One rice doesn't fit all in Nepal

RIU

Validated RNRRS Output.

One type doesn't fit all when it comes to rice varieties for the huge diversity of physical and socio-economic environments in Nepal. But by putting customers—rice farmers—first, varieties that match a range of needs can be produced rapidly. The term 'client-oriented breeding' means that farmers select strains specifically for the particular environments in which they live. Using these methods, the Nepalese farmers saw tremendous increases in productivity over the old varieties. Many farmers in many districts are now using the varieties selected by this process and several community groups across the country are also producing and distributing seed. The area planted to the new varieties is expanding two- to three-fold a year and there is huge potential for further expansion.

Project Ref: **PSP13:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **LI-BIRD, Nepal**
Source: **Plant Sciences Programme**

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Nepal,

Target Audiences for this content:

Crop farmers,

Document Contents:

Description

PSP13

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Better rice varieties by client-oriented breeding (COB) in Nepal

Rice for ***Chaite*** **(spring season):** Judi 572, Judi 582, Judi 565, Judi 567; for **upland main season**: Barkhe 1027, Sugandha 1, Judi 572, Judi 582, Judi 565, Judi 567; for **medium land main season:** Barkhe 2014, Barkhe 2024, Sunaulo Sugandha; **lowland main season:** Barkhe 3004, Barkhe 3019, Super 3004

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Plant Sciences Research Programme (PSP)

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RiUP activities.

R7122, R8071

Local Initiatives for Biodiversity Research and Development (LI-BIRD)
CAZS-Natural Resources, UK
National Rice Research Programme (NRRP), Nepal Agricultural Research Council (NARC)
Forum for Rural Welfare and Agricultural Reform for Development (FORWARD)
District Agriculture and Development Offices (DADOs) of the Department of Agriculture (DOA)

4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? ***(max 400 words)****. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Output proposed: Using novel client-oriented breeding (COB) methods we identified, developed, tested, and promoted, on a limited scale, several **main season** and **spring (*Chaite*) season rice varieties** for **Nepal** in diverse **rice ecosystems** and socio-economic environments**. Client-oriented breeding (COB)** is a **participatory breeding approach** to generate new crop varieties with farmers which overcomes the limitations of traditional plant breeding which is oriented towards selection for high on-station yield (Witcombe et al., 2005). The varieties are tested with farmers using **participatory varietal selection (PVS)** and are adapted to all seasons and all of the **low-altitude rice environments** in Nepal (Table 1 / Figure 1). In addition, there are several other promising lines being evaluated in disease screening nurseries, organoleptic assessments, multi-locational yield trials, PVS-mother and baby trials.

- These varieties are high yielding; have better eating quality, drought tolerant, do not lodge, have multiple insect and disease resistance and are adapted to low nitrogen conditions.
- Sunaulo Sugandha (Sugandha 2002) has an exceptional combination of high yield with aroma and currently is the best available improved aromatic variety. Sugandha 1 is also aromatic and drought tolerant. NRRP has not yet released an aromatic variety.
- Recently released variety Barkhe 3004 has a yield advantage of 23% over the best locally available alternative, Masuli (Annex 1 & 2) with better economic return (Gyawali et al., 2006).
- In addition to other traits, the yield advantage of COB varieties is 7 - 45% (Table 2, Question 10) with strong preferences by farmers for many traits (Annex 3, 4 and 5).

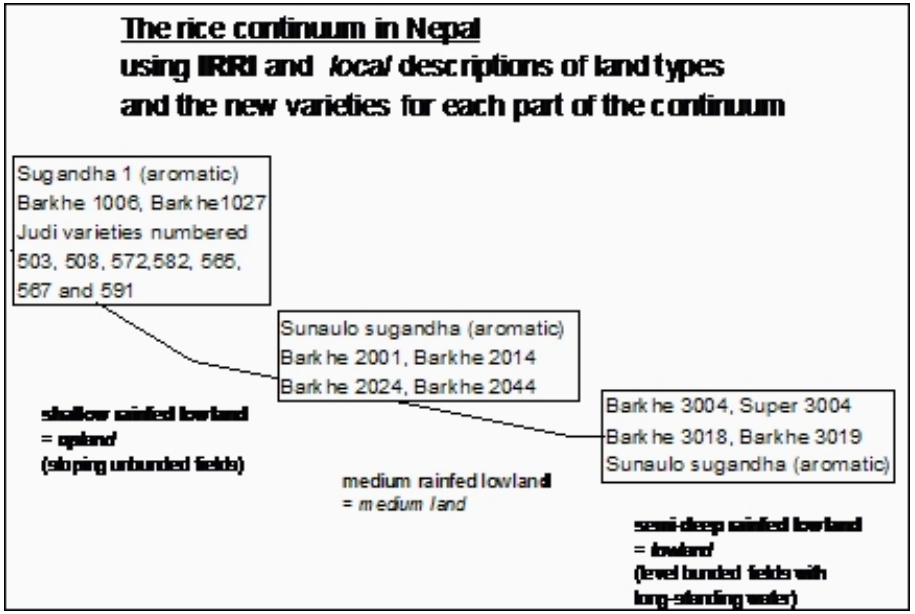


Fig. 1. The rice continuum in the rainfed lowlands in Nepal using IRRI and local names and the adaptation of the new rice varieties to niches in this continuum.

Table 1. Summary of the new rice varieties produced by COB for Nepal.

Variety name	*Seasonal adaptation*	*For rice ecosystem (IRRI)*	*First tested in PVS*	*Release status*	*Special traits*
Barkhe 3004†	Main	SDRL	2002	Released	High yield, wide adaptation
Barkhe 2001	Main	MRL	2002	To be registered	High yield, good cooking quality
Barkhe 2014	Main	MRL	2002	To be registered	High yield, better cooking quality

Barkhe 1027	Main	SDRL	2002	To be registered	High yield, drought tolerant
Sugandha 1	Main	SDRL	2002	To be registered	Aromatic, drought tolerant
Sunaulo Sugandha	Main	MRL	2002	Pipeline	Exceptional combination of good eating quality, aroma with high yield
Super 3004	Main	SDRL	2004	Pipeline	High yield, wide adaptation, disease resistant
Barkhe 3019	Main	SDRL	2005	Pipeline	High yield
Barkhe 2024	Main	MRL	2003	Pipeline	High yield, good cooking quality
Barkhe 3018	Main	SDRL	2005	Promising	High yield
Barkhe 2044	Main	MRL	2003	Promising	High yielding, cold tolerant
Barkhe 1006	Main	SDRL	2003	Promising	High yield, drought tolerant
Judi 572†	Chaite and main	SDRL	2003	To be registered	High yield
Judi 565†	Chaite and main	SDRL	2006	Pipeline	High yield
Judi 582†	Chaite and main	SDRL	2005	Pipeline	High yield
Judi 567†	Chaite and main	SDRL	2005	Pipeline	High yield
Judi 503	Chaite	SDRL	2002	Promising	High yield, drought tolerant
Judi 508	Chaite	SDRL	2003	Promising	High yield, drought tolerant
Judi 591†	Chaite	SDRL	2004	Promising	High yield, drought tolerant

†Tested in Bangladesh and India, SDRL = Semi-deep rainfed lowland, MRL = Medium rainfed lowland,

When produced: The PSP research only began in 1997 and the first varieties from the programme were produced by 2000. The products of COB were more widely tested from about 2002. **Barkhe 3004** was the first variety released from COB in 2006.

Problem addressed and description of outputs: Baseline data (Rana et al., 2004) showed a great lack of varietal diversity. Varieties such as CH 45 in the *Chaite* season and Masuli in the main season were over 25 years old and vulnerable to pests and diseases. Masuli was occupying nearly 80% of the rice area in Chitwan and Nawalparasi districts (Fig. 2). Varietal diversity in *Chaite* rice was very narrow (Witcombe et al., 2001). Though more varieties were grown in main-season rice, the diversity was again low when weighted by the area occupied by each variety (Joshi and Witcombe, 2000).

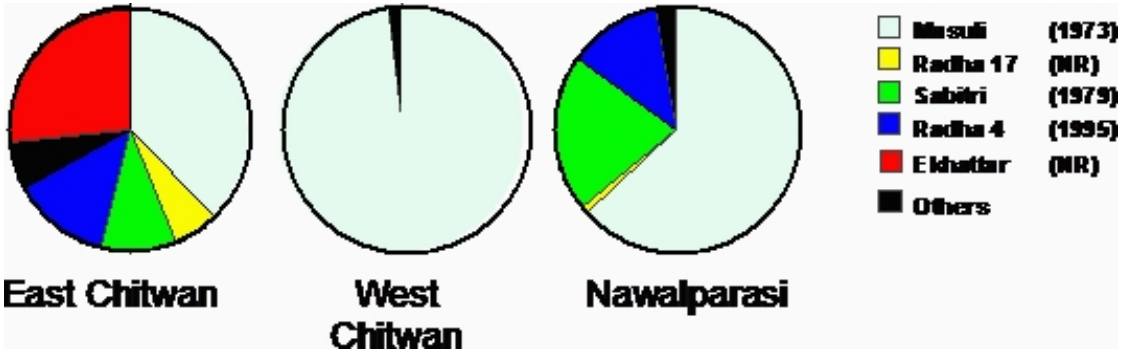


Fig. 2. Varietal diversity in two districts of the *Terai*. From a survey in 1997

There is a great diversity in physical and socio-economic environments within and between high potential production systems (HPPSs) but blanket recommendations of technologies did not match this diversity, greatly reducing overall productivity (Witcombe, 1999; Witcombe et al., 2001; Warner et al, 1999). COB provided a means of rapidly producing better rice varieties that match the diversity of environments found in the *Terai.*

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
x	*x*		*x*	*x*	

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

This output (rice varieties produced from COB) is related directly only to rice. However many of the shorter duration varieties facilitate timely planting of a post-rainy season legume or wheat crop (see Dossier 35). The process of COB can be applied to any crop (see dossier 34).

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
x	*x*						*x*

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
x	*x*	*x*				

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**). Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.*

COB rice in Nepal generated a large number of promising rice varieties for main and *Chaite* season rice suitable for Nepal as well as for India (dossier PSP 10) and Bangladesh (dossier PSP 12). COB and PVS involve farmers testing varieties on their own fields under their customary agronomic practices and this can be combined with testing many other interventions involving crop protection, community-based seed production (PSP dossier 36) and improved agronomic practices (PSP dossiers 25 and 35).

It can be combined with outputs from other RNRRS themes:
CPP, Cost effective weed management packages for lowland rice in Bangladesh, R8412, R8234, R7471
CPP, Extension and promotion of rodent technologies in rice-based systems, R8424, R8164
CPP, Good seed initiative, R8480
CPP, Linking demand with supply of agricultural information, R8429, R8281
CPP, Managing rice pests in Bangladesh by improving extension service information management for policy and planning, R8447
CPP, Rice sheath blight complex, R7778
CPP, Weed management in irrigated rice, R8409, R8233, R7377
NRSP, Participatory Technology Development, R7412

Validation

B. Validation of the research output(s)

***10. How** were the output(s) validated and **who** validated them?*
*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

How validated: New COB varieties are tested with farmers in PVS trials (see dossier 33). In PVS validation is always by farmers using their customary agronomic practices in on-farm participatory trials using participatory

evaluation of many traits (e.g. matrix ranking, surveys, visual, micro-milling and organoleptic assessment) considered important by farmers. End users such as millers, traders and consumers helped test the post-harvest quality traits. Validation of yield was often done by government organisations in on-station trials. The trials were always replicated to provide a test of statistical significance. **See also outcome assessments Q 20.**

COB varieties were bred in a single location in Nepal (in Chitwan) but tested and disseminated much more widely on a much larger scale throughout the *Terai* and low-altitude areas of Nepal. All the COB varieties in Table 1 were further validated through scaling up through community-based seed production (CBSP).

Who validated: Validation was done by farmers working with researchers from many organisations involved in the validation process in Nepal (Devkota et al., 2006).

1. LI-BIRD
2. CAZS-NR
3. NRRP, and other NARC stations
4. 31 DADOs (21 *Terai* and 10 midhill districts). **See also uptake and promotion pathways Q 16.**
5. Three NGOs: FORWARD, SUPPORT Foundation and CDRC
6. 10 Community Based Seed Producers Groups
7. Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal
8. Several CBOs and Agrovets and individual farmers from different parts of the country

These are also validated and promoted in India and Bangladesh (see PSP dossiers 10 and 12).

The target groups of male and female farmers were from all social groups representing resource rich, medium and poor farmers, identified through local key informants using key proxies for wealth such as landholding size.

Evaluation of PVS trials included participating farmers (with a representative proportion of women) and their neighbours, relatives and friends (this always included some women). The evaluation of the post-harvest traits always involved women.

Increases in productivity: Tremendous increases in productivity were achieved over the local cultivars (see Table 2). There is improvement in traits other than grain yield. For example, earlier maturity, better lodging resistance, higher straw yield, increased drought tolerance, and better grain and cooking quality resulting in a higher market price.

Table 2. Examples of yield increase of new varieties given in PVS trials

Variety	Yield advantage (%) over local §
Sunaulo Sugandha	17
Barkhe 3004	23
Super 3004	21
Barkhe 3018	30
Barkhe 3019	42

Barkhe 2001	20
Barkhe 2024	34
Barkhe 2014	34
Barkhe 2044	7
Barkhe 1027	32
Barkhe 1006	30
Judi 565	38
Judi 582	45
Judi 567	37
Judi 572	23
Sugandha 1	19
Judi 503	23
Judi 591	20

[§] For first dates of evaluating these varieties in PVS trials, the rice ecosystem/s and the season/s see Table 1.

*11. **Where and when** have the output(s) been validated? Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

Most validation has been done in rice-based farming systems in the low-altitude regions of Nepal (the *Terai*) in the rice continuum from upland to semi-deep lowland (Fig. 3). Some of the varieties have been tested in low hill region of Gorkha, Lamjung, Tanahun, Palpa and Syangja districts and varieties where Barkhe 2014, Barkhe 3017, Barkhe 1006, Barkhe 1027, Sugandha 1 and some of the Judi lines were preferred and adopted by farmers.

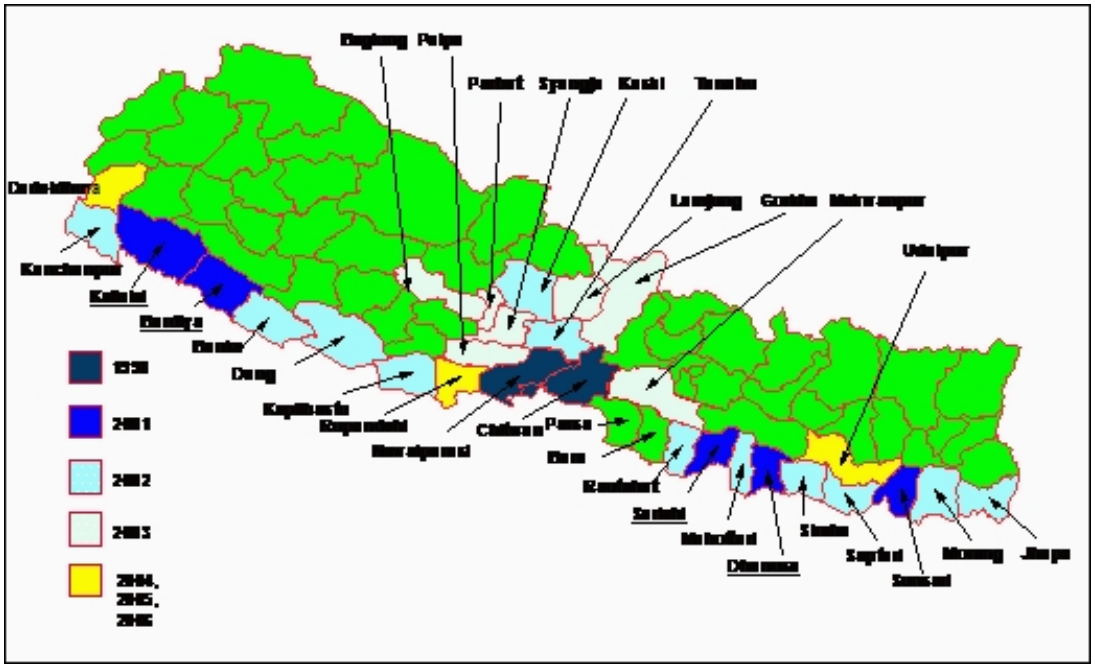


Fig. 3. Where and when (year of first entry) the activities have taken place.

Hundreds of male and female farmers from all social categories have been involved in this validation, particularly at the scaling up stage. The work has been done in all districts of the Nepal *Terai* that, contrary to what might seem to be a reasonable assumption, include some of the poorest in Nepal.

The UN has compiled a poverty and deprivation index for each district of Nepal. The all-Nepal index and that for the *Terai* are the same (0.47) on a scale of 0 for least developed to 1 for most developed. This average development in the *Terai* is only because a few districts are highly developed (Fig. 4). Of the 20 *Terai* districts, 14 are average or below average in development. Rautahat, the poorest district in the *Terai* has a population of over 500,000 and is the fourth poorest district in Nepal. Several population groups in the *Terai*, including the *Tharus* and *Musahars*, have been disadvantaged for generations and remain so. Moreover, the improvement in the human development index from 1996 to 2000 in the *Terai* as a whole (12%) was lower than in the hills (18%).

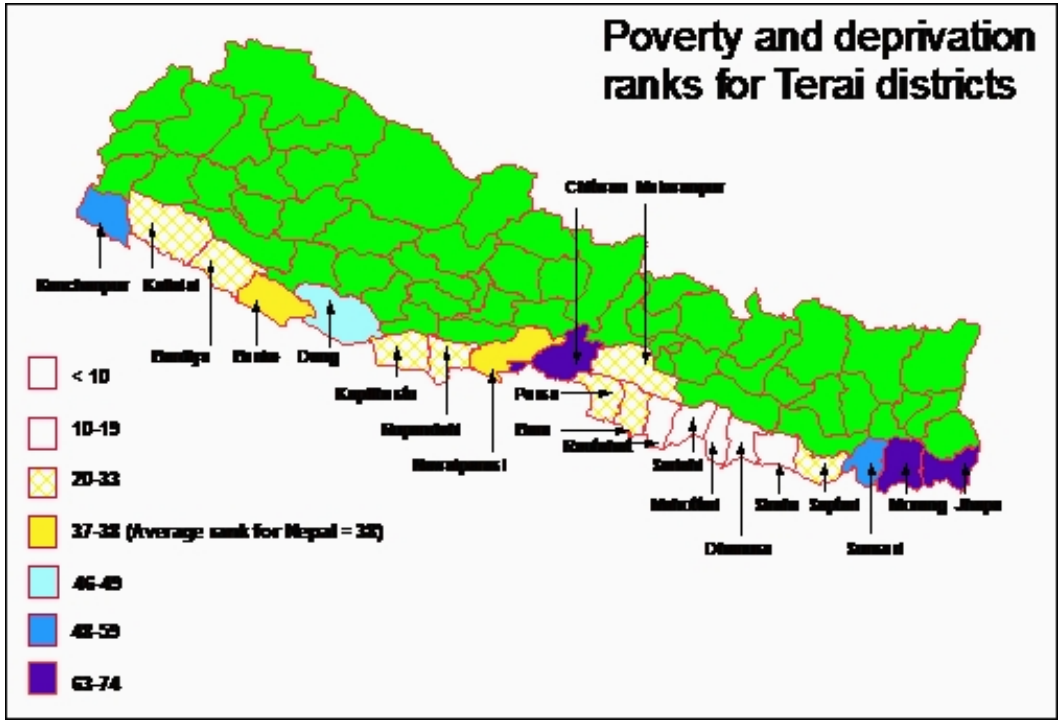


Fig. 4. Poverty and deprivation index ranks (1 = least developed district, 75 = most developed district) for the *Terai* districts, 2001.

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words**).*

Many farmers from various districts of Nepal (e. g. Table 3) are using the new varieties (see Question 14) to increase their rice productivity. In July 2006, Barkhe 3004 was officially released and seed of this and several other promising varieties are being produced and distributed by the community-based seed producers groups across the country in Nepal. Barkhe 3004 is a high-yielding medium-grain variety suitable for long standing water condition. Farmers in Bara, Prasha and Rautahat districts (with the highest poverty index) prefer this very much as the majority of rice growing area is rainfed lowland. In the Western region of Nepal, there are more drought-prone areas and farmers are using Sugandha 1 and Barkhe 1027 for their drought tolerance and early maturity. Similarly, other COB varieties were adopted and used by the farming communities in several districts to suit to their production environments.

Table 3. Current use of COB variety and reason for adoption in Nepal

Variety	Districts where they are most popular	Approx. area covered (ha)†	Varieties being replaced	Reasons for adoption of new varieties
Barkhe 3004	Bara, Parsha, Rautahat, Chitwan, Nawalparasi	2500	Swarna, Masuli	High yield, suitable for lowland areas
Barkhe 2001	Jhapa, Saptari, Sarlahi, Dhanusha, Chitwan, Nawalparasi, Kailali, Kanchanpur	3000	Sabitri, Kanchi Masuli, Masuli, Sarju 52	High yield and quality
Sugandha 1	Jhapa, Morang, Kapilbastu, Dang, Banke, Bardiya	1200	Radha 4, Bineswori and some other local	Aroma, drought resistant
Barkhe 1027	Dang, low hills of Lamjung, Palpa	800	Bindeswori	Drought resistant
Barkhe 2014	Jhapa, Morang, Sunsari, Saptari, Chitwan, low hills of Lamjung, Kailali	1500	Kanchhi masuli, Sabitri	High yield, medium maturity
Judi 572	Morang, Chitwan,	200	Radha 4, Sabitri	Early maturity, high yield

†data based on monitoring reports and personal communication with DADOs of respective districts

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

See map in Question 11.

In Nepal, all the varieties are adapted to the rice growing areas in the *Terai* and low hills but the adaptation to altitude differs (Table 4). The *Terai* makes up the vast majority of the rice growing area in Nepal and covers the rainfed lowland ecosystem from shallow unbunded fields to semi-deep rainfed lowlands.

Table 4. Geographical region where COB varieties are being scaled up

Variety	Altitude up to (m)	Also in midhills	Special traits
Sugandha 1	1200	yes	Early maturity, eating quality, aromatic, drought tolerance
Barkhe 1027	1200	yes	Early maturity, drought tolerance
Judi 565	1200	yes	Early maturity, high yielding
Judi 572	1200	yes	Early maturity, high yielding
Judi 582	1200	yes	Early maturity, high yielding
Barkhe 2014	900		High yielding, better eating quality than Kanchi Masuli‡,

Barkhe 2024	900	High yielding, better eating quality
Barkhe 2001	900	High yielding, better eating quality
Barkhe 3004	800	High yielding, fertilizer responsive, no lodging in high fertility condition
Super 3004	800	High yielding, fertilizer responsive, no lodging in high fertility condition
Barkhe 3019	800	High yielding, fertilizer responsive, no lodging in high fertility condition
Sunaulo sugandha	900	High yielding, aromatic, fertilizer responsive, no lodging in high fertility condition

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

We estimate usage is increasing in area at least two to three fold a year (and even more in terms of numbers of users), but current use is far below the potential adoption ceiling. Most of the varieties are yet to be officially released and widely taken up by the government and other agencies. Currently, the organised sector (government and private sectors) are supplying less than 5% of the total rice seed needed (Baniya et al., 2000). Community-based seed producer groups have initiated production of substantial quantities of seeds. This is increasing every year (Table 5, Fig. 5) in several *Terai* and midhill districts of Nepal. LI-BIRD and FORWARD are strengthening community-based seed producers groups in eleven districts to increase seed supply, and these groups are producing and supplying a significant amount of rice seed.

As an example of scale of use, in 2003, 37 t seeds of Barkhe 1027, Sugandha 1, Barkhe 2014, Barkhe 3004 and Barkhe 2001 was marketed. An advertisement on FM Radio (which can be heard in 35 districts of Nepal) was done for COB varieties one month before nursery raising time in April-May. Following this, many seed buyers came and the seeds were sold out within seven days. The reasons for such a response may be several, e.g. the popularity of those varieties among farmers, quality of seed, reasonable price, no bureaucratic hurdle.

However, this is still on a very small scale compared to actual needs. It is a reasonable assumption that the COB varieties are better alternatives to others on at least 40% of the total of 1.1 M ha of rice in the *Terai*. If only 10% of this area is sown to purchased, quality seed each year then sufficient seed to transplant 0.042 M ha of rice is needed. This amounts to over 2100 t of rice seed each year at a rate of 50 kg $ha^{\bullet 1}$. At present, only 7 % of this amount (and a 10% replacement rate is a modest target) is being supplied through the formal sector, clearly showing that even though the varieties have been scaled up to some extent, it is not enough.

Table 5. Amount of rice seed (main and spring) produced and marketed (t) since 2002-2006 by the community-based seed producer groups facilitated by LI-BIRD

	2002	**2003**	**2004**	**2005**	
	Individual farmer	**CBSP**	**CBSP**	**CBSP**	Total
Barkhe 1027		4	2.0	2.0	8
Sugandha 1	2.6	11	2.3	0.6	17

Barkhe 2014	1.1	1.2	5.6	7.5	15
Barkhe 3004	1.1	8.8	5.1	13.8	29
Barkhe 2024			1.3	0.6	2
Barkhe 3017			0.3	0.3	0.6
Judi 572	0.4		1.6	0.1	2
Super 3004			0.2	4.2	4
Barkhe 1006			1.2		1.2
Sugandha 2002			3.6	5.5	9
Barkhe 2001	2.1	12.2	1.5		16
Total	7.4	37.2	24.7	34.9	122

†Approach of seed production and distribution. The quantity produced in 2000 was 6 t and in 2001 12 t.

Table 6. Number of PVS sets of *Chaite* and main season COB bred rice varieties distributed in various districts of Nepal, 2003-2006

	2003		2004		2005		2006	
	Chaite	**Main**	**Chaite**	**Main**	**Chaite**	**Main**	**Chaite**	**Main**
No. of 2 kg sets	300	10200	430	5900	1020	5800	480	10500
No. of varieties	24	5	13	11	15	11	12	9
No. of districts	3	29	17	13	5	25	9	31

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key factors of success? ***(max 350 words).***

Process: Rice varietal promotion in Nepal is coordinated by NRRP; varieties introduced or bred in Nepal are evaluated by NRRP and NARC for yield and agronomic performance, proposed for release to the National Seed Board and then widely disseminated by the Department of Agriculture and its networks, other NGOs, CBOs and seed companies. In the conventional approach, actual adoption takes place 5-6 years after a variety is released. Assuming a variety development phase of 12 years, it would need at least 18 years before appreciable variety adoption took place.

An institutional innovation took place in COB rice by bringing together the stakeholders very early in the breeding process. For example, NRRP was involved in disease screening, DADOs participated in the evaluation and promotion of varieties and farmers groups were involved in the production and marketing of the seeds.

Outputs: This new innovation platform was very helpful in very rapidly developing and disseminating these varieties across many districts of Nepal. The variety Barkhe 3004, released through a partnership between LI-BIRD, CAZS-NR and NRRP, was also an outcome of this institutional innovation. LI-BIRD, an NGO, has fully institutionalised all the elements of COB, and is successfully developing rice varieties for diverse environments. NARC, through NRRP, collaborates in this programme, testing varieties from COB in its disease nurseries and

entering them into its on-station yield testing. It also provides its own varieties to LI-BIRD for testing in PVS trials. NRRP contributes to identifying and verifying rice varieties though coordinated yield trials. There is evidence that the NRRP now makes fewer, more carefully chosen crosses. NRRP is also a co-proposer on varieties bred by COB such as Barkhe 3004.

Key factors in this success in Nepal have been specific research partnerships related to COB over a long period, and formalising collaboration with LI-BIRD and NRRP. This enabled NRRP breeders to officially collaborate in more participatory approaches and allowed many opportunities for NRRP scientists to learn of these approaches.

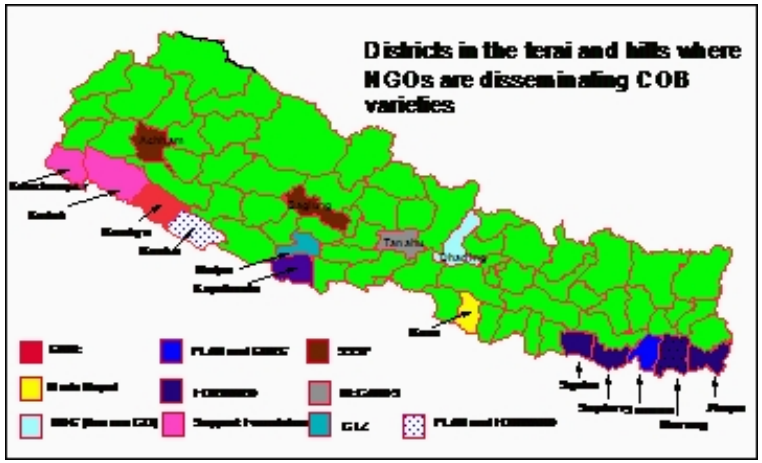
Current Promotion

D. Current promotion/uptake pathways

*16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

Rice varieties developed from COB are promoted in Nepal, through various governmental and non-governmental research and development organizations such as DADOs, NGOs, and Agrovets. (Fig. 5). They are being multiplied by at least 10 community-based seed producer groups in at least six districts, namely

- Unnat, Shree Ram and Devujjal Seed Producers groups in Chitwan,
- Nawa Adharsha Farmer Seed Producers Group in Jhapa,
- Radhakrishna and Krishnapranami Women Seed Producers Group in Rautahat,
- Surayadaya Bahu Uddeshe Krishak Sahakari Sanstha Ltd. in Dang,
- Kalika Seed Production Group in Kailali and
- Siddhanath Seed Producers Group in Kanchanpur districts of Nepal,
- Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal.



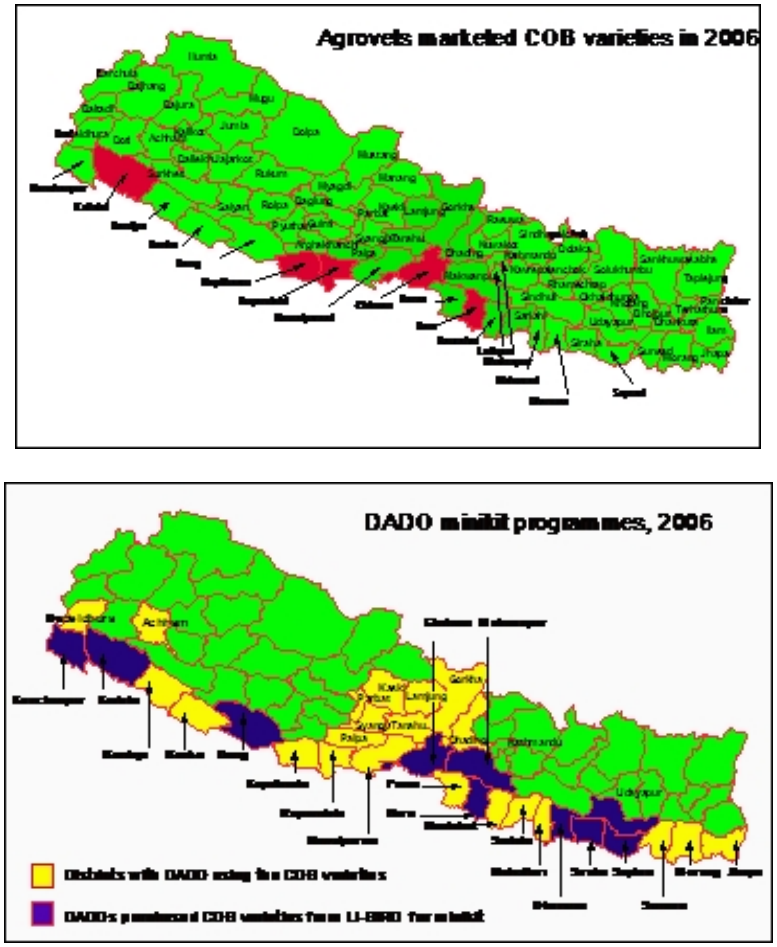


Fig 5. The extent of promotion of these varieties by NGOs, Agrovets (the private sector) and the District Agriculture Development Offices as of 2006.

The extent of adoption was assessed (Devkota et al., 2005, Rawal et al., 2006; Gauchan, 2006, Joshi et al., 2006) and found to be quite extensive in relation to how recently seed of the varieties has been available.

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17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

Outputs: The formal seed channels in Nepal do not officially promote non-released varieties but collaboration from the Department of Agriculture in promoting non-released COB varieties was very good, and NRRP no longer oppose COB, as PVS is seen as integral to the varietal testing system.

Policy issues: Changes in the seed regulatory framework to encourage farmer participation have been made. For example, in the release proposal for Barkhe 3004, on-station and on-farm data from participatory trials were given equal status and validity. This is illustrated by Figure 6 taken from the release proposal where CVT (on-station)

and mother and baby trials data were presented in a single analysis.

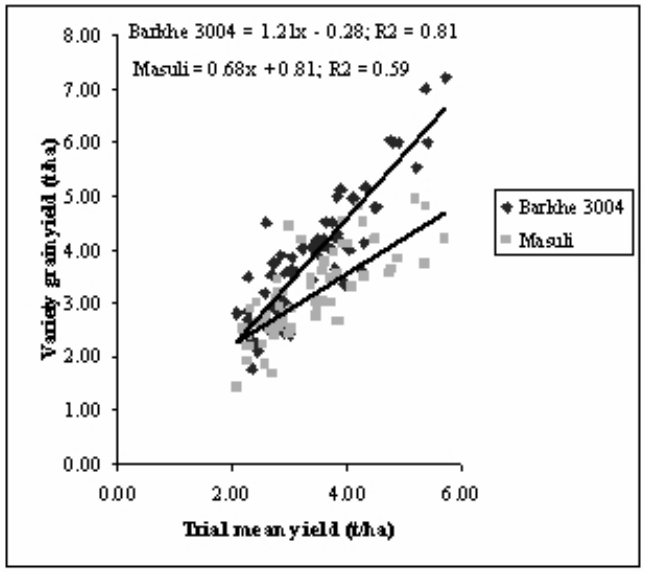

Fig. 6. Stability of Barkhe 2004 over standard check variety Masuli in CVT (n=28) mother trials (n=18) and baby trials (n=23) data. Linear regression trend lines are shown.

However, there has been inertia in the process of marketing new varieties, evidenced by the slowness in meeting only a small proportion of current demand.

Process: A huge barrier in adopting COB methods is the **mindset** of breeders who have been taught about the effectiveness of the classic 'green revolution' approach involving on-station breeding for wide adaptation and making hundreds of crosses each year, reinforced by **official policies** on varietal identification, release and dissemination. Variety recommendation is highly formalised, regulated by customary practices and laws (seeds acts) that **conflict with the participatory technology development approach.**

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18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

The best way to remove the barriers will be to change mindsets through wide scale training of GO and, to a lesser extent, NGO staff in the COB process to appreciate its potential impact. There is limited human resource capacity, particularly in GOs, in participatory approaches to research, while NGOs have limited capacity in seed-related issues, and most would regard plant breeding as being well beyond their capabilities. We do not believe this to be true since the COB methods are very simple and adapted for use by NGOs without access to a research station. Moreover, NGO/GO collaboration has been shown to be possible and effective for COB.

Policy makers need to be brought into this dialogue, as they are rarely involved.

There need to be changes in curricula in Universities to mainstream participatory, client-oriented approaches to plant breeding. Once convinced of the approach, there would not be any problem to increase the adoption of the output of this process.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words). 311***

Using Rogers (2003) method as a framework for the lessons learnt:

1. The relative advantage of a technology compared to what it is replacing;
This is generally high (see Table 1) and farmers generally agree on the reasons why they prefer a new variety.

2. The compatibility of the technology with existing systems and ways of doing things, closely related to culture;
Compatibility with farmers is high as they are used to experimentation in their own fields. For scientists and extensionists trained in the transfer of technology model, compatibility is low but awareness of participatory approaches in Nepal is better than elsewhere. For the process of COB large changes are required.

3. The complexity of the technology in terms of what people need to learn to make it work;
Complexity is low for farmers (baby trials are extremely simple) and the new rice varieties do not require altered agronomy. Technology is moderately complex for scientists/extensionists who must learn a range of new participatory techniques. COB methods are simpler than those currently used.

4. The observability of a technology in terms of how easy it is to demonstrate and observe performance;
Observability is high for many traits, e.g. maturity and yield, although post-harvest traits are more difficult.

5. The trialability of a technology in terms of how easy it is to test it before deciding to adopt.
Trialability is high if seed is available, but impossible without seed and difficult to do properly without information (high risk of growing the new variety in the wrong part of the rice continuum).

The most important lesson, assuming the lesson of using participatory approaches has been well accepted, is the need for provision of seed on a large scale and the provision of information to all stakeholders in the innovation system, by specifically including policymakers, traders and consumers as well as researchers, extensionists and farmers.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on

poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

1. Devkota K.P., Gyawali S., Subedi A., Witcombe J.A.D. & Joshi K.D. (2005). Adoption study of main season rice in Chitwan and Nawalparasi districts of Nepal from 2001 to 2002. Discussion paper no. 6 (in press) Wales, Bangor: CAZS Natural Resources, University of Wales www.dfid-psp.ac.uk
2. Gauchan, D. (2006). Assessment of the outcomes of rice-fallow rainfed rabi cropping (RRC) project in Nepal *Terai*. A report of the RRC outcome assessment in Kapilvastu, Saptari and Jhapa districts, Nepal. Bangor, UK: CAZS Natural Resources, University of Wales, Bangor.
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4. Joshi, K.D., Biggs, S., Devkota, K. and Gyawali, S. (2003). Delivering impacts from participatory crop improvement projects in Nepal. PSP Annual Report 2003. Section 1: Introduction and General Overview. Research Outcomes. pp 11-18.
5. Rawal, K.B., Bhatta, V.R., Joshi, G.R. & Singh U. (2006). Adoption and spread of rice varieties in Sarlahi and Kailali districts identified by participatory crop improvement (PCI) and bred by client-oriented breeding (COB). Kanchanpur, Nepal: SUPPORT Foundation.
6. Witcombe, J.R. Joshi, K.D., Gyawali, S., Devkota, K. & Subedi, A. (2002). An impact assessment of participatory crop improvement in the low-altitude regions of Nepal. PSP Annual Report 2002. Section 1: Introduction and General Overview. Research Outcomes. pp 11-18.
7. Witcombe, J.R. Joshi, K.D., Gyawali, S., Devkota, K. & Subedi, A. (2004). Participatory crop improvement in the low-altitude regions of Nepal. Plant Sciences Research Programme. Highlights and impact. Participatory crop improvement. pp 21-50.
8. Witcombe, J.R., Joshi, K.D., Gyawali, S., Devkota, K. & Subedi, A. (2004). Participatory crop improvement in the low-altitude regio&ns of Nepal. Impact assessment working document 6.2 October 2004. Stand-alone report CAZS and LI-BIRD. (Earlier version published as: An impact assessment of participatory crop improvement in the low-altitude regions of Nepal. (2003) JR Witcombe, KD Joshi, S Gyawali & A Subedi PSP Annual Report for 2002)

Several financial analyses have been done. All show high rates of return and large NPVs. The estimates, of course, do vary greatly according to the assumptions used but present adoption is probably closest to the high scenario (see Fig 7. below).

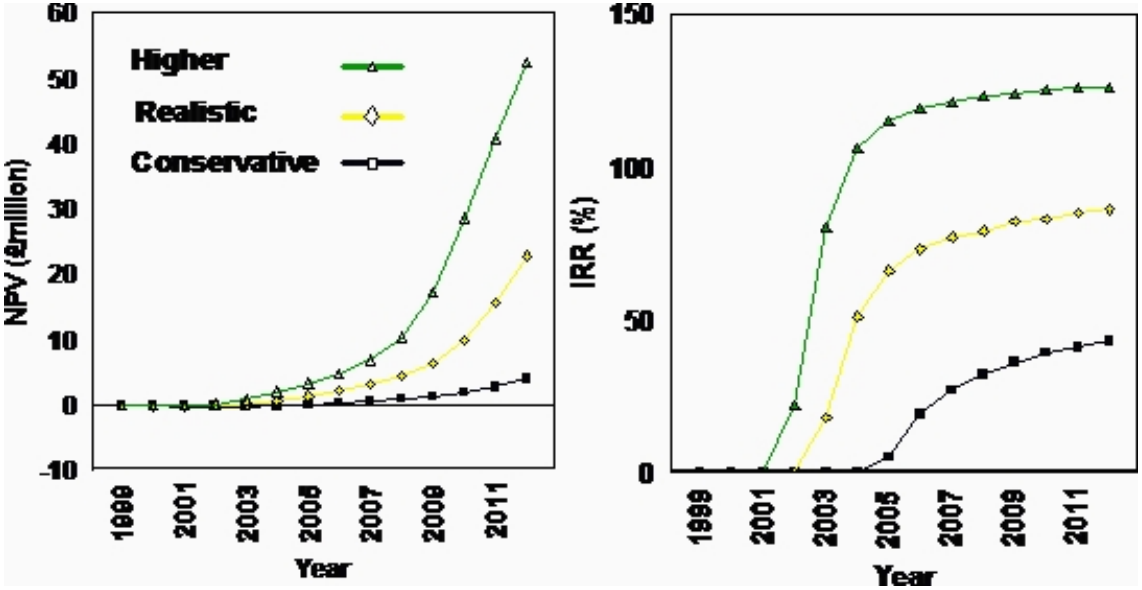


Fig. 7. The NPV and IRR over time with the 'conservative', 'realistic' and 'higher' scenarios (source Witcombe et al., 2004 reference 8 above)

Below is an example of one of many interviews with farmers on the new varieties.

Keshar Khatiwada is a food balance farmer (Category A). He grew Sugandha 1 in about 0.1 ha land and

harvested about 500 kg rice. He found it can be successfully grown with moderate fertility and irrigation. It can even give reasonable yield where other varieties do not perform well, e.g. area where topsoil has been removed for brick making and under water-limited conditions.

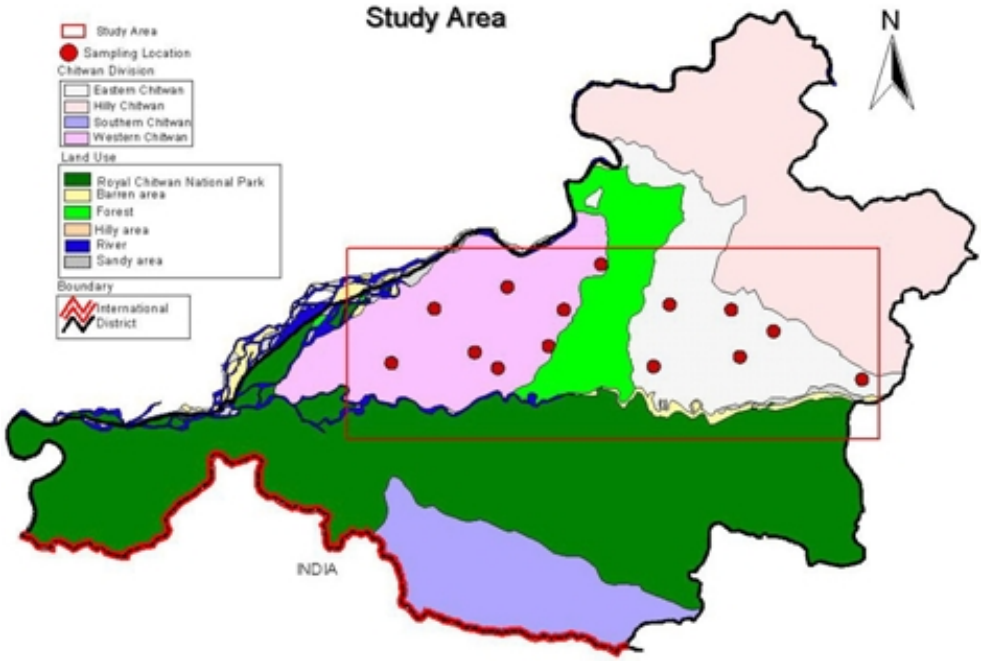
Its straw yield is nearly one and a half times that of other varieties and because of quite tall length of the straw, it is very much suitable for making *gundri* (a kind of mat made using rice straw).

Sugandha 1 matures nearly 10-12 days earlier than other varieties enabling the early/timely planting of potato, other vegetables or winter maize that fetch a premium price in the market.

It has high milling recovery and the eating quality of rice is good in spite of stickiness. One thing noted by most farmers growing Sugandha 1 was also mentioned by Keshar, that was that rice cooked from freshly harvested lot has strong aroma and cannot be consumed in great quantities (it is heavy and highly satisfying). This is known as *aman garaune* .

Adoption studies have used sophisticated methods to obtain unbiased estimates of adoption such as the random identification of points for transects using geographical positions systems (see below).

Study area in Chitwan district showing the randomly elected points for the transects. These points were found precisely using GPS and systematic transects made to sample 50 precise predetermined points.



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21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

The adoption of main season rice varieties was 18% within two to six years of intervention, with a high number of adopting households. Since 2002, a significant amount of seed of several COB varieties has been distributed and sold in various districts of Nepal. Considering a seed rate of 50 kg to plant one hectare and at least trebling in farmer-to-farmer seed distribution every year, several thousands of farmers in several districts covering thousands of hectares of rice area in Nepal have sown the new varieties.

The yield gains in all of the COB varieties clearly showed that participating farmers benefited from the new varieties (Table 2). These increased yields along with the higher quality of the new varieties contributed considerably to reducing poverty and addressing food and livelihood security, e.g. food sufficiency was increased from six months to one year in the majority of cases. Increased family income was crucial for e.g., life-saving health care, children's schooling, meeting household requirements, social obligations (marriage), and farm improvements, and for food surplus households cash income increased from the sale of surplus grains (Joshi et al*.,* 2003).

The issue of social inclusion was addressed by engaging with disadvantaged and marginalised communities. Results of outcome assessment indicated that >75% of sampled beneficiaries for *Chaite* rice activities were indigenous people and disadvantaged communities, while this percentage was nearly 53% for main season rice (Joshi et al*.,* 2006).

A range of varietal choices were created for the less favourable areas where the crop is grown under rainfed conditions or with limited irrigation or for example in long-standing water. Rice varietal diversity increased considerably in the study villages reducing the area under old, obsolete and disease susceptible varieties by growing new, better-adapted, early-maturing, higher-yielding and farmer-preferred varieties, so improving overall systems productivity and strengthening food security (Devkota et al., 2005).

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Direct and indirect benefits:

- The adoption of the COB process will reduce wastage on a national level by reducing the number of varieties that are breed and tested only to be ultimately rejected by farmers.
- Increased productivity per unit area without the use of additional external inputs, especially pesticides, is environmentally beneficial. The new varieties have better nitrogen-use efficiency: nitrate is an important pollutant and its synthetic production is a significant contributor to global warming (IPCC, 2001).
- Increased productivity will reduce the pressure to increase the area under cultivation (Evenson and Gollin, 2003).
- Varietal diversification will help reduce crop loss due to pests and diseases and thereby reduce the use of pesticides. Introduction of new varieties always increases on-farm diversity as farmers adopt different cultivars for different niches.
- The better disease and pest resistance of the new varieties can reduce the use of water- and soil-polluting agro-chemicals. Reduced use of pesticides and insecticides will also reduce the risk to human life and help in the creation of a balanced pest-predator cycle.
-

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Any adverse environmental impact is unlikely in the present case as the new varieties are scale neutral and do not require any special cultural, management and production inputs.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

Earlier maturing varieties have increased the resilience of farmers by making available extra time for other operations, lower cost of production, reduced use of water and nutrients besides, in some cases, increasing cropping intensity (two crops a year in the place of one)

Varietal diversification is a means of coping with climate change. For example, the staggered deployment of varieties that take different times to mature reduces the risks from drought, diseases and pests, and adverse weather (high winds, hail, and floods). The new varieties do well under low irrigation but respond to better conditions thus increasing the resilience of farmers to cope with variation.

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Annex 1. Grain yield of Barkhe 3004 from crop cut survey from Baby trials, 2005

District	N	Farmers' variety	Grain yield t ha^{-1}		Yield advantage	t-at
			Farmers' variety	Barkhe 3004	over farmers' variety (%)	p =0.05
1. Morang	9	Masuli	3.6±0.23	5.2±0.37	45	***
2. Siraha	11	Jhapali Masuli, Rambilash, Mala, Masuli, Sona Masuli	2.5.34	3.3±0.48	34	*
3. Bara	22	Sona Masuli	4.2±0.29	4.4±0.26	5	ns
4. Chitwan	11	Masuli, Sabitri	3.5±0.22	4.5±032	27	*
5. Nawalparasi	9	Masuli, Mala, Sabitri, Swarna	3.80.37	4.8±0.53	28	*
6. Kailali	16	Sarjoo 52, Radha, Masuli,	3.1±0.16	3.3±0.29	5	ns
7. Kanchanpur	7	Sarjoo 52, Jhapali Masuli, Pusa 44	3.2±0.33	3.9±0.25	21	ns
Overall	85	Various farmers' varieties reported above§	3.5±0.12	4.2±0.14	19	***

†Mean ± SEM, § Number of farmers growing various varieties as check in Baby trials were: Masuli (23), Sona Masuli (23), Sarjoo 52 (18), Mala (5), Sabitri (4), Rambilash or Radha 11 (4), Jhapali Masuli (3), Swarna (2), Pusa 44 (1) and Radha 4 (1)

Annex 2. Farmers' perceptions for Barkhe 3004 in 111 Baby trials in 2003, 27 baby trials in 2004 and 124 baby trials in 2005 and their intentions for growing the variety in the following year in Chitwan, Nawalparasi, Jhapa, Morang, Sunsari, Siraha, Bara, Makawanpur and Saptari districts of Nepal.

Trait	Year	Number of farmers				Probability†
		B 3004 preferred	Equally preferred	Check preferred	Preference for B 3004 (%)	
Maturity	2003	13	19	78	12	***
	2004	6	3	18	22	*
	2005	30	41	45	26	ns
	Overall	49	63	141	19	***
Lodging	2003	45	59	7	41	***
	2004	14	5	7	54	ns
	2005	107	0	3	97	***
	Overall	166	64	17	66	***
Disease	2003	53	48	5	50	***
	2004	15	3	7	60	ns
	2005	61	31	28	50	***
	Overall	129	82	40	51	***
Threshing	2003	69	31	9	63	***
	2004	18	5	3	69	**
	2005	61	41	18	51	***
	Overall	148	77	30	58	***
Milling recovery	2003	77	28	3	71	***
	2004	7	12	3	32	ns
	2005	38	67	10	33	***
	Overall	122	107	16	48	***
Market price	2003	45	19	20	54	**
	2005	23	70	21	20	ns
	Overall	68	89	41	27	ns
Straw yield	2003	53	38	20	48	***
	2004	8	8	9	32	ns
	2005	24	42	55	20	***
	Overall	85	88	84	34	ns
Grain yield	2003	52	36	22	48	***
	2004	14	8	5	52	*
	2005	58	41	22	48	***
	Overall	124	85	49	49	***
Will grow again?	2003	71		38	65	**
	2004	13		11	54	ns
	2005	81		36	69	***
	Overall	165	-	85	65	***

†'Barkhe 3004 preferred' *versus* 'Check preferred' using χ^2 test.

Annex 3. Farmers' perceptions for Barkhe 2014 on 154 baby trials in eleven districts of Nepal [Chitwan (36), Bara (10), Jhapa (9), Kailali (4), Makawanpur (10), Morang (5), Saptari (7), Siraha (10), Sunsari (38), Gorkha (3) and Kaski (4)] during 2005

	Number of farmers			Preference for	
Trait	Barkhe 2014 preferred	Equally preferred	Check preferred	Barkhe 2014 (%)	Probability†
Maturity	86	41	21	56	0.000**
Tillering capacity	77	60	12	50	0.000**
Lodging	43	105	1	28	0.000**
Disease	81	54	15	53	0.000**
Threshing	96	43	10	62	0.000**
Milling recovery	75	67	2	49	0.000**
Eating quality	69	67	7	45	0.000**
Market price	24	89	22	16	0.768ns
Straw yield	63	49	38	41	0.013*
Grain yield	71	45	26	46	0.000**
Will grow again	114		31	74	0.000**
Overall performance	85	41	11	55	0.000**

†'Barkhe 2014 preferred' *versus* 'Check preferred' using χ^2 test.

Annex 4. Farmers' perceptions for Sugandha 2002 on 32 baby trials in seven districts of Nepal [Kailali (2), Kanchanpur (1), Makawanpur (10), Morang (2), Saptari (3), Siraha (5) and Sunsari (9)] during 2005

	Number of farmers				
Trait	Sugandha 2002 preferred	Equally preferred	Check preferred	Preference for Sugandha 2002 (%)	Probability†
Maturity	9	15	6	30.00	0.439ns
Tillering capacity	12	16	3	40.00	0.020*
Lodging	5	25	0	16.67	0.000**
Disease	16	8	8	53.33	0.102ns
Threshing	17	13	2	56.67	0.001**
Milling recovery	14	15	3	46.67	0.008**
Eating quality	27	3	2	90.00	0.000**
Market price	9	12	1	30.00	0.011*
Straw yield	13	11	8	43.33	0.275ns
Grain yield	15	14	3	50.00	0.005**
Will grow again	25		4	83.33	0.002**
Overall performance	25	4	1	83.33	0.000**

†'Sugandha 2002 preferred' *versus* 'Check preferred' using χ^2 test.

Annex 5. Farmers' perceptions for Sugandha 1 on 89 baby trials in ten districts of Nepal [Bara (7), Chitwan (14), Jhapa (10), Kailali (6), Kanchanpur (4), Kaski (4), Makawanpur (9), Saptari (7), Siraha (12) and Sunsari (11)] during 2005

Trait	Number of farmers			Preference for Sugandha 1 (%)	Probability†
	Sugandha 1 preferred	Equally preferred	Check preferred		
Maturity	59	17	13	66.29	0.000**
Tillering capacity	26	26	29	29.21	0.686ns
Lodging	49	39	1	55.06	0.000**
Disease	40	26	23	44.94	0.032*
Threshing	62	22	5	69.66	0.000**
Milling recovery	44	40	6	49.44	0.000**
Eating quality	75	10	4	84.27	0.000**
Market price	42	42	7	47.19	0.000**
Straw yield	43	33	15	48.31	0.000**
Grain yield	45	25	19	50.56	0.000**
Will grow again	76		11	85.39	0.000**
Overall performance	75	11	1	84.27	0.000**

†'Sugandha 1 preferred' *versus* 'Check preferred' using χ^2 test.