RIU

Client-orientated breeding is quick, cheap and effective

Validated RNRRS Output.

'Client-Oriented Breeding' is a pioneering approach that puts the customer—the farmer—first. Farmers set the goals. They say what qualities they want in new varieties. Next, they select those that work best under local conditions from a large batch of possible varieties, and then test them in their fields using their own farming practices. It's a quick, cheap and effective approach. This system helps develop improved varieties very quickly. Farmers in India, Bangladesh, Nepal and Ghana already use maize, rice, chickpea and cassava varieties developed this way. So, putting farmers first could have a rapid impact in areas where conventional plant breeding has failed to produce the choice of varieties farmers need.

Project Ref: **PSP34:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

Description

PSP34

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

Geographical regions included:

Bangladesh, India, Nepal,

Target Audiences for this content:

Crop farmers,

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.

Concept and approaches of client-oriented breeding (COB)

Better varieties from better plant breeding

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

Plant Sciences Research Programme (PSP). Joint PSP with the Crop Protection Programme. DFID India.

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.

R6636, R7080, R7122, R75565, R7838, R8071, R8099

India
CAZS-Natural Resources (CAZS-NR), UK
    Prof J.R. Witcombe, Dr D.S. Virk, Dr K.D. Joshi
Gramin Vikas Trust (GVT)
    Dr J.P. Yadavendra
Birsa Agricultural University (BAU)
    Dr. B.N. Singh
International Crops Research institute for the Semi-Arid Tropics (ICRISAT)

Nepal
CAZS-NR
Local Initiatives for Biodiversity Research and Development (LI-BIRD)
    Mr. K. Devkota
Nepal Agricultural Research Council (NARC)

Bangladesh
CAZS-NR
Peoples Resource-Oriented Voluntary Association (PROVA)
    Dr. A Musa

Ghana

University of Greenwich, UK
Dr R Gibson
Crops Research Institute, Kumasi, Ghana
Dr J. Manu-Adueniung

The list above includes only those who were partners in the research projects with R numbers. In addition there are many other collaborators involved in the scaling up of varieties bred by COB that are too numerous to list here.

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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.*

Outputs proposed: The PSP has developed and formalised a **participatory research** approach to the breeding of new varieties with farmers called **client-oriented breeding** (**COB**) that overcomes the limitations of traditional, on-station plant breeding. COB was also known as **participatory plant breeding (PPB**) but recently we revised the name to reflect the *purpose* of farmer participation (**improved client orientation**) rather than simply describe the *activity* (farmer participation) (Witcombe et al., 2005). COB involves stakeholders in **setting breeding goals** i.e., specifying the traits required in the new varieties. **Parents of crosses** are **carefully chosen** to meet the specified needs. The breeding method uses many **fewer crosses** than is conventionally the case and **large population sizes** are grown (Witcombe and Virk, 2001). Selection inn the segregating generations is done in environments that match the fields of the target clientele. Quality testing takes place with end users before more expensive yield trials. Once a new variety is produced it is immediately tested with farmers in **participatory varietal selection (PVS)** trials in the **target population of environments** – the farmers' fields (see PSP dossier 33).

The wider adoption of this improved method of breeding new varieties has profound implications for increasing food security as it can produce much higher yielding varieties in situations where modern plant breeding had previously produced none.

When produced: The PSP research began only in 1997 and the first varieties from the programme were produced by 2000. The products of COB were more widely tested from about 2002. The research has been pioneering and is the best documented body of work in this area. Other examples of COB are rare, generally poorly documented, and usually have been concerned with the **empowerment of farmers** rather than, as in our case, **improving the efficiency of plant breeding**. None have tried the few-cross, high-population-size method of breeding.

Problem addressed and description of outputs: Low-resource farmers in marginal areas usually grow either obsolete varieties (low yielding and disease susceptible varieties that were released often more than 20 years before) or landraces (Witcombe et al., 1998). This causes low yields and consequent food deficits. We found that although PVS was often able to identify suitable varieties among those that already existed this was not always possible. For example, no maize variety was found that was suitable for drought prone areas of western and eastern India and the best upland rice variety identified by PVS for western and eastern India had undesirable traits such as poor lodging resistance. COB provided a means of rapidly producing better material based on the best germplasm identified in PVS. In several cases the varieties produced by COB have been **officially released**.

Farmers have adopted new varieties from COB that were of a higher utility to them (a combination of improved agronomic traits, higher yield, and improved quality) and were superior to any available alternatives. As a result of this research, we are able to say that COB is **cost-effective** and produces **widely adapted varieties;** for example, COB varieties produced in Chitwan, Nepal perform well throughout the entire Terai region of Nepal and in Bangladesh (see Q22). We have also been able to confirm that making very few crosses is both effective and much cheaper than conventional methods.

Adoption of COB varieties by farmers increased **on-farm biodiversity** and improved livelihoods of resource poor farmers (Mottram, 2005; Virk et al., 2005).

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

The process of COB is not commodity specific and is applicable to all crops in all agricultural systems. It has been used in most farming systems but has been extensively used in semi-arid systems, smallholder rainfed dry/cold farming system and wetland rice-based system (Witcombe et al., 2005). It has been used in the following crops:

- Maize in western India (Witcombe et al., 2003; PSP dossier 15); maize in eastern India (Virk et al., 2005; PSP dossier 15), maize in Nepal (Tiwari et al., 2001, 2004).
- Upland rice in India (Virk et al., 2003; PSP dossier 16).
- High altitude rice in Nepal (Joshi and Witcombe, 2003).
- Lowland rice in Nepal (Joshi et al., 2002; Gyawali et al., 2006; PSP dossier 10).
- Chickpea in western and eastern India (PSP dossier 17).
- Cassava in Ghana (CPP dossier).

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*	*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*	*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 is, compared to other interventions such as seed priming or participatory varietal selection, a relatively complex process that involves specific scientific interests (plant breeding) with farmer participation. It could be aligned with work that involves farmer field schools as training of farmers in COB is required for maximum effectiveness.

The PVS stage of COB involves the testing of a new intervention – a crop variety – with farmers in the farmers' fields. Other interventions can be tested that are synergistic with new crop varieties such as improved crop agronomy, including seed priming (e.g., PSP dossier 30), and crop protection. Since farmers evaluate material for all traits including fodder quantity and quality then clustering with improved livestock nutrition would be an advantage. PVS (PSP dossier 33) is an essential technique for COB. PVS is also and an essential component in participatory approaches to replacing rice fallows (PSP dossier 35).

COB is also synergistic with all RNRRS outputs relating to the provision of seed and can involve community based seed production (PSP dossier 36).

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: The validation stage of COB is the value of new varieties produced by the breeding. This has always used PVS where validation is always by the first end users of a new variety – farmers - in on-farm participatory trials. These use participatory evaluation (employing many techniques e.g., matrix ranking, surveys, organoleptic assessment) of many traits considered important by farmers. The trials were always replicated to provide a test of statistical significance. Where grain quality was important end users such as millers, traders and consumers helped test post-harvest quality traits. Validation of yield increases was often done by government organisations in on-station trials. See also outcome assessments Question 20.

The final step of PVS - the wider dissemination of farmer-preferred varieties - tests the acceptability of a variety on a much larger scale and varieties bred using COB in a single location in Nepal have done well throughout the low-altitude areas of Nepal and in Bangladesh (Joshi et al., 2006). Varieties bred in eastern India have been recommended in states in western India.

Who validated: Validation was done by farmers working with researchers from many organisations who were involved in the validation process [1]:

The target groups of male and female farmers were from all social groups representing resource rich, medium and poor farmers. Wealth categories (usually three) were determined through local 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.

[1] Including:
India: State Agricultural Universities, State Departments of Agriculture; GVT, CRS, ASA.
Nepal: NARC, DADOs; LI-BIRD, FORWARD.
Bangladesh: DAE, Wheat Research Centre; PROVA.

Increases in productivity: Tremendous increases in productivity were achieved over the local cultivars in many crops across countries (see Table 1) that were associated with other improvements (Table 2).

Table 1. Examples of yield increase of new varieties from COB

Crop	**Where**	**Increase in grain yield of the preferred PVS varieties (range of better performing varieties as % increase over local check in farmers' fields)**
Rice (transplanted)	Jharkhand, W. Bengal, Orissa, India	up to 44 (depending on year and variety)
	High Barind Tract, Bangladesh	33-105 (depending on variety)
Rice upland	Gujarat, MP, Rajasthan, India	14-46 (2 varieties over years against Kalinga III) 43-48 (2 varieties over years against local)
	Jharkhand, W. Bengal, Orissa, India	27-56 (2 varieties over years)

Maize	Gujarat, India; Jharkhand, India Nepal	9-29 (range one variety across years) 42 (mean BVM-2 over years) 3-27 (range four varieties)

Table 2. Examples of improvement in traits other than grain yield.

Crop	Traits improved
Rice	Grain quality, maturity, lodging resistance, higher straw yield, drought tolerance, cooking quality, market price, weed suppression.
Maize	Maturity, grain size and colour, cooking quality, stover yield, ear size, grains per ear, disease resistance, drought tolerance.

*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)**.*

Validation of the process: this is related to the number of cases where COB has been effective. It has produced validated results in **three countries** and **two crops,** so far, namely **rice and maize**.

- In rice, it is validated in three countries from two separate breeding programmes across **most of the rice ecosystems** from upland (shallow rainfed unbunded) to semi-deep rainfed lowland, as well as high altitude.
- In maize, it has been validated in three distinct areas **in three separate breeding programmes** (western India, eastern India and Nepal).

The validation of the few cross breeding strategy has been done over four crosses in rice (three were successful) to give a **statistically significant improvement in the success rate** compared with conventional breeding.

COB has also been tested in **cassava** in Ghana (see CPP dossier) and there are preliminary results from **chickpea** and other legumes in India.

Products: Thousands of farmers, in collaboration with NGOs and GOs, validated the products of COB in three countries (India, Nepal, and Bangladesh) over wide areas. For where and when see Table 3. The process was validated across very diverse farming systems ranging from marginal rainfed to high potential production systems.

There were never fewer than hundreds of farmers involved in the PVS of varieties produced by COB as the validation was replicated in each year and done across at least three years (Table 3).

Table 3. Regions and farming systems where the outputs were validated. In all cases, validation was with thousands of farmers.

Crop	Where and (when started)	System	Farmers

Rice (transplanted)	Jharkhand, W. Bengal, Orissa (2003) Nepal *terai* (1998) High Barind Tract, Bangladesh (2002)	Rainfed lowlands	Low, medium and high resource
Rice (upland, direct-sown)	Gujarat, MP, Rajasthan (2001) Jharkhand, W. Bengal, Orissa (2000)	Semi-arid: primarily shallow unbunded rainfed lowlands	Low resource
Maize	Western India (1997) Eastern India (1999)	Semi-arid	Low, medium and high resource

Current Situation

C. Current situation

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

Here we are concerned with the COB as a *process* rather than the varieties produced by the process (detailed in other dossiers). COB is now integral to the rice innovation system in Nepal where LI-BIRD works with CAZS-NR and NARC to carry out a continuing programme. The breeding programme has many varieties that are in advanced trials (including Sugandha 2002 and Barkhe 2014 that have already been identified for release proposals to be made in 2006/07). LI-BIRD, in its adoption of COB, uses all of the major elements developed by the PSP research projects i.e., client-oriented objectives, careful choice of parents, few crosses, selection in the target population of environments, quality testing before yield trials, and yield testing through PVS mother and baby trials. NARC collaborates in this programme. More recently PROVA are collaborating with LI-BIRD and CAZS-NR, using germplasm supplied by the latter, in a rice breeding programme for the high Barind Tract.

Products from COB programmes are currently being tested in on-station and PVS trials. These include chickpea, horsegram and blackgram in India, maize in eastern and western India, rice and kidney bean in Nepal, and cassava in Ghana.

We are convinced that many other breeding programmes have adopted elements of the approach but resources have not been available to carry out a detailed survey. For example, in the rice and wheat breeding programmes in Nepal there has been a reduction in the number of crosses that are made and we have reasons to believe this is also true in certain wheat breeding programmes in Bangladesh. Other collaborators have proven to be remarkably resistant to change even though they have collaborated with CAZS-NR for many years.

In IRRI the recommendation to have high volume crossing (Mackill et al., 1966) has been dropped in the latest breeding manual (Fischer et al., 2003) that now has specific reference to some of the PSP work.

As a result of training courses to African national programme plant breeders there is evidence of elements of the approach being adopted in Africa but no detailed survey has yet been made.

*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 question 12. The areas are:

- In Nepal, for all of the rice growing areas in the Terai and low hills. This accounts for the great majority of the rice growing area in Nepal and covers the rainfed lowland ecosystem from shallow unbunded fields to semi-deep rainfed lowlands.
- In Bangladesh, in the High Barind Tract in a similar set of rice ecosystems to those in Nepal.
- In India, in maize the semi-arid rainfed uplands of eastern and western India.
- In India, in chickpea the semi-arid rainfed (residual soil moisture in the post-rainy season) production systems are targeted.
- In Ghana, cassava growing regions (forest agriculture interface).

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

The current use of COB may be limited in terms of crops, countries and organisations but in terms of potential outputs (varieties) from COB the scale is large. In the case of rice alone, the COB targets at least 1 M ha of there 1.5 M ha of rice in Nepal and can produce varieties suitable for much of the 14 M ha of rice in Bangladesh and for at least 10 M ha in India.

We have reason to believe that elements of the process are still spreading as awareness of the method increases through publications from the PSP research. Many of the publications in the area have just been published (2006), are in press, or will be published in 2007 (or later).

*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).***

The rice breeding programme in Nepal is an interesting example of the adoption of the process of COB. LI-BIRD, the NGO, has completely adopted all of the elements of the breeding scheme. NARC, through its National Rice Research Programme (NRRP) collaborates in this programme. It tests varieties from COB in its disease nurseries and enters them into its on-station yield testing. It also provides its own varieties to LI-BIRD for testing in PVS trials. However, its own rice breeding programmes have been less affected and they continue on more traditional grounds although there is evidence that the NRRP now makes fewer, more carefully chosen crosses. The NRRP is also a co-proposer on varieties bred by COB such as Barkhe 3004.

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

In the Institute of Agriculture and Animal Sciences (IAAS), Tribhuvan University, Rampur, some uptake of the concept of COB is evident at both the graduate and postgraduate level, e.g., COB concepts are included in assignments, seminars and examinations but are yet to be included formally into the curriculum of the University.

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).***

Promotion of COB is still being undertaken by CAZS-NR in the form of publications on COB that describe its effectiveness, and its input on training courses for African Plant Breeders (see Annex 1). In addition, CAZS-NR is promoting these methods in Ethiopia through projects funded by Ireland Aid.

LI-BIRD continues to promote COB by its advocacy and its ongoing COB programme.

Promotion is also occurring through what is now a Rockefeller funded project in eastern India for the client-oriented breeding and dissemination of upland rice in eastern India.

The Gramin Vikas Trust continues to promote COB and other related methods through its continuing involvement with State Agricultural Universities and the Madhya Pradesh Rural Livelihoods Project (MPRLP).

Scientists in SAUs in Bihar, Gujarat, Rajasthan and MP have been trained in COB techniques. The extent of adoption was assessed (Gill et al., 2006) and there was some adoption.

*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)**.*

Some, but not all, of the organisations that have directly worked with RNRRS projects have adopted the COB process but they have not taken steps to promote it with others so there is a **lack of awareness of the new approaches**. This is, in part, because evidence has only recently been produced on the effectiveness of the COB approach. Key papers are only ‘in press’ in 2006 and others are still under review. As with PVS, a huge barrier is the **mindset** of breeders who have been taught about the effectiveness of the classic ‘green revolution’ approach that involves on-station breeding for wide adaptation and the making of hundreds of relatively poorly chosen crosses each year. This poor discrimination is an inevitable consequence of making many crosses; as the number goes up the quality has to go down as the best choices have already been made.

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 most important factor to remove the barriers are the changes in mindsets through wide scale training of GO and, to a lesser extent, NGO staff in the COB process to appreciate the impact that it can have. There is a limited human resource capacity, particularly in GOs, on participatory approaches to research. In NGOs there is a limited capacity on 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 highly simplified and adapted for use by NGOs that have no 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 about breeding methods as they are rarely involved.

There needs to be changes in curricula in Universities to mainstream participatory, client-oriented approaches to plant breeding.

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).***

Using Rogers (2003) diffusion of information as a framework for the lessons learnt:

1. The relative advantage of a technology compared to what it is replacing;
This is extremely high as it enables varieties to be bred where classical plant breeding has failed to deliver. For example, Ashoka 200F and Ashoka 228 rice varieties produced by COB are the first to be adopted in the upland ecosystem on any scale in eastern India on a potential area of over 5 million ha (PSP dossier 16).

2. The compatibility of the technology with existing systems and ways of doing things, which is closely related to culture;
The compatibility is low as the breeding strategy is very different from those generally accepted. However, the changes required are simple and very cheap to adopt as they actually reduce the resources required.

3. The complexity of the technology in terms of what people need to learn to make it work;
The complexity is low as the breeding methods are much simpler than those used conventionally.

4. The observability of a technology in terms of how easy it is to demonstrate and observe performance;
The observability is high once outputs are produced from COB.

5. The trialability of a technology in terms of how easy it is to test it before deciding to adopt.
It does take a long time to test a new breeding method. However, it can be accommodated as part of a conventional programme to provide a ‘side by side’ comparison.

Hence training of scientists is the most important factors in getting this research into use with target institutions.

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.

India

1. Virk, D.S., Bourai, V.A., Choudhary, A., Misra, M. and Witcombe, J.R. (2003). Participatory crop improvement in eastern India: An impact assessment. PSP Annual Report 2003 Section 1: Introduction and General Overview. Research Outcomes. pp 26-33.
2. Virk, D.S., Bourai, V.A., Choudhary, A., Misra, M., Mottram, A. and Witcombe, J.R. (2005). Highly client-oriented breeding: The impact of two upland rice varieties in eastern India. CAZS Discussion Paper 7, pp. 1-11. Available at www.dfid-psp.org
3. Mottram, A. (2005). Impact of new upland rice varieties in eastern India from client-oriented breeding: evidence from whole village surveys. Available at www.dfid-psp.org pp. 1-15.
4. Virk, D.S., Bourai, V.A., Choudhary, A., Misra, M. and Witcombe, J.R. (2004). Participatory crop improvement in eastern India: An impact assessment. Plant Sciences Research Programme: Highlights & Impact. Participatory crop improvement. Pp. 87-96. Available at www.dfid-psp.org

Nepal

5. Witcombe, J.R., Joshi, K.D., Gyawali, S., Devkota, K. and 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.
6. Witcombe, J.R. Joshi, K.D., Gyawali, S., Devkota, K. and 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. Available at www.dfid-psp.org

Bangladesh

7. Joshi, K.D., Musa, A., Johansen, C., Harris, D., Devkota, K.P., Gyawali, S. and Witcombe, J.R. (2004). Short duration rice varieties for the high-barind tract of Bangladesh: the initial impact of varieties from client-oriented breeding and selection in Nepal. CAZS Discussion Paper. Pp 1-33. Available at www.dfid-psp.org

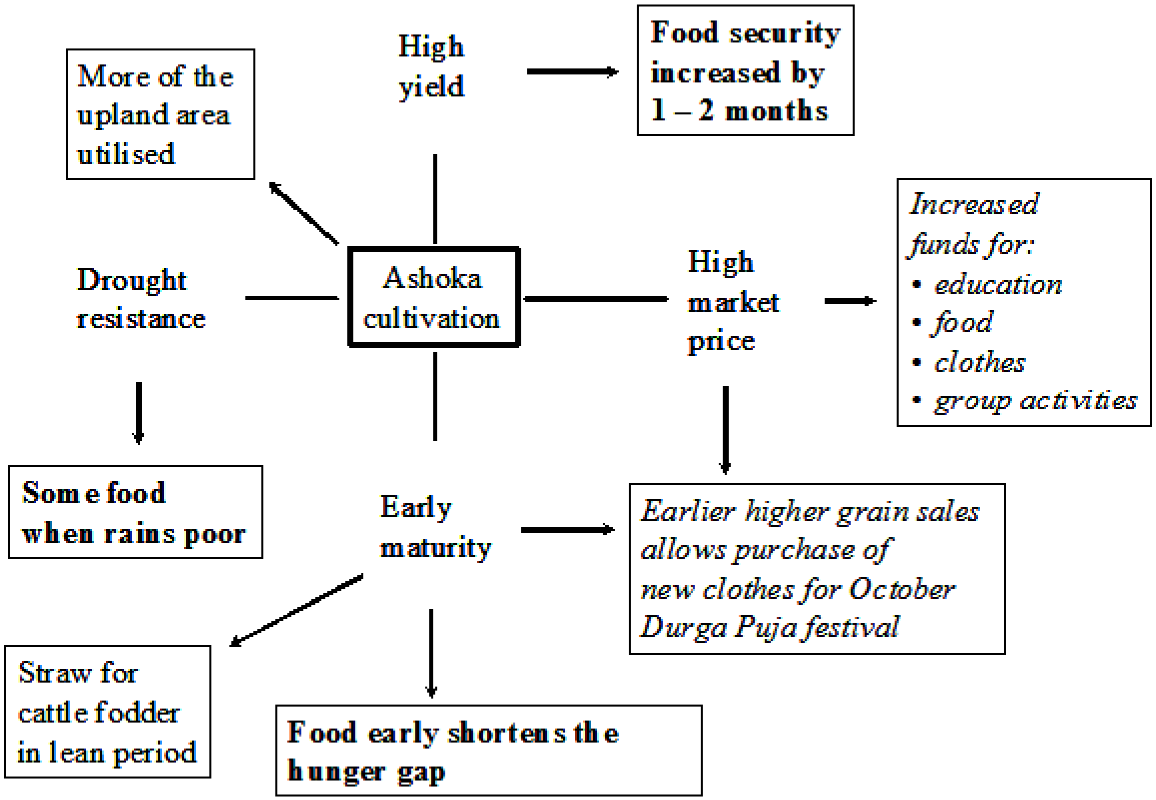
Financial analysis: As one example of economic benefit from COB we calculated the benefits of the production of two upland rice varieties for eastern India. By 2010 the benefits were estimated to be in the region of £20 million using a 10% discount rate (see PSP dossier 16).

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 yield gains in all of the COB programmes clearly show that the participating farmers benefited from the new varieties (Table 1). The increased yields increased household food self-sufficiency and in food surplus households cash income increased from additional grain sales. Outcome assessments showed improvements in health care, schooling and nutrition.

One example of manifold impacts is:



*Impacts (shown in rectangles) of the adoption of Ashoka 200F and Ashoka 228 in eastern India. Direct effects (**bold**), multiplier effects (italics) and farming system effects (underlined). Source Mottram (2005).*

More examples of impact are outlined in PSP dossiers 1*0* and 13 to 17.

Environmental Impact

H. Environmental impact

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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 wide scale adoption of the COB process will reduce national wastage associated with the breeding and testing of varieties that farmers would ultimately reject.
- 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 and nitrogen 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 increased on-farm diversity as farmers adopted many 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 will help to create a more 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.

Annex

References

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Annex 1. International training courses on 'participatory crop improvement' led by CAZS-NR or with significant contributions from CAZS-NR staff

Participants country	For	Years	Funding agency	Type and place(s) of training
Algeria, Burkino Faso, Egypt, Ethiopia, Kenya, Libya, Mali, Morocco, Niger, Nigeria, Senegal, Sudan, Tanzania, Tunisia	NARS plant breeders	2004 2005 2006	FAO	International: Institute of Agronomy, Florence, Italy (major contribution by CAZS-NR staff)
Bangladesh	CARE staff	2000	CARE Bangladesh	In-country: Dhaka by CAZS-UK staff
Bangladesh, Nepal	NARS staff	2004	PETRRA, DFID	International: Nagarkot, Nepal by CAZS-NR and LI-BIRD staff
Ethiopia	University staff	2004	British Council and Ireland Aid Project	International: Kathmandu, Nepal by CAZS-NR and LI-BIRD staff
Ethiopia	SoRPARI staff	2003	British Council	International: CAZS-NR, UK
Ethiopia	SoRPARI staff	2004	British Council	International: CAZS-NR, UK
Ethiopia	University and Research Institute staff	2005	Ireland Aid Project	In-country Mekelle University and Debub University by CAZS-NR staff
India, Pakistan and Bangladesh	GVT, SAUs, AKRSP, BARI, BRRI staff	2000 2000	DFID bilateral project; AKRSP, PETRRA funded by DFID	International: CAZS-NR, UK, and at Kathmandu and Pokhara, Nepal with LI-BIRD
India, Nepal and Bangladesh	ICAR, SAUs, NARC, NGOs, BARI, BRRI staff	2002 2003 2004 2006	DFID project to CGIAR	International: Kathmandu, Nepal by CAZS-NR, CIMMYT and LI-BIRD staff
India	SAUs and GVT staff	2002	DFID bilateral project	In-country: Bhopal, India by CAZS-NR staff
India	SAUs and GVT staff	1997	DFID bilateral project	International: CAZS-NR, UK
Namibia	Govt. Research and Extension staff	2002	EU	In-country: Namibia by CAZS-NR staff

Abbreviations not found elsewhere in the text:

- AKRSP = Agha Khan Rural Support Programme
- FAO = Food and Agricultural Organisation of the UN
- PETRRA = Poverty Elimination Through Rice Research In Asia
- SAU = State Agricultural University
- SoRPARI = Somali Region Pastoral and Agro-pastoral Research Institute, Jijiga, Ethiopia
- BRRI = Bangladesh Rice Research Institute