Constructing Improved Cook Stoves for Rural Women

About half the population in developing countries relies on firewood and other biomass for cooking and heating homes. The traditional cooking stove, called *chulha*, is energy inefficient and produces a lot of smoke. In India alone, at least 815 million households use firewood and other biomass in *chulhas*; of these, about 90 percent households are in rural areas. The smoke pollutes the environment and poses serious health hazards (particularly lung and eye ailments), especially for women and children, who spend more time at home than men. At the same time, the demand for firewood often leads to deforestation.

The Biofuels Programme of ICRAF, in partnership with TIDE (Technology Informatics Design Endeavor), a Bengaluru-based NGO with expertise in producing improved stoves, conducted a training workshop on constructing improved cook stoves for local communities in the district of Hassan, Karnataka State, India, on 4 January 2015. The low-cost improved stoves, called Sarala, have several advantages over traditional ones: they produce much less smoke, are more energy efficient, and built with locally available and affordable materials (a piece of asbestos cement pipe, a cast-iron grate, mud and bricks). Apart from providing a better cooking environment, the stove is easy to use and maintain, and can be used with indigenous biomass as fuel.

A participant constructing her Sarla cook stove at the training workshop.
© ICRAF-Biofuels Programme

Thirty women from 20 villages, where Biofuels Programme activities are underway, were trained on how to construct Sarala stoves. They were each given a stove mould and construction material. They all successfully constructed Sarala stoves under the guidance of the trainers, and expressed their feelings of achievement. They were happy that the training

Participants and trainers of the Sarla cook stove training workshop.
© ICRAF-Biofuels Programme

would help them to replace their traditional *chulhas* with the low-smoke stoves, thus protecting the health of their families. During the workshop, participants provided feedback on the energy resources they used. The trainers discussed the benefits of adopting agroforestry with the participants.

At the end of the workshop each participant was given a construction manual and a mould to help them construct the stoves at their own homes and also at the homes of their friends and neighbors.

An important lesson learned from the workshop was that an aggressive awareness programme is needed to educate the rural population (with information material in local languages) about how the smoke from their *chulhas* not only threatens the health of their families but also of the environment.

ICRAF is working not only to promote the use of improved stoves, but also on the adoption of cleaner and more efficient renewable biofuels. The Centre is testing and evaluating, in partnership with the University of Agricultural Sciences, Bengaluru several options for producing briquettes from biomass waste, such as oilseed cake and husks, which are abundant in the region, to replace firewood and charcoal for cooking.

Training in Geoinformatics for Mapping Agroforestry

A 5-day training on the "Use of Geoinformatics for Mapping Agroforestry" was conducted on 1-5 December 2014 at the World Agroforestry Centre headquarters in Nairobi, Kenya. The workshop, organized by the Indian Council of Agricultural Research (ICAR) and ICRAF, brought together eight participants from different ICAR institutes, State Agricultural Universities, and from the Borlaug Institute of South Asia.

Dr Tor-Gunnar Vågen, Head of GeoScience Laboratory, and Mr Muhammad Ahmad, Geoportal Developer, at ICRAF, led the training. Dr Leigh Winoweicki, Soil Scientist from the International Centre for Tropical Agriculture introduced the participants to R statistics and spatial modeling in R.

The topics covered during the training included open source GIS, spatial data infrastructure (SDI) development, metadata standards, mapping trees outside forests (TOF) based on high resolution satellite imagery using object-oriented analysis in Python, and statistical and machine learning methods for mapping TOF based on moderate resolution satellite imagery using R statistics. The training included lectures, laboratory visits, hands-on exercises and interactive sessions. Participants gained knowledge in advanced techniques and instrumentation in the emerging field of Geoinformatics.

Indian scientists at the geoinformatics training at ICRAF, Nairobi.

Geoinformatics trainers and trainees at ICRAF, Nairobi.

ICRAF's South Asia Regional Programme is working with CAFRI to develop a joint project on effective use of Geoinformatics in mapping agroforestry.

Workshop on Indentifying Capacity Development Needs in South Asia

SARP, in collaboration with Bangladesh, organized a workshop on "ICRAF's Capacity Development Strategy and South Asian Partners' Capacity Development Needs" in Dhaka, on 30-31 January 2013. The workshop brought together 29 participants: 14 from Bangladesh, 3 from Bhutan, 5 from India, 2 from the Maldives, 1 from Nepal, and 4 from Sri Lanka. Participants belonged to two constituencies: Institutional Partners (staff of ministries and government departments related to agroforestry, who drive the process of capacity development) and Research Partners (with whom SARP carries out collaborative research). The workshop was designed and facilitated by Mr Mehmood Muhammad Ul-Hassan, Capacity Building Head, and Ms Hellen Ochieng, Capacity Development Specialist, from ICRAF's headquarters in Nairobi, Kenya.

Dr Hassan Mahmud, honorable Minister of Forests and Environment, Bangladesh inaugurated the workshop.

Participants carried out the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of ICRAF's Capacity Development (CD) Strategy. The information that emerged from the analysis was useful in identifying where ICRAF needs to make adjustments in its CD strategy. A scoring and ranking methodology was then used for the participants to identify and prioritize their CD needs. Not surprisingly, each of the six countries had its own specific capacity development needs, ranging from direct financial assistance to training courses in specific areas to graduate research (M.Sc. and Ph.D.) under the supervision or co-supervision of ICRAF scientists. The prioritized country needs were then discussed in a plenary session.

Participants and trainers of the Capacity Development workshop, held in Dhaka, Bangladesh.

Apart from the key objective of obtaining feedback on ICRAF's CD strategy and identifying CD needs of partners in South Asia, the workshop also served as a networking platform. ICRAF created a group email for South Asian CD partners, and will keep them updated on CD in agroforestry activities.

A detailed report on the outcomes of the workshop was prepared by ICRAF's CDU and shared with scientists at headquarters, in SARP, and partners in South Asia. The insights gained from the workshop should help them in making provisions for appropriate CD activities in their proposals and concept notes for donor funding.

Capacity Building of Farmers and Scientists on Carbon Sequestration

One of the major components of the NAIP-supported project "Enabling smallholders to improve their livelihoods and benefit from carbon finance," was the orientation and training of smallholder farmers on carbon sequestration and emission reduction approaches and practices and their application at different levels--- household, farm, landscape, and community. Once the smallholder farmers learn how to build up carbon stocks, they can explore the international market to sell their carbon. The key research highlights of this project were reported above under "Major Achievements". The capacity building activities are reported below.

The project developed "business processing units" (a kind of incubators) at the community level by engaging and training the groups of entrepreneurial individuals, who were identified by the community. Similarly, training of Indian scientists on various aspects of carbon finance markets and carbon trading options was another major activity.

The consortia-led project conducted 67 training events/ workshops/project meetings for various stakeholders, including the scientific staff, on a range of topics, involving 4294 participants. Of these, there were three international training courses, one each in Kenya and the Philippines, and the third conducted by international resource persons in India. The international training events brought together 27 participants from the project and 35 non-NAIP personnel.

The management of these activities involved several steps. First, the villages in each grid were organized into a legal entity, called Gram Samaj as a registered body under Societies Act of the government, one entity at each site. Over the five years, four such legal entities were established, with the community as its functional members. This was followed by mapping the livelihood/farming systems of the households in each grid, conducting an ex-ante analysis of potentially smart agricultural practices, and having them reviewed by the community to choose the preferred ones. Next was the training of the smallholders, including women and the landless, and of the incubators on various aspects of the project at the site, and arranging their cross-site visits. Using farmers as the resource persons was a key component in these training sessions.

The training of the teams of Indian scientists from each grid covered the various aspects of carbon finance markets and carbon trading options, including the carbon stock assessment using approved methodologies, verification and validation, market intelligence, and negotiations. Arrangements were also made for their in-country and overseas visits to expose them to these aspects from other similar projects.

International Workshop on Design of Agroforestry Experiments

An international training workshop on "Design of Agroforestry Experiments" was jointly organized by the Central Agroforestry Research Institute (CAFRI) and ICRAF's South Asia Regional Programme, 1-5 December 2014, in Jhansi, at CAFRI. There were 21 men and 5 women participants. Two of the participants came from from Sri Lanka, two from Bangladesh, one from Nepal, and the rest from agricultural universities across India.

The objective of the workshop was to help researchers design practical, valid, and efficient agroforestry experiments. Participants were introduced to some of the modern areas of research experimentation, including multi-environment trials for understanding complex interactions of agroforestry with ecological and social factors.

Dr Richard Coe, Principal Scientist (Research Methods), ICRAF, Nairobi, and Dr Ajit Gupta, Principal Scientist, IASRI (Indian Agricultural Statistics Research Institute), Delhi, were trainers. Dr Javed Rizvi, Regional Director, SARP, organized international participation.

The workshop was built around experimental designs and problems that participants had brought, which helped the trainers to identify priority experiments and topics to cover in the workshop sessions. These included principles of experimental design and the complexity of applying them in agroforestry, the practical steps in designing experiments with specific objectives, modeling and carbon sequestration, and involving farmers in all stages of experimentation. A variety of methods was used, including small-group exercises and group discussions, and a field tour to ensure the active involvement of the participants in the workshop activities.

INTERNATIONAL COLLABORATION

SARP uses an 'outward looking' approach to expand its partnerships. Other than promoting partnerships in South Asia, the Programme has been actively involved in forging both inter-regional and international collaboration. The overall objective is to exploit synergies, complementarities and comparative advantages; identify potential areas of mutual interest for collaboration; add value to the joint efforts; and produce multiple impacts.

The 3rd World Agroforestry Congress

The 3rd World Agroforestry Congress, themed "Trees for Life", was held on 10-14 February 2014, in Delhi. The Congress was opened by the President of India, Honorable Shri Pranab Mukherjee. A key highlight of the Congress was the launch of the National Agroforestry Policy of India by President Mukherjee.

The Congress was organized by ICRAF, ICAR, the Indian Society of Agroforestry, and Global Initiatives (GI). Supported by international, regional and national donors, the Congress brought together over 1,000 delegates from more than 80 countries, representing a range of specialties and constituencies: researchers and research managers, policymakers and high-ranking government officials; representativ es from major businesses, students, and others. SARP played an active role in the preparation for, and the organization of the Congress.

The Congress programme was organized around six main sessions: Agroforestry Systems, Income and Environmental Benefits; Climate Change, Multi-functionality, Livestock and Fish Systems; The Business of Agroforestry: Applying Science; Sustaining Development through Agroforestry; Applying Science to the Future of Agroforestry; and Policy Innovation and Global Issues.

A compendium of the abstracts of the papers presented at the Congress is available on ICRAF's website: www.icraf.org

In his inaugural address, President Pranab Mukherjee (at lectern) announced the launch of India's Agroforestry Policy.
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The South Asia-Africa Bridge

South Asian and African countries share common features of climate, soil, water, and small landholdings. To develop linkages with Africa, SARP, working with ICAR, hosted the first meeting of scientists from Kenya, Malawi, Tanzania, Uganda, Cameroon and Mali, along with Indian scientists, to develop a proposal for a multi-year collaborative programme. This was followed by a meeting of Ministers of Agriculture from Africa in New Delhi, where the policymakers' support was achieved, and the project proposal, which includes research support and scholarships for young African scientists, was approved in principle. The collaborative project covers the following areas: land degradation and land care; tree germplasm (varieties) exchange, characterization and domestication, especially of improved varieties of selected fruit species from India and Sri Lanka, in Mali, Cameroon, Kenya and Tanzania; agroforestry agribusiness, tree product development, including fruits and medicinal plants, market chain, value addition; carbon poverty reduction and carbon markets; bio-energy; bio-diesel, dendrothermal energy (gasification) and flash pyrolysis; tree pathology to prolong the life of trees; health and nutrition; and skills enhancement.

Subsequently, ICAR sponsorship was obtained for Ph.D. research and postdoctoral fellowships in agroforestry for young researchers from African countries. Under this programme, ICRAF researchers will also have opportunities for training and skills enhancement.

In another project, USAID (United States Agency for International Development) is also leveraging India's skills and experience to contribute to food security and development efforts in Africa. Efforts are underway to transform the India-Africa bridge as a model of a triangular partnership (India-Africa-USAID) for better use of resources and faster progress. USAID is financially supporting project-specific initiatives of not-for-profit research institutions and NGOs in India under the umbrella of this triangular partnership.

The South Asia-Southeast Asia Bridge

Southeast Asia and South Asia share both their cultural heritage and agricultural practices. To forge linkages, SARP has initiated interaction, through meetings and personal visits with the key players in research and development programmes in Southeast Asia, in collaboration with ICRAF's Southeast Asia Regional Programme, based in the Philippines. The progress has been very encouraging. The following areas have been identified in principle for collaboration: improvement of traditional agroforestry systems; rubber agroforestry systems in Indonesia; fruit orchards in Vietnam and Thailand; afforestation impact—China and India experiences; eastern Himalayan watersheds; and skills enhancement.

Efforts are underway to formalize the collaborative projects with the institutions and other partners concerned, and develop joint project proposals for donor funding.

THE WAY FORWARD

Increased emphasis will be placed on upscaling and outscaling of the proven technologies, on impact assessment, and on generation of international public goods (models, tools, technologies, methods, and materials) to contribute to the Millennium Development Goals, particularly those related to poverty reduction, food and nutritional security, and protection of the environment.

Agroforestry has been playing an important role in safeguarding the health of both human beings and mother Earth for centuries, but that role has not received the recognition it deserves. Advocacy and public awareness efforts, combined with advances in research-for-development, by ICRAF and other players are contributing to earning that recognition. Agroforestry, today, has created an identity of its own in both national and global research and development agendas. These efforts must continue, even more aggressively so. TV and radio programmes must continue to be produced in collaboration with national broadcasting channels to share information and knowledge with farmers. Incorporation of agroforestry in school curricula and production of educational material, deserve increased attention.

Guided by lessons learned, researchers would need to expand their farmer-participatory approaches and exploit indigenous knowledge to develop innovative, climate-smart, location-specific, gender- and culture-responsive agroforestry systems. Since farmers depend on indigenous trees—often referred to as 'Cinderella' trees—because of their ability to sustain livelihoods by providing fruits, timber, medicinal and other products, improvement and exploitation of such trees by the use of cutting-edge science would need increased emphasis. Tribal agroforestry, with its multiple systems and the complexity of the tribes claiming rights on forest lands, has received little attention and support from governments, researchers, and donors so far. It deserves greater attention in research and development agendas in South Asia.

Efforts must continue to develop a better understanding of how to assess the value of ecosystem services, and develop efficient mechanisms to negotiate and pay/reward farmers and others involved in the maintenance and delivery of those services.

Research on policy, institutions, and gender would need to be strengthened and the recommendations that emerge shared with policy- and lawmakers. SARP will be actively involved in developing action plans for the implementation of India's National Agroforestry Policy, as well as inspiring other countries in the region to develop their own policies. The action plans would need to be pro-poor and pro-farmer in their design and should help create an enabling environment in which farmer expectations could be addressed. These include such aspects as land tenure, loan and insurance avenues, efficient extension systems for transfer of technology, better infrastructure, formation of farmer cooperatives, access to markets and value chain, market intelligence, post-harvest storage facilities, and payment/reward for environmental services. Social safety nets and a provision for farmers to use their trees as collateral for loan from financial institutions would deserve special attention in the coming years. Concerted efforts would need to be made to stimulate the private sector to invest in agroforestry both for profit and as a social responsibility.

Donor-specific strategic approaches, activities, and information material, both in electronic and hard-copy forms, would need increased attention to maintain/achieve increased support from the current donors, and attract new donors to support SARP's activities as well as those of the SARP-Africa and SARP-Southeast Asia bridges.

SARP would place increased emphasis on upscaling and outscaling of the proven technologies, on impact assessment, and on generation of international public goods (models, tools, technologies, methods, and materials) to contribute to the Millennium Development Goals, particularly those related to poverty reduction, food and nutritional security, and protection of the environment.

The road ahead is both long and serpentine, but the journey of ICRAF's South Asia Regional Programme must continue.
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Annex 1. Training and Workshops

1. Enhancing farmers knowledge in agroforestry for sustainable livelihood and environment, 12 – 14 July 2004, held at the World Agroforestry Center-South Asia NASC Complex, Pusa, New Delhi. Organized by ICRAF and Action Green Earth (NGO).
2. A regional workshop-cum-training programme on tree domestication, 9 - 10 March 2005, held at the Postgraduate Institute of Agriculture University of Peradeniya, Peradeniya, Sri Lanka. Organized by CARP-ICRAF Tree Domestication Project, ICRAF Regional Programme for South Asia.
3. New frontiers in agroforestry planting material utilization, 28 August-2 September, 2006, held at ICRAF South Asia, New Delhi. Organized by ICRAF's South Asia Regional Programme.
4. Improving strategies for tree germplasm supply, 29 October-3 November, 2007, held at ICRAF headquarters, Nairobi. Organized by ICRAF.
5. International workshop on improving strategies for tree germplasm supply, 29 October-3 November, 2008, held at ICRAF headquarters, Nairobi. Organized by ICRAF.
6. Level 2 certificate training programme for Maldives, 14 March-8 May 2010, held at Agriculture Centre, Hanimadhhoo, Maldives. Organized by ICRAF-South Asia Regional Programme.
7. Carbon footprint assessment training workshop and climate change research planning workshop, 23-27 April 2012, held at ICRAF headquarters, Nairobi. Organized by ICRAF.
8. Training workshop on field sampling for monitoring and reporting of carbon stocks of mangrove ecosystems (conducted by the experts from CIFOR, Indonesia and USAID, USA), 15- 17 May, 2013, held at Bhubaneswar, Odisha, India. Organized by ICRAF-South Asia Regional Programme and Orissa University of Science and Technology.
9. On the job training on the use of carbon stock tool box, carbon measurement and stock assessment and field visits to active sites in Southeast Asia, 8 -15 July, 2013, held at ICRAF-Southeast Asia Regional Programme, Los Banos, the Philippines. Organized by ICRAF-South Asia Regional Programme.
10. Workshop on ICRAF's capacity development strategy and South Asian partners' capacity development needs, 30-31 January 2013, held in Dhaka, Bangladesh. Organized by ICRAF-South Asia Regional Programme in collaboration with Bangladesh.
11. The 3rd World Agroforestry Congress, 10-14 February 2014, held in Delhi, India. Organized by ICRAF, ICAR, the Indian Society of Agroforestry, and Global Initiatives (GI).
12. Design of agroforestry experiments (an international training workshop), 1-5 December 2015, held at the Central Agroforestry Research Institute (CAFRI), Jhansi, India. Organized jointly by ICRAF-South Asia Regional Programme and CAFRI.
13. Use of geoinformatics for mapping agroforestry, 1-5 December 2014, held at ICRAF headquarters, Nairobi, Kenya. Organized by the Indian Council of Agricultural Research (ICAR) and ICRAF.
14. Sustainable Rural Biofuel Energy Options: A Dialog with Farmers (a training workshop), 3 January 2015, held at the Biofuel Park at Madenur, Hassan district of Karnataka. Organized by ICRAF's Biofuels Programme in collaboration with the University of Agricultural Sciences, Bengaluru.
15. Training workshop on constructing improved cook stoves for local communities, 4 January 2015, held at the Biofuel Park, Hassan, Karnataka. Organized by the Biofuels Programme of ICRAF, in partnership with TIDE (Technology Informatics Design Endeavor), a Bengaluru-based NGO.

Annex 2. South Asia Regional Programme Partners

Afghanistan	Kabul University; Afghanistan Academy of Agricultural Sciences
Bangladesh	Bangladesh Agriculture Research Council; Bangabandhu Sheikh Mujibur Rahman Agricultural University; Bangladesh Agricultural Research Institute; Bangladesh Rice Research Institute; Bangladesh Rural Advancement Committee (BRAC); Rangpur Dinajpur Rural Service (RDRS)
Bhutan	Ministry of Agriculture and Forests, Renewable Natural Resources Research Centre;
India	Indian Council of Agricultural Research institutions; Department of Agriculture Cooperation; State Agriculture Universities; M.S. Swaminathan Research Foundation; Foundation for Ecological Security; Watershed Organization Trust; Utthan Centre for Sustainable Development and Poverty Alleviation; GRAVIS
The Maldives	Ministry of Fishery and Agriculture; World Vision, APN, IUCN, WWF
Nepal	Ministry of Agriculture Development, Ministry of Forest and Soil Conservation, Nepal Agricultural Research Council; Asia Network for Sustainable Agriculture; ICIMOD
Sri Lanka	Ministry of Coconut and Janatha Estate Development; Coconut Research Institute; Kurunegala Plantation Ltd.; Ministry of Environment and Natural Resources; Ministry of Agriculture; Department of Agriculture; Forest Department; agricultural universities and research institutions in Sri Lanka; Bandaranayake Memorial Ayurvedic Research Institute; Department of Botanic Gardens; Department of Export Agriculture; Industrial Technology Institute; International Water Management Institute (IWMI); Jay Health Foods (Pvt) Ltd.; CIC Agribusiness; Sarvodaya (NGO); Saraketha (NGO); Green Movement (Sri Lanka)
CGIAR Centers	Bioversity, CIMMYT, CIP, ICARDA, IFPRI, ILRI, IRRI, IWMI
Other International Centers	AVRDC, BISA

Annex 3. South Asia Regional Programme Staff

Bhalla, Preeti
Administrative Assistant
p.bhalla@cgiar.org

Bohra, Babita
Programme Scientific Officer- Biofeuls
b.bohra@cgiar.org

DKNG Pushpa Kumara
Country Liaison Scientist, Sri Lanka
ngpkumara63@gmail.com

Giashuddin Miah, Md.
Honorary Country Liaison Scientist, Bangladesh
giash1960@gmail.com

Nayak, Devashree
Research Associate
d.nayak@cgiar.org

Noor, Jamal Pervez
Regional Finance & Administrative Officer for South Asia
J.P.Noor@cgiar.org

Rizvi, Javed
Regional Director South Asia
j.rizvi@cgiar.org

Sablok, Neeti
Finance Assistant
n.sablok@cgiar.org

Singh, Pal Virendra
Senior Advisor for Policy and Impact
v.p.singh@cgiar.org

Sharma, Navin
Programme Director – Biofuels
n.sharma@cgiar.org

Tomar, Sanjay
Scientist
s.tomar@cgiar.org

Singh, Vinod Kumar
Driver

Singh, Sukh Veer
Office Boy

Consultants

Choudhary, Rajendra
Senior Liaison & Monitoring Officer
r.choudhary@cgiar.org

Pragya, Namita
Biofuel Programme
n.pragya@cgiar.org

Annex 4. South Asia Regional Programme Offices

India

Dr Javed Rizvi

Regional Director

1st Floor, Block C, National Agricultural Science Complex (NASC)

Dev Prakash Shastri Marg

Pusa Campus, New Delhi, India 110012

Tel: +91 11 25609800/25847885/6

Fax: +91 11 25847884

Email: j.rizvi@cgiar.org

Bangladesh

Dr Giashuddin Miah

Country Liaison Scientist for Bangladesh

C/o Department of Agroforestry and Environment

Bangbandhu Sheikh Mujibur Rehman

Agricultural University (BSMRAU)

Gazipur - 1706, Bangladesh

Tel: +88 02 9205310-14, Ext: 2104

Fax: +88 02 9205330/9205333

Mobile: +88 01715401443

Email: g.miah@cgiar.org

Sri Lanka

Dr D.K.N.G. Pushpakumara

Country Liaison Scientist for Sri Lanka

C/o Faculty of Agriculture

University of Peradeniya

Peradeniya 20400, Sri Lanka

Tel: +94 81 239 5110

Fax: +94 81 239 5110/81 2388041

Mobile: +94 714933591

Email: ngpkumara@pdn.ac.lk or

d.pushpakumara@cgiar.org