A billion people stand to benefit from pigeonpea production improvements

RIU

Validated RNRRS Output.

Research has overcome a long-standing barrier to improved pigeonpea production by identifying the cause of the pigeonpea sterility mosaic virus (SMD). This has permitted the development of diagnostic tools and improved methods of screening for resistance, as well as integrated technologies to combat this and two other major pigeonpea problems: fusarium wilt and pod borer. Over 600 resource-poor farming families who grow pigeonpea in India now have high-yielding, disease-resistant varieties, integrated control components, village-level seed systems, special machines to help them in hulling, and bio-pesticides to safeguard their harvests. Pigeonpea is the principal dietary protein source for an estimated 1.1 billion people.

Project Ref: **CPP17:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **ICRISAT**
Source: **Crop Protection Programme**

Document Contents:

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Geographical regions included:

India,

Target Audiences for this content:

Crop farmers,

Description

CPP17

A. Description of the research output(s)

1. Working title of output or cluster of outputs.

Management of pigeonpea technologies

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

Promotion of integrated pest management technologies for increasing pigeonpea productivity and livelihood security of smallholder farmers in the semi-arid tropics

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

Crop Protection Programme

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.

'R' Numbers
R8481
R8205
R7452

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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.*

Pigeonpea is a drought tolerant multipurpose grain legume crop cultivated in 3.5 million ha by the resource poor smallholder farmers in marginal farming systems in the **Indian subcontinent**. The protein-enriched seed of pigeonpea is the principal dietary protein source for an estimated 1.1 billion people. Pigeonpea productivity is severely affected by three major biotic constrains: **Sterility Mosaic Disease** (SMD), **Fusarium Wilt** (FW) and **pod borer** (*Helicoverpa armigera*). Significant progress has been achieved in managing pod borer and wilt, but impasse in identification of the SMD causal agent has hampered the disease control. Through the DFID projects the SMD agent (**Pigeonpea sterility mosaic virus**) was identified, (R7452), which led to the development of **diagnostic tools**, improved **host-resistance** screening methods (R8205), leading to the development of integrated technologies to combat the three major biotic constrains of pigeonpea (R8481). These outputs generated during 2000–04 forms the basis for this cluster:

<u>**Outputs**</u>

1) **Disease resistant varieties:** High yielding SMD and wilt resistant pigeonpea varieties (ICP7035 and ICPL96058) were promoted in the endemic areas, cultivation of which resulted in 5-10 times yield gain over local varieties, and contribute to high income at no extra cost to farmers.

2) **Integrated management of SMD, FW and Pod borer:** IPM, combining host-plant resistance for SMD and FW, and low-cost biological control approaches (use of botanicals and NPV sprays) for pod borer management, contributed to effective and eco-friendly control of three major biotic constrains of pigeonpea, and resulted in increased income.

3) **Sustainable seed production at village level:** Village-level seed systems contribute to sustainable production of improved varieties for ready access to farmers.

4) **Seed dehulling using dhal mills:** Training to farmers in making pigeonpea dhal (split seed) using mini dhal mills at village level doubled the income gain.

5) Diagnostic tools: Tools for the detection of SMD pathogen, differential genotypes for the identification of SMD and FW pathogen strains, contribute to precise selection of resistance sources by NARS.

6) New sources of disease resistance: New sources of SMD and wilt resistance identified in germplasm lines for broadening the genetic base of resistance to SMD and wilt.

7) Capacity building modules and resource material: Training to farmers in IPM, including manufacturing of bio-pesticides and seed dehulling and seed-village systems contributed to the farmers' resilience in coping with the biotic and abiotic problems.

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		Training

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 main commodity is pigeonpea (*Cajanus cajan* L. Millsp), a multipurpose grain legume crop mainly cultivated by the resource poor farmers in the Indian subcontinent. The proposed outputs are specific to enhance pigeonpea yields through eco-friendly technologies, thereby contribute to higher revenue to farmers at no or little extra input cost. The integrated pest management and seed systems are broadly applicable to other crops for the management of wilt and pod borer, which affects a range of crops grown in the subcontinent.

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			

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		

*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.

The proposed outputs deal with promotion of improved disease resistant varieties and integrated pest management (IPM) of pigeonpea, widely grown in the semi-arid tropics of the Indian subcontinent and South-eastern Africa. Farmers often cultivate pigeonpea as mixed and intercrop. The integrated crop management technologies promoted will also help other crops grown simultaneously or in rotation. Similarly, technologies dealing with avoidance of virus inoculum, vector control and management of soil-borne 'fusarium' wilt fungus and pod borer management, and seed processing storage practices are applicable to other legume and vegetable crops grown in the similar production systems. In this context, this output cluster can have synergies with the Clusters listed below.

- Promotion of bean ICPM (R8414, R7965, R7568, R7569, R8316)
- Sweet potato virus disease management and promotion (R8243)
- Tomato leaf curl virus management (R8425, R8247)
- Management of rice tungro virus (R6519, R5243, R5244, R5245)
- Adaptive evolution within *Bemesia tabaci* and associated begomoviruses (R8222)

Additionally, availability of seed is the major problem to the farmers and development of seed-village system is most essential in order to enhance availability of seed at local level. Several strains of SMD and FW pathogens occur in the Indian subcontinent, and resistance sources to some of the strains are lacking. Therefore there is a need to identify further sources of resistance. Recently, pigeonpea hybrids were developed which were shown to provide 100-200% more yield than conventional varieties. The hybrids need to be evaluated for disease resistance and suitable control strategies need to be established to sustain the potential yields of the hybrids.

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)**.*

Technology development, tools and processes: The project outputs concerning the characterization of the

SMD causal agent, development of diagnostic tools resistance screening procedures and data on evaluation of pigeonpea genotypes for SMD resistance, selection of promising varieties for farmers' cultivation were published in 'peer reviewed' journals and also in scientific conferences. Information about the various technologies and products was widely publicised in mass media, technical bulletins and flyers in local languages.

Several training courses were conducted during 2000-05, demonstrating the SMD diagnostic tools (enzyme-linked immunosorbent assay (ELISA)) and resistance screening procedures to scientists from NARS. Technical manuals detailing the procedures have been published. Diagnostic tools and seed of differential pigeonpea genotypes for the identification of 'SMD strains' were supplied to NARS and farmers, these have facilitated adoption and independent validation by NARS.

Sources of SMD and wilt resistance: Pigeonpea genotypes (land races, varieties, breeding lines and wild species) were evaluated by NARS in Coimbatore (Tamil Nadu), Bangalore (Karnataka) and Kanpur (Uttar Pradesh), India. The most promising lines identified were evaluated in multilocational on-farm trials and promoted for adoption.

Disease resistant pigeonpea varieties: The two most promising SMD and wilt resistant varieties, ICP 7035 and ICPL 96058, were extensively validated in >50 multilocation on-station trials conducted by the NARS and NGOs and also by the farmers during 2004-06. During all these trials, the resistant varieties yielded 2-3 times more than local varieties during low disease pressure, but it was 5-8 times more than local varieties during epidemic years. The varieties were validated particularly by resource poor smallholder farmers (<3 ha land holdings) in marginal farming systems.

The ICP7035 was extensively validated by the University of Agriculture Sciences-Bangalore, Karnataka State Extension Education Unit and Karnataka State Department of Agriculture in multilocation trials. After satisfactory review, this variety was released for farmer cultivation in Zone-5 agro-eco region of Karnataka.

Both, ICP7035 and ICPL96058 have been adopted by the private seed sector and commercialized since 2004.

Validation of IPM: IPM technologies for the management of SMD, wilt and pod borer were validated by NGOs (intermediary users) and farmers (end users) in Andhra Pradesh and Agriculture Research Station in Gulbarga, Karnataka state during 2003-06. Women farmers trained in preparation of botanical pesticides are continuing to produce bio-pesticides for pod borer control.

Validation of dehusking process: Dhal (split seed) making mill for dehusking of pigeonpea seed was established in Achampet, Mahaboonagar District, AP, was validated and adopted by the farmers. Sale of split seed fetches 100% income gain over sale of whole seed in the local market.

Seed village systems: This concept gaining wide popularity for local production of improved varieties for seed purpose. This was validated by the NARS, NGOs and farmers (end users) in Andhra Pradesh and Karnataka states. A minimum of 400-500 kg seed is being produced per annum through the 3 seed-village systems established till now.

*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)**.*

The outputs concerning tools and processes were validated by the NARS in India during 1998–2006. The user groups of these outputs are scientists and NGOs in the NARS who are working for the pigeonpea production systems.

The output concerning ‘seed material’ was validated primarily in India, by the NARS, NGOs and farmers (smallholder rainfed and humid; rainfed and semi-arid, peri-urban regions) in Agriculture Research Stations in Bangalore, Bidar and Gulbarga (Karnataka state), Coimbatore and Vamban (Tamil Nadu state) and in Kanpur (Uttar Pradesh). Farmers validated two high yielding SMD and FW varieties (ICP7035 and ICPL96058) during 2003-06, in more than 50 villages in Andhra Pradesh (Mahaboonagar, Ranga Reddy and Waranagal districts) and Karnataka states (Gulbarga, Bidar, Bangalore Rural and Tumkur districts) during 2001-06.

The promising disease resistant pigeonpea genotypes (landraces, varieties, breeding lines and wild species) were evaluated during 2000-06, by NARS in India, and the most promising sources are being used in the resistance breeding programmes.

IPM modules were validated in about 10 villages in Andhra Pradesh and Karnataka states in India. Women farmers are mainly involved in the preparation of biopesticides.

Community-based seed village systems for the multiplication of ICP7035 and ICPL96058 have been established in 3-locations in Achampet and Kasturipalli in Andhra Pradesh, and Tumkur in Karnataka in 2003-04, are well established and contributing 2 – 3 quintals of seed per location per year.

Mini dhal (split seed) making unit, was established as a community facility in Achampet, Mahaboonagar District, AP, is being successfully operated by the farmers.

Current Situation

C. Current situation

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

The Outputs of the project are being used in SMD, wilt and pod borer endemic areas in Andhra Pradesh and Karnataka states, by the poor farmers who depend on pigeonpea for income generation. Farmers in >50 villages in Andhra Pradesh and Karnataka state are cultivating SMD resistant varieties developed through the project. The IPM module is being implemented by farmers in ten villages in Andhra Pradesh. Farmers have access to disease resistant seed varieties, which are being used to manage wilt and SMD. For pod borer management botanical extracts prepared locally by the women farmers are being used in Mahaboonagar district.

Scientists in NARS have been using disease resistant varieties in breeding programmes, to develop new varieties suitable for the local conditions and also to transfer disease resistance into popular varieties adopted by the farmers. During this process, diagnostic tools and resistance screening procedures developed in DFID projects are being followed.

Community owned ‘Mini-dhal mill’ is being used in one village (Achampet, Andhra Pradesh) for seed dehusking, and split seed is solid in the local markets.

Production of disease resistant varieties is being continued at University of Agriculture Sciences, Bangalore and also at ICRISAT for supply to farmers at free of cost. Karnataka State Department of Agriculture is also producing the seed for farmers. Private seed companies are also marketing the seed in Karnataka.

*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).***

The outputs are being used mainly by the farmers in over 50 villages in Andhra Pradesh and Karnataka States of India. Diagnostic tools and processes (resistance screening procedures) are being used by NARS in Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu; University of Agriculture Sciences, Bangalore; Agriculture Research Station, Gulbarga; Banaras Hindu University, Varanasi, Uttar Pradesh.

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

Over 600 farming families are cultivating disease resistant varieties in over 150 ha in India. The outputs concerning development of varieties have taken 2-4 years. After introducing into farmers fields, adoption was rapid. The ICP7035 in Southern Karnataka has spread from 0.5 ha in the year 2000, to >100 ha by the year 2005 in Tumkur district, Karnataka. The ICPL 96048 has spread from 0.5 ha in the year 2000 to >40 ha in Mahaboobnagar District of Andhra Pradesh by the year 2005. These varieties are speeding into new geographic regions each year with more area coming under the varieties and IPM modules. The pigeonpea crop improvement programmes at ICRISAT and NARS are using the diagnostic tools and process for developing new disease resistant varieties.

*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 facts of success? **(max 350 words).***

Tackling demand driven Issue in farmer-friendly way: The main drive for the promotion of outputs have come from the farmers interest, and urgency to resolve the aetiology of SMD that is responsible for up to 90% yield loss in endemic areas. Cost-effective technologies and products that require minimum or no extra investment for adoption, and suitability to the existing farming practices have led to the good adoption at field level. Emphasis on tackling all the major issues that confront pigeonpea growers in the marginal areas has attracted farmers’ attention. Demonstration of technology value through farmer participatory validation has attracted several farmers leading to good uptake and widespread promotion.

Participatory Approach: From the inception, all the project partners from NARS, NGOs, and farmers were involved in the development of products and processes. This has enabled simultaneous validation of the outputs at multilocations by various groups (intermediary- and end users). Workshops were conducted regularly to obtain feedback on performance of the outputs and appropriate actions were taken to enhance the performance, uptake and spread of the outputs. Consortium of stakeholders drawn from various expertises (breeders, pathologists, extension specialists, State Agriculture Officers, NGOs, farmers) has facilitated an opportunity to contribute knowledge in their respective field to the output development and work towards a common goal.

Publicity: Awareness and training programmes were conducted in diverse regions to demonstrate the benefits of the outputs. Communication in local language, involvement of local leaders, extension officers and progressive farmers during the farmers gatherings and field days attracted farmers attention. Farmers participated in the project were used as ambassadors to promote the outputs.

Showcasing the Benefits: Farmers participated in the evaluation of outputs have fetched higher revenues compared to control farmers, which trigged the interest among the neighbouring farmers and also in the region, leading to the spread of disease resistant varieties.

In addition, collective decision-making, regular meetings to discuss on activity progress, *in situ* workshops to NARS and farmers have encouraged active participation and collective ownership on the outputs. This has infused enthusiasm among all the stakeholders, leading to the successful promotion of the outputs.

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).***

Disease resistant varieties (ICP7035 and ICPL96058) and IPM modules are being promoted by the NGOs and the State Agriculture Universities and farmers. Currently the promotion is taking place within the project villages in Bangalore Rural, Gulbarga, Bidar and Tumkur Districts in Karnataka State; Mahaboobnagar, Nizamabad, Rangareddy and Warangal Districts in Andhra Pradesh state, India. ICRISAT is introducing the improved varieties into new areas through supply of breeder's seed. So far the outputs have spread to >100 ha in two states.

*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)**.*

- Non-availability of improved seed varieties to farmers in wide regions. Proper seed multiplication and distribution system is lacking. Private seed sector is not active in pigeonpea seed production and government production is scanty. Farmers often depend on self-saved seed for sowing next season, but storage pests are major problem affecting the seed viability.

- The state run agencies such as Universities and Agriculture Extension divisions do not have adequate resources to promote technologies. Poor coordination between state Agriculture Universities and Research Stations, who adopt and validate technologies, and the state Extension Departments, who are mainly concern with technology dissemination to farmers.
- Poor awareness among the farmers about the availability of new technologies. Farmers in marginal areas have poor access to the seed of improved varieties.
- Inadequate / discontinuous funding support to NGOs involved in promotion of the outputs.
- Inadequate emphasis on disease and pest management in the crop improvement programmes.
- Inadequate policy support for the improvement of dry land farming systems, compared to irrigated farming systems. Marginal crops such as pigeonpea attract minor or no attention from government, despite very high demand in the market.

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).***

- Establishment of community-managed seed-village systems for sustainable production of improved varieties. Establishment of infrastructure for seed storage at village levels. Training of farmers on issues related to IPM and preparation of botanical pesticides using locally available ingredients
- Promoting informal/formal institutional arrangements to link farmers and markets
- Creation of awareness on technologies and its benefits to farmers and NGOs
- Sustenance allowance to farmers to cope up with risks during technology adoption phase.
- Continuous financial support for the project outputs till the establishment is complete.
- Favourable government policies to promote farmer friendly technologies in dry lands.

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).***

Participatory research involving regional scientists and NGOs contributed to the strengthening of local capacity, and also created interest due to ‘ownership of the work’, which has sustained the activities. These centres then form the local nodes for region-specific research and dissemination.

Training to NARS in usage of technologies has extended the range of outputs. Trained candidates served as ’ambassadors’ for the promotion of outputs.

Good communication of project outputs through mass media, informal publications, information brochures in local languages, short television programmes in local language, village-level field days, demonstrations in farmers fields and workshops provided wide publicity to the outputs and attracted attention of the intermediary and end-users. Publications in high impact journals and conferences have contributed to the peer review of the outputs and good appraisal of the technology.

Farmer-participatory approach was the key to deliver technologies to farmers and instigated a number of farmers to adopt new technologies/products. This also increased the visibility at farm level.

Simple technologies that are cost-effective, suitable to diverse agro-eco and socio-economic conditions, appropriate to the regular farming practices contributed to wide spread use.

Seed-based products are the most cost-effective and convenient for farmers' adoption.

Consortium capitalizing on the synergies from diverse stakeholders having different skills and expertise (science, farming, extension) had enabled the development and validation of products in quick succession and attain the objectives more quickly. Clearly defined objectives and activities for each partner, operational flexibility, encouragement to creativity, collective decision making, networks with wide range of stakeholders in public and private sector, transparency in budget and accounting, trust among the partners and mutual respect, has all contributed to good promotion of outputs to the poor 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.

Formal impact studies have not been undertaken during the project period. Moreover, full-scale promotional activities were initiated only in 2005. However, baseline surveys were conducting in villages to assess the impact of crop productivity on the farmers' income. Farmers who have used improved varieties had obtained higher yields from the same unit land without any additional input on the crop, which contributed to the income increase by 3-5 times. Farmers who followed IPM methods for pest control had reduced their input costs by about 5 times compared to non-IPM farmers. The disease resistance varieties and IPM modules have contributed to the farmers resilience in coping with pests and diseases and reduced the burden on household income. Sale of spilt seed has doubled the farmers revenue.

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 of disease resistant varieties was higher than that of local cultivars by about 5-10 times during the high disease pressure years in Andhra Pradesh and Karnataka region. This was achieved at no extra input cost to the farmers. IPM modules, although high on labour time, the net returns/ benefit-cost ratio obtained for farmers who followed IPM was high.

The project impact is on moderate and extreme poor farmers who grow pigeonpea in the marginal farming systems and this contribute to the alleviation of poverty. High pigeonpea yields in the farmer fields contribute to increased access to protein-rich diets among the households. Women are particularly benefited from marketing of vegetable type pigeonpea variety ICP7035 in peri-urban regions in Bangalore rural district in Karnataka.

Over 600 farming families have benefited from the use of improved varieties, which granted them income raise at least by 2-4 times, as a consequence of yield increase due to pest and disease management. Majority of the farmers, NGOs and NARS participated in the project were satisfied with the advantages granted by the DFID project outputs. These outputs have driven community-approach for seed production, implementing IPM and also use of dhal mill for selling split seed (dhal) in the local markets.

So far the DFID project outputs are adopted mainly by NARS in diverse regions and participatory farmers in two States, Andhra Pradesh and Karnataka. Farmers outside the project are widely benefited from the disease resistant seed varieties, obtained from farmer-to-farmer seed exchange. A number of additional farmers are growing disease resistant varieties in diverse regions through seed procured from State agencies and private sector.

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.

The project outputs emphasis to use eco-friendly methods to control three important biotic constrains on pigeonpea. This is through the cultivation of genotypes possessing innate resistance to two important biotic constraints, sterility mosaic and wilt diseases. The IPM technologies for the management of pod borer (*Helicoverpa armigera*), the most important pest of pigeonpea and other crops in tropics, emphasis use of botanicals (neem kernal sprays, application of chilli-garlic extracts), and nucleopolyhedrovirus (NPV), which are eco-friendly and greatly reduces the use of harmful chemical pesticides.

Pigeonpea cultivation offers several direct and indirect benefits to the soil and environment. Pigeonpea mobilises phosphorous and nitrogen making it available to subsequent crops. Pigeonpea assimilates more nitrogen per unit of plant biomass than most other legumes, can nodulate in most soils and mobilises soil-bound phosphorous benefiting both the pigeonpea crop and subsequent crops in rotation and thus contributing to increased productivity and soil amelioration. Deep extensive root system enhances the soil-biomass and fallen leaves to the soil fertility.

Because of these features, pigeonpea is being increasingly used to restore soil fertility and to prevent soil erosion and landslides in hilly slopes in Uttaranchal state, India; Yunnan and Guangxi provinces in China, Yamen and Sri Lanka.

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

The outputs/outcomes have no negative impacts on the environment.

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)***

The outputs contribute to the sustainable and enhanced yields of pigeonpea – a crop that offers a distinct advantages to the farmers in dry tropics, particularly in the Indian subcontinent and Sub-Saharan Africa, where extreme climate variability (drought, unseasonal rains) has been shown to influence the cropping systems. Pigeonpea is drought tolerant, with fast-growing extensive root system that allows plants to grow and produce grain in drought conditions when no other crop can survive. Furthermore, the slow growth of the plant above ground during its early phase offers very little competition to other crops and allows productive inter-cropping with virtually any crop (maize, sorghum, pearl millet, groundnut, soybean, cowpea) under wide climatic conditions. The high pest incidence (dry spells contributing to the increase in SMD incidence, whereas wet conditions at flowering contributes to the high incidence of pod borer and fungal diseases, like wilt) can be countered through IPM. The improved pigeonpea varieties endowed with disease resistance makes it an insurance crop for the farmers to cope with vagaries of climate.
