Smart Agriculture and Safe Vegetable Production: Key Learnings of CEAPRED

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Abstract

The agro-climatic diversity of Nepal favors production of different vegetables, vegetable seeds, fruits, ornamental plants, flowers and herbs. They have comparative and competitive advantages both in local and export markets. However, Nepal is highly vulnerable to natural disasters and is the fourth among most vulnerable countries to climate change. For minimizing the effect of climate change and overuse of pesticides, different farming systems have been developed aligned with integrated pest management, safe food production, organic farming and climate smart agriculture (CMA). Since 2015, CEAPRED has been involved in the promotion of sustainable and environment friendly safe food production, therefore, this paper includes those key learnings of good practices and experiences. During implementation of "rural livelihoods and climate change adaptation," "development of climate change resilient agriculture," and "resilient mountain solutions" projects; CEAPRED has gained learnings to bring improvement in production and income of farmers through promotion of fresh as well as vegetable seeds, development of Package of Practices, installation of solar and dug-well irrigation, promotion of bio-insecticides, bio-pesticides and bio-fertilizers including application of Jholmals, capacity strengthening, identification, selection, conservation and multiplication of potential local cultivars, establishment of CMA model farms, construction of soil-cement tanks, demonstration of wastewater collection ponds, promotion of participatory guarantee system (PGS), registration of PGS certified products under SINDHUKA brand, establishment of RMS Knowledge Park, and information and communication technology services to the beneficiary farmers. In collaboration, cooperation and partnership with related developmental partners, upscaling of these successful experiences may have positive impact to sustain wider-scale of development.

Keywords: *Cultivars, Fruit crops, NARC, Post-harvest management, Registration, Recent technology*

1. INTRODUCTION

Over the past decades, globalization and other drivers are fundamentally changing societies and economic systems, growing populations and demands putting increased pressure on the natural resources and ecosystems. In addition, the risks and impacts of climate change are profoundly altering the conditions for human livelihoods. Nepal is the fourth most vulnerable country in case of climate change (Maple croft, 2011). NDR (2017) also reported that

globally Nepal ranks 4th and 11th in terms of its vulnerability to climate change and earthquakes, respectively. Due to its higher dependence on monsoon and weather, Nepalese agriculture is more sensitive to climate change. Fluctuation in temperature and precipitation has direct impacts on crop yield and food security. Marginality and inaccessibility combined with high dependency on natural resources and vulnerable sectors like agriculture, creates a high degree of risk from climate and environmental uncertainties.

Nepal is also highly vulnerable to natural disasters and most vulnerable country to climate change impact due to higher rate of temperature increase, exposure to all type of climatic conditions, high dependence on nature based livelihood, fragile geology, inadequate human resources and poor economy. Rural people are likely to bear adverse effect of climate change. Climatic variability in this fragile ecosystem and nature-based livelihood system of the rural communities has further threatened the livelihood of the poorest communities, including the small and marginal farmers, who constitute the bulk of poor population and without having resources to mitigate the deleterious effects of climate change (Maple croft, 2011)

However, the agro-climatic diversity of Nepal favors the commercial production of different kind of vegetables, vegetable seeds, fruits, ornamental plants and flowers and herbs, and also has both the comparative and competitive advantage for local markets as well as for exports (Acharya, 2019). Agriculture in Nepal remains the principal economic activity, employing 65% of the population and providing 27.59% of Gross Domestic Product (GDP) (MoALD, 2019). However, it has long been based on subsistence farming, particularly in the hilly regions, where peasants derive their living from fragmented plots, cultivated in difficult conditions.

Moreover, the use of pesticides in current farming system in the country is high and the trend of pesticide use is increasing in Nepal by about 10-20% per year (Aryal et al., 2016). They also reported that studies have shown that more than 90% of the total pesticides are used in vegetable farming. A study showed that chemical pesticides are used by 25% of Terai households, 9% of mid hill households and 7% of mountain households (Aryal et al., 2016). Sharma et al. (2012) reviewed that injudicious and haphazard use of pesticides and presence of pesticide residues in food, fruits, vegetables and environment is a matter of wider negative effect and impact. Banned and highly hazardous pesticides have been used without any precautionary measures. Exposure of farm families to pesticides and intake of pesticides by consumers are a major health threat.

In this regard, different farming systems have been developed in agriculture together with other concepts such as integrated pest management, integrated crop management, ecological farming, safe food production, organic farming and climate smart agriculture technology. It is well known that the climate smart agriculture technology would sustain and cope with the above-mentioned effects and provide the basis of livelihoods to the population dependent upon agriculture production (FAO, 2015; Nagargade et al., 2017).

Since 2015, CEAPRED has been actively involved in the development and promotion of sustainable and environment friendly safe food production model through the cultivation of highly adaptable local varieties and ecotypes. Initiative stems from the fact that agriculture is the basis for Nepal's economic recovery, and fundamental for overcoming the emergency caused by the 2015 earthquake. This paper aims to share the learnings of good practices, approaches, methodologies and experiences of CEAPRED in the sector so that development partners would replicate them to sustain the livelihood of poor, women and marginalized communities including both subsistence and

commercial farmers and to favor the commercial production of different kinds of vegetables, vegetable seeds, fruits, spices and herbs for local as well as international markets.

2. KEY LEARNINGS

2.1 Rural livelihoods and climate change adaptation

The Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica) pilot project was jointly implemented by CEAPRED and International Centre for Integrated Mountain Development (ICIMOD) in Udayapur district for a period of 2.5 years starting from July 2015. The project was financed by the European Union aiming to support poor and vulnerable mountain communities in the Hindu Kush Himalayan region in mitigating and adapting to climate change.

2.1.1 Approaches and methodology adopted

Udayapur district was selected for piloting of Himalica because it is one among the highest climate change vulnerable districts of Nepal and falls along the Sagarmatha highway road corridor. Three sites ranging from an elevation 350 to 1150 meters above sea level representing the mid hills were selected for piloting the project so that the results of the pilot could be scaled-out and scaled-up in similar mid hill regions of the country.

Vulnerability assessment and value chain study were conducted at the beginning of the project for identification of the priority intervention areas. Participatory approach involving all the value chain actors was adopted while planning, implementing and monitoring the pilot. The participant farmers were organized into groups and federated into cooperatives. They were registered with the related government agencies for their sustainability beyond the project period. A total of 549 participant households including 67% women and 33% men (12% Dalit, 65% Janjatis and 23% others) were organized in to 25 groups, registered at District Agriculture Development Office (DADO) and linked with the cooperatives for sustained production and marketing of the vegetables and vegetable products.

Simple and affordable technologies were promoted by integrating the farmers' knowledge and scientific technologies to increase the adoption quickly and widely and sustain the results beyond the project period. The climate resilient technologies (water smart, soil nutrient smart, cropping and weather smart, energy smart, IT smart) were demonstrated at the farmers' fields and farmers were trained on the technologies using practical training approaches.

The project also supported in construction of 17 irrigation schemes covering 365 households. The schemes have been providing year-round irrigation facility in 63 hectares (Ha) of land for vegetable farming and other cash crops production.

Promotion of different climate smart technology and improved practices in vegetable production resulted in increased production, increased consumption and sale of surplus by all the Himalica project beneficiary groups. Promotion of value chain and market strengthening through establishment of collection centers, cooperatives, sales outlets, facility centers and networking and coordination with the stakeholders supported the farmers in increasing and marketing their products.

During the project period, farmers produced about 3420 MT of fresh vegetables and sold about 2993 MT in the markets earning about 64.5 million NPR. The net annual income of each HH through vegetable sales came about NPR 87,700. This figure also indicates that the farmers consumed about 427 MT vegetables

at the household level. It roughly accounts about 1.98 kg fresh vegetable consumption per household per day, reflecting the contribution of the program towards improvement in human nutrition and wellbeing of the communities as compared to the pre-project period.

Due to establishment of linkage between the traders and the producers and coordination among the district stakeholders, supply of vegetables from Himalica sites to Gaighat market reached to 90% of demand against same percentage (90%) fulfilled from Siraha, Saptari, Sunsari and India markets in the past.

2.1.2 Key achievements

Vulnerability/risks of target communities identified and value chain study conducted

A climate change vulnerability assessment of the project area was conducted in 2015 using tools developed by Ministry of Science, Technology and Environment to better understand the impacts of climate change in agriculture and livelihoods. In addition, the adaptive practices adopted by the communities and the prevailing risks and their intensity so that appropriate planning could be done to address the risks.

Using the vulnerability assessment tools we found that the changing rainfall pattern causing increased drought and increased intensities of diseases and insect-pests were identified by the communities as the top ranked vulnerabilities. The adaptive capacity of the communities against these vulnerabilities was found below 50%.

Similarly, value chain study was carried out to identify the involvements, relationships, roles, constraints and opportunities of value chain actors involved in fresh vegetable production and marketing. The study also analyzed the current market situation, future market potentialities with demand and supply of fresh vegetables and spices in local, district, regional, national markets; service provisioning and other aspects of value chain development; and identified leverage points where the pilot project could add value to improve the efficiency of the chains and increase income of target households. The value chain study clarified the huge demand of fresh vegetable within the district and in neighboring districts. This study also identified different value chain actors and their roles in value chain development. The results of both the studies were used for development of Himalica implementation plan. Reports of both studies are available at ICIMOD website.

Development of package of practices (PoP) for resilient production system and its implementation

A) Development of PoP

The development of Package of Practices (PoP) in Nepali and English languages (Plate 1) on vegetable production with focus on five elements of climate resilient agriculture practices (water, energy, soil nutrients, crop and weather and knowledge) was carried by the Himalica teams in CEAPRED and ICIMOD. The Source Book in Nepali version was prepared and widely used by the extension workers, innovative group leaders, cooperatives, the staff of Himalica project and related line agencies as resource materials for conducting training and dissemination of technologies. Similarly, English version was developed for on-line use. The copies of both the PoPs are available at ICIMOD.

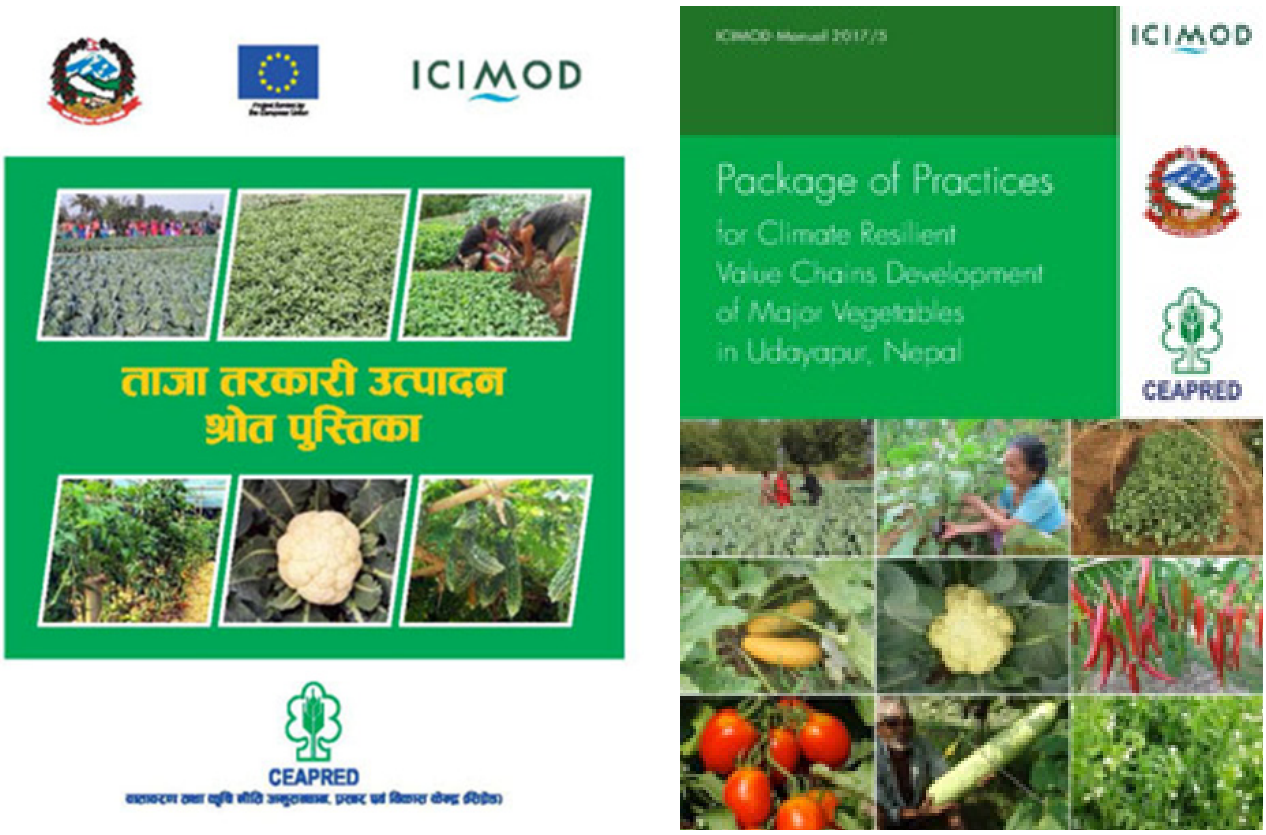

Plate 1. Climate resilient agriculture practices for vegetable production

B) Implementation of PoP

The recommended climate resilient technologies were demonstrated in farmers' fields and farmers were trained on the practices at all three sites. The farmers adopted the recommended practices which included drought and or frost tolerant varieties, use of drip irrigation, waste water collection pond for irrigation, mulching, plastic tunnels for off-season vegetable farming, improved compost preparation, Jholmal preparation, application as bio-pesticide and bio-fertilizer, solar and dug-well irrigation systems (Plate 2) and different crop management practices.

Plate 2. Solar and dug-well irrigation

i) Social mobilization and group strengthening

The social mobilization of the communities was an entry point for implementation of the project. A total 549 beneficiary households were organized into 25 groups comprised of 65 (12%) HHs of

Dalits, 357 (65%) HHs of Janjatis and 127 HHs from other (Brahmin and Chhetri) with 67% female representation in the groups. The groups were registered at DADO for continuation of technical services beyond the project period and they were linked with the cooperatives for sustainability in production and marketing of vegetables.

ii) Training and demonstration on climate resilient technology

A series of trainings were organized for the project beneficiaries to strengthen their capacity on improved technologies. The training and demonstrations organized for 25 farmers' groups during the project period (Table 1 and Table 2).

Table 1. List of training on climate resilient technology

Training module	Participants		
	Female	Male	Total
Nursery management	1326 (63%)	786 (37%)	2112
Crop management	1348 (63%)	877 (37%)	2150
Jholmal preparation and application	980 (66%)	514 (34%)	1493
Commercial vegetable production	1004 (72%)	551 (28%)	1555
Postharvest	791 (56%)	639 (44%)	1430
Group management and social mobilization	959 (66%)	497 (34%)	1466
Marketing techniques	347 (68%)	165 (32%)	512
Improved compost making	251 (65%)	140 (35%)	385

Table 2. List of demonstration on climate resilient technology

Demonstration module	No. of demonstration
Cowshed improvement demonstration	25
Waste water collection ponds demonstration	44
Plastic house (tunnel) demonstration	25
Drip irrigation demonstration	50
Vegetable nurseries (flat bed, tunnel and Tande) demonstration	125

Besides, a total of 435 farmers participated in inter cluster visit from all 25 groups where 282 women (65%) and 153 men participated; 427 farmers were orientated on safe food production in all the groups where 275 (64%) female and 152 male participated; 75 Farmers Field School (FFS) conducted – one per season for 3 seasons in each of 25 groups and all group members participated in the schools. The topics of the FFS were Integrated Pest Management (IPM), effect of Jholmal as fertilizer and pesticide in different vegetable crops, mulching practices; and a training of lead farmers was conducted and demonstration conducted on improved bee keeping by establishing 15 improved beehives at different groups.

iii) Saving credit mobilization

All the group members have been collecting saving and they have been mobilizing the collected amount to meet different productive and household needs of the group members. The groups have prepared the guidelines for group saving and its mobilization. During the project period, all the 25 groups as saving collected NPR 277,990 and NPR 199,330 was disbursed as loan to group members for different purposes.

iv) Construction of irrigation Schemes

The project has supported the construction of 17 irrigation schemes covering 365 households. The completed schemes have been providing year round irrigation facility for 63 ha of land for vegetable farming and other cash crops production.

Increased number of farmers using climate smart agricultural practices (CSAPs)

Table 3 shows the encouraging adoption rate of CSAPs through this project.

Table 3. Adoption rate of climate smart agricultural practices

S.N.	Indicators of CSAPs	Adoption rate
1	Production and application of Jholmal 1,2,3	90%
2	Application of improved seeds	100%
3	Adoption of improved nursery (tunnel, raised, solarisation)	90%
4	Adoption of improved cultivation practices (line planting, raised bed planting, irrigation between rows, weeding, timely fertilization etc.)	>85%
5	Adoption of crop rotation practices	70%
6	Waste water collection for irrigation	70%

Increased income through commercial vegetable production

During the period of about 18 months (June 2016 – Dec 2017), majority of the farmers of all three clusters started growing vegetables adopting improved climate smart technologies, produced about 3420 MT of fresh Vegetables and sold about 2993 MT in the market earning about 64.5 million NPR. This figure also indicates that the farmers consumed about 427 MT vegetables at the household level. It roughly accounts about >1.98 kg vegetable consumption per household per day, reflecting the contribution of the program towards improvement in human nutrition and wellbeing of the communities. The net annual income of each HH through vegetable sales was found about NPR 87,700.

Networking and coordination for building relationships

Advisory committee at the central level and coordination committee at the district level were instrumental not only for policy feedback but also for networking and coordination with other stakeholders and value chain actors at different levels. Formation of the groups of producer farmers, their registration with DADO, and their formal link with the local cooperatives ensure regular services to the farmers to continue production and input supply. Similarly, linkage of the groups and cooperatives with the traders at the local level as well as upstream and downstream markets was steps towards sustained marketing of the vegetables and vegetable products.

2.2 Development of Climate Change Resilient Agriculture

Development of Climate Change Resilient Agriculture in Nepal (DCCRA) Project was funded by the Italian Government and implemented by CEAPRED in partnership with ASIA, OIKOS and Punto sud. starting from April 1, 2017 to 30 March 2019 with no cost extension until June 30, 2019. The project was implemented in three districts viz. Sindhupalchok, Sindhuli and Kavre. Field activities were developed in consultation among partners/stakeholders, Gaupalika (municipalities), cooperatives and farmers group for suitable site selection, varieties identification, collaboration and planning of field activities.

The project was primarily aimed at strengthening the existing farming system for sustainable agricultural production, with an inclusive model

that favors food security focusing on the market. The project intended to increase food production of higher quality in a sustainable way while using optimum natural resources and reducing the use of synthetic chemicals. The project sought to promote a sustainable and environmentally friendly production model that increases the producers' incomes and set up a certified production system.

Project activities were implemented through 161 farmers' groups in 4076 households, comprised of 2502 women and 1574 men members. During the project period, farmers' groups were mobilized for cultivation of indigenous cultivars through different smart agricultural practices to increase production of fresh vegetables, seeds, fruits and medicinal plants. Twelve nurseries and nine model farms were established to provide demonstration, nine collection centers for the processing and marketing of 13 selected agricultural products.

2.2.1 Approaches and achievements

Participatory mapping of potential locations for the nurseries and construction of 12 nurseries using material purchased locally and sourced by the farming groups

Establishment of nursery was one of the major activities of the project. For this, project team organized series of workshops and interactions with farmer groups and stakeholders to identify suitable locations to establish nurseries. During the project period, twelve events of mapping were conducted where 458 participants including farmers, traders, local input suppliers and representatives of local government participated, discussed and identified the locations for nurseries.

Local varieties also called the ecospecies are the genetically distinct geographic variety, which is genotypically adapted to specific environmental conditions. These are the species, which has over a long period of time, adapted to the local natural environment in which they live. The seeds of such ecotypes maintained genetically diverse crops that were particularly suited to their local environment and were resistant to diseases and various abiotic stresses. These plants can be valuable genetic resources for future generations. With this view, DCCRA established 12 nurseries in three different ecological zones in the project districts (Plate 3).

Plate 3. Fruits nursery at Sindhuli and vegetables nursery at Sindhupalchowk

Participatory identification and selection of local varieties and ecotypes of specific vegetable species

Participatory variety selection criteria were diverse, reflecting their multiple purposes. In addition

to yield, early maturity and disease resistance, food value, long-term storability, suitability for sequential harvesting and resistance to abiotic stresses, such as drought, wind, heavy rainfall and hail were the criteria. Through, participatory mapping, a long list of different local varieties and cultivars were identified and from the list, 13 potential varieties of different crops were selected for project intervention.

Collection of the priority crops and varieties for conservation and multiplication by the farmers

Seeds of crop varieties when stored correctly can remain viable for decades. Seeds were deposited into secure storage with the intention of withdrawing them in the future when these will be needed. Consequently, the project mobilized the beneficiaries to store and multiply indigenous cultivar into secure storage with the intention of using them in the future when they will be needed. During the period, project supported the collection of some location specific local cultivars of the respective districts (Table 4) and preserved them for further multiplication in future.

Table 4. District-wise selected local cultivars and quantity of seeds stored for conservation and multiplication

Kavre			
Crop	Variety	Qty (gm)	No. of farmers involved
Cauliflower	Local	400	40
Bean	Trishuli	1000	10
Bean	Jureli	2000	15
Onion	Local	750	35
Tomato	local Jhuppe	400	25
Sindhuli			
Pumpkin	Local	400gm	5
Pumpkin	Jate	200	5
Hot chilly	Akabare	50	5
Bitter gourd	Local green	25	5
Sponge gourd	Local	100	10
Cowpea	Seto	100	5
Chilly	Jire	30 gm	3
Bottle gourd	White green long	50	5
Cowpea	Sarlahi Tane	100	3
Bean	Local	200	5
Bottle gourd	Short	200	5
Bean	Tate	50	2
Sindhupalchowk			
Cucumber	Bhaktapur Local	270	27
Broad Leaf Mustard	local	670	35
Bean	Chaumase	4000	16
Bean	Makai Simi	1000	4
Coriander	Local	200	10

Identification of the varieties based on production and marketing potential

Plate 4. Market trials of local varieties

With the technical and input support from the project, farmers in the project areas produced different local and indigenous crop varieties. These products were presented in market through different events to test (Plate 4) if they had potential for marketing. During the event, farmers took their products to the market among consumers, traders, private sectors and related stakeholders and briefed on the production process and pricing mechanism. Feedbacks from the participants were collected through discussion and interaction. Finally, farmers identified the suitable varieties based on their production potential and market opportunity.

Improved production of fresh vegetables and selected spices in the production areas

The major field interventions in the project aimed to increase the production of selected varieties, through adoption of smart agricultural practices and efficient marketing. This helped the farmers to diversify their farm products and to increase total production. Group members produced different vegetable crops in their farms (Plate 5) through the project. Field staff regularly monitored their farms and supported in production, insect pest management, postharvest as well as change in behavior with increased consumption and sell of surplus. Farmers in the project area cultivated vegetables in 6200 ropani (310 Ha) of land against less than 1000 ropani (50 Ha) in baseline allocated for vegetable production only. The total vegetable production from the land was 3310786 Kg during the project period (Table 5). Out of this, farmers sold 3023080 Kg of surplus and earned a total of NPR 65211415.

Table 5. Area, production and total income of farmers from vegetable business

District	Area under cultivation (ropani)	Total production (Kg)	Total consumption (Kg)	Total sell (Kg)	Income from sell (NPR)
Kavre	2250	1260000	109494	1150506	24478740
Sindhuli	2150	1125804	97832	1027972	20554711
Sindhupalchowk	1800	924982	80380	844602	20177964
Total	6200	3310786	287706	3023080	65211415

Plate 5. Plastic mulching for cauliflower production and exposure visit to production site

Establishment of climate smart agriculture model farms

With an objective to train and disseminate the climate smart technology among the farmers, the project established nine model farms (Table 6) in different locations of the project districts. These model farms (Plate 6) served as resource and demonstration centres providing technical assistance and technology transfer for groups. It was the focal point for community coordination, networking and linkages with service providers, input suppliers and product marketing. Project staff regularly visited these resource farms and strengthened them through input supports, technical guidance, improved practices and introduction of low-cost technology.

Table 6. Details of model farms established in the project districts

S.N.	District	Farmer's name	Area of the farm (ropani)	Technologies established and demonstrated
1	Sindhuli	Bhim Kumar Baidhya	2.0	Plastic house, drip irrigation, Jholmal. mulching, plastic pond, improved shed
2		Ram Singh Lama	2.5	Plastic house, drip irrigation, Jholmal. mulching, plastic pond, improved shed with green net
3		Sangita Darlami	3.0	Plastic house, drip irrigation, Jholmal. mulching, plastic pond, improved shed
4	Sindhu-palchowk	Yedunath Rimal	2.5	Plastic house, drip irrigation, Jholmal. mulching, plastic pond, improved shed with green net
5		Sabita Lamichhane	3.0	Plastic house, drip irrigation, Jholmal, mulching, improved shed
6		Bal Bahadur Khadka	3.0	Plastic house, drip irrigation, Jholmal. mulching, plastic pond, improved shed with green net
7	Kavre	Parsuram KC	3.0	Mulching, plastic house, drip irrigation improved shed, waste water collection tank
8		Khoka Prasad Khanal	2.5	Mulching, plastic house, drip irrigation, improved shed, waste water collection tank
9		Jagat Bahadur Tamang	2.5	Mulching, plastic house, drip irrigation, improved shed, waste water collection tank

Plate 6. Model farms at Kavre

A model farm in the project was an experimental farm, designed to research, develop and demonstrate technology, innovations and improvements in climate smart agricultural techniques. Model provides education to smallholder farmers through demonstrations and encourages adoption of improved agricultural practices. It is dedicated to both scientific approach to agriculture and connection of individuals of all social classes to the technology.

This is a group-based teaching and demonstration process where group members came and learnt skills and improved technologies by seeing and practicing themselves. Project staff supported every demonstration at the respective sites that included demonstration and transformation of different improved practices and technology for crop production and management practices. Thus, farmers introduced new ideas and techniques through guided exercises and stimulate discussion among farmers. Group members learnt through regular participation, observations and analysis of results. Knowledge gained from these activities enables participants to adopt improved technologies at their own field.

Developing teaching materials (Manuals/ booklets, pamphlets)

Teaching materials in the project served as the manual for field level training to the Local Service Providers (LSPs) and the project staff benefitted to deliver technology. Each trainer requires a range of tools to draw upon in order to assist and support farmers practice. It is important to make reading material easily available to all farmers by placing important chapters.

DCCRA promoted environmentally friendly bio-insecticide, bio-pesticide and bio-fertilizer. A video documentary of Jholmal was developed and displayed to the farmers during nursery establishment, social mobilization activities and capacity development trainings. The video included the types of Jholmal and the procedures for preparation and its application in different crops in different stages. Similarly, as a training material, fresh vegetable training manual and vegetable seed production manual with package of practices were also distributed among the leader farmers, LSPs and project staff. Teaching materials in the project were important because they created a visual and interactive experience for the farmers. As the materials (Plate 7) are visual and in Nepali language, they were highly liked by the farmers as it was easier to understand.

Plate 7. Produced and distributed some teaching materials

Organizing on-site training courses including study visits to model farmers

It was always effective to tailor any courses and curriculum to suit the ground circumstances, goals and requirements of the project as well as participants' prior knowledge and skills. If desired training course can focus on special subjects that are critical to the farmers. DCCRA organized different onsite trainings designed especially for the farmers at field level. It was always effective to enjoy significant savings and spare travel expenses to teach farmers through onsite training. After group formation, onsite demonstrations on different cultural practice of local varieties, recommended by Nepal Agricultural Research Council (NARC) and DADO were conducted at different agro-ecological regions in the respective districts.

Dissemination of climate smart agriculture practices among producers of seeds and vegetables

In order to undergo significant transformation in agriculture system, to keep optimum production and to respond to climate change, different climate smart agricultural practices were introduced in the project districts. Adopting an ecosystem approach, working at landscape scale and ensuring intersectional coordination and cooperation as well as the conservation and production of selected varieties were considered crucial for effective climate change responses. Besides, institutional and technical supports were provided to enable farmers to make the transition to climate smart agriculture. During the project period, the beneficiary farmers also visited, observed and learnt about different climate smart practices. More than 10 smart agricultural practices were introduced and disseminated among the project beneficiaries. Plate 8 presents some of the major practices disseminated to the farmers during project period.

Plate 8. Major practices disseminated to the farmers during project period

Developing PGS standards and practical procedures

Participatory Guarantee System (PGS) in DCCRA is a system of quality assurance of the products, not a system of production. Both PGS and third-party certification systems are based on the same principles of organic agriculture, so allowable inputs in PGS certified organic agriculture are generally the same as those in third-party certified organic agriculture. Considering the view of fast growth of the PGS movement over the last few years, the project reflects the need to include smallholder farmers in the organic movement. In developing countries like Nepal, most of the third-party certified farms rely on distant export markets to cover the cost of certification, so products from those farms are not available to local consumers.

With an objective, bringing more farmers into a system of committed organic production, and linking that to direct and local sales, the project supported Fulbari Cooperative to register a Brand called SINDHUKA under Department of Industry with clear guidelines and standard to be maintained by the farmers in their production system to get PGS certification.

Promoting bio-insecticides, bio-pesticides and bio-fertilizers

DCCRA promoted different activities to promote safe production using bio-pesticides and bio-fertilizers like Jholmal, vermi compost, bokasi, compost, green manure and different intercultural practices. The project established demonstration sites, conducted trainings, exposure visits and field days to aware the farmers on organic as well as safe production and supported them to adopt best practices. Different Information, Education and Communication (IEC) materials developed and disseminated among the farmers. Twenty-two demonstrations on Jholmal conducted at field among 475 farmers and mobilized them for its massive application at household level.

Composition of Jholmal

Jholmal – 1: 17 kg Farmyard manure, 16 liter of animal urine and 16 liter of water and 1 liter of Jeevatu added.

Jholmal – 2: 24.5 liter of urine and 24.5 liter of water and 1 liter of Jeevatu.

Jholmal – 3: Leaves and stems of locally available plants with bitter, sour or pungent taste (stinging nettle, Mugwort, Melia, century plant, Sichuan pepper) 8-9 kg approx., animal urine and water mixed in equal proportion poured to fill the jar, 1 liter of Jeevatu added.

SINDHUKA brand for safe products

SINDHUKA, a branding system in the project was aimed at creating a trademark in Nepal that provided a differentiated and well recognized image to locally grown products that were aligned with sustainable and environmentally friendly production models responding to climate change effects through climate change resilient cultivation practices, using local ecotypes. The main objective was to create a win-win situation in which, on the one hand, local producers, were expected to improve the quantity and the quality of their production, hence enhancing their visibility and competitiveness within the market, while on the other hand, consumers could access to high quality, harmless and locally produced products. Consequently, it was expected from the project that local producers found higher incentives to transit from generic agriculture to the promoted producing models.

Through various meetings, seminars, and big effort of Fulbari Cooperative in Kavre registered SINDHUKA service brand (Plate 9) under department of industry. Further different sub-committees formed to implement daily activities of SINDHUKA. All the beneficiary farmers, producing different crops, if meets the minimum standard can come into the brand for marketing their products.

Market trial under DCCRA activities was one of the best and popular approach to provide the platform for all the stakeholders including consumers, vendors, traders and market enablers for direct exposure and interaction with the producers about the products. It also provided the opportunity to the producers to present their organic as well as safe products in the events (Plate 10) and brief on the production process and inputs used to the consumers and traders for better marketing.

Plate 10. Market trial events

2.3 Resilient Mountain Solutions (RMS)

The Resilient Mountain Solutions (RMS) is a new initiative under the ICIMOD's Regional Program 'Adaptation and Resilience Building' jointly implemented by CEAPRED and ICIMOD at 3 municipalities of Kavre (Dhulikhel, Pachkhal, Namobuddha) and 1 municipality of Dadeldhura district (Bhageshwor) since 2019.

The project has conducted field-testing at several farmers plots on climate smart practices and been promoting them among the 771 smallholder farmers to enhance the resilience of women and men in the Hindu Kush Himalayan (HKH) to socioeconomic and environmental changes, including climate change. The major aim of the project is to equip people in the HKH region with simple and affordable technology and knowledge required to build long-term resilience. CEAPRED has been facilitating 31 farmer groups at ground; conducting field-testing on farmers field, establishing demonstration plots and coordinating with various line agencies for extension of these technology and practices.

2.3.1 Approaches and achievement

The districts for establishment of RMS sites were jointly selected by ICIMOD, CEAPRED and Department of Environment (DoE). ICIMOD,

CEAPRED and respective municipalities for selection of the sites within the municipalities conducted the scoping study jointly such that the selected sites could represent the municipal agro-ecological and socio-economic conditions.

Conducting validation trials on efficacy (concentration and application intervals) of Jholmal -1 on Bitter gourd (Momordica charantia L.)

Soil nutrient management is essential in obtaining the better vigor and yield of the crop. Soil nutrient management is an important component of the RMS program. This year (FY 2019/20), the project is conducting efficacy trial of Jholmal-1 in soil nutrient status, insect incidence and crop productivity. The field trials at Kavre have six replications each for efficacy testing of Jholmal -1 concentration and application interval on Bitter gourd. Three replications are carried out in foothills while remaining six are carried out in high hills for both concentration and application interval trials. Each replication has three treatments in Randomized Complete Block Design. Each plot in the treatments has 25 m2 area. The crops are at reproductive stage and harvesting of the crop has just started in the areas. Detail of validation trials on efficacy of Jholmal is given in Table 7.

Table 7. Detail of validation trials on efficacy of Jholmal -1 on Bitter gourd

S.N.	Name of trials	Treatments
1	Concentration trials	T1: Jholmal-1 1 part: water 3 parts T2: Jholmal-1 1 part: water 5 parts T3: Control
2	Application interval trials	T1: Application at 14 days (2 weeks) interval T2: Application at 21 days (3 weeks) interval T3: Control

Comparative study on efficacy of different doses of Jholmal-2 and Jholmal-3 on Bitter gourd

With the objective to reduce the level of the chemical pesticides, different bio-pesticides like Jholmal-2 and Jholmal-3 are under field trials (Plate 11). In order to find out the efficacy of the different doses of Jholmal-2 and Jholmal-3 and their comparative performance in controlling the pest trials are being conducted at Kavre district. Twelve replications with five treatments are being carried out in Randomized Complete Block Design. Six replications are carried out in foot-hills while remaining six are being carried out in high hills. Each plot in the treatments has 25 m2 area. The crops are at reproductive stage and harvesting of the crop has just started in the areas. Data on insect trapped on the traps, fruit infestation and yield are being recorded.

Treatments for concentration or doses trials:

T1: Jholmal-2 1 part: water 3 parts

T2: Jholmal-2 1 part: water 5 parts

T3: Jholmal-3 1 part: water 3 parts

T4: Jholmal-3 1 part: water 5 parts

T5: Control

Comparative study on efficacy of different interval of application of Jholmal -2 and Jholmal-3 on Tomato (Solanum lycopersicum L.)

With the objective to reduce the level of the chemical pesticides, different bio-pesticides like Jholmal-2 and Jholmal-3 are under field trials. In order to find out the efficacy of the application interval of Jholmal-2 and Jholmal-3 and their comparative performance in controlling the pest trials are being conducted at Kavre district.

Twelve replications with five treatments each are being carried out in Randomized Complete Block Design. Six replications are carried out in foot hills while remaining six are being carried out in high hills. Each plot in the treatments has 25 m2 area. The crops are at seedling stage. Data on insect trapped on the traps, fruit infestation and yield are being recorded.

Treatments for application interval trials:

T1: Application of Jholmal-2 at 14 days (2 weeks) interval

T2: Application of Jholmal-2 at 21 days (3 weeks) interval

T3: Application of Jholmal-3 at 14 days (2 weeks) interval

T4: Application of Jholmal-3 at 21 days (3 weeks) interval

T5: Control

Plate 11. i. Jholmal-1 trial insect trap monitoring at Baluwa, Kavre ii. Monitoring of the Jholmal-2 and Jholmal-3 trial at Kalchebeshi, Kavre

Measurement of urine collection from cattle, buffalo and their comparative analysis

Urine collection from a cowshed is linked with the proper management of the cowshed with cemented floor, gutter and the collection tank. With the objective to know the ability of the urine production for Jholmal preparation, comparative study on urine production by cattle and buffalo is being carried out at Kavre. Approximately 60 to 80 percent of the nitrogen in animal urine is in the form of urea (Ishler, 2016). As nitrogen is one of the expensive and important plant nutrients, if this nutrient can be preserved could help in reducing the purchase of the chemical fertilizers for nitrogen supplement in the soil. In cowshed management, farmers were supported to improve the floor and made urine to drain through the gutter and collect into a tank constructed at the end of gutter (Plate 12). The farmers are collecting data on amount of water consumed by the animal along with amount of urine collected in the tank. The collected urine will be then utilized for preparation of Jholmal. Altogether eight cowsheds are under construction at various project sites.

Plate 12. Cowshed management for urine collection

Efficacy of Jholmal-3 as bio-pesticide on Maize (Zea mays L.) and Rice (Oryza sativa L.)

Efficacy testing of Jholmal-3 as an effective bio-pesticide on maize and rice is being carried out at Kavre. The trial has 12 replications and two treatments i.e. Jholmal-3 sprayed plot and control plot. Each plot in the treatments has 50 m2 area. Data on insect infestation and yield is being recorded. Currently, the maize is at the vegetative growth stage and the rice is at seedling stage.

Soil cement tank demonstration for waste water collection and irrigation

Soil cement ponds are constructed by mixing soil, sand and cement at the ratio of 1:3:3 respectively. These ponds are durable than plastic ponds and farmers can easily construct them with simple guidance. Soil cement tanks were popular since RMV project and being used to collect wastewater and rainwater from various sources. Two soil cement tanks have been constructed for demonstration in Kavre district (Plate 13). The farmers mentioned that the tanks are more durable than the plastic ponds and are not easily damaged by rodents and other creatures dwelling on the soil.

Plate 13. Soil-cement ponds constructed at Kavre

Identification of gender friendly technology and their demonstration

Workload to the women in household and farm activities was found to be a major problem in reducing the efficiency of the farmers in the RMS sites. To reduce the workload and number of intercultural operations, demonstration of mulching practice on bitter gourd was practiced at Kavre. To quantify the reduction on workload the plots were separated into two having each of 50 m2. One plot was covered with mulching plastic and another was used for control i.e. without mulching. The data for numbers of labor hours used in carrying out the intercultural operations are being recorded for the comparison. The crops are at early harvesting stage and the performance of the crop seems to be better in the mulching practice plot said the test farmers.

Establishment of RMS Knowledge Park for demonstration of climate resilient technology

'The farmers easily get aware and adopt the technology when they can visualize its effectiveness with their own eyes' was the main objective behind the development of RMS Knowledge Park. The hidden interest inside its establishment was silent up-scaling of the technology to the farmers who visit the park. Knowledge parks were established at Kavre (Kalchebeshi, Dhulikhel, Charangefedi, Namobuddha) and Dadeldhura (Plate 14). The construction of the knowledge park contained soil cement tank, mulching practice, vermi-compost and several IPM tools that were used in different crops for their integrated management.

Plate 14. Established 'knowledge park' at Kavre and Dadeldhura

ICT services to farmers

From RMV project we are able to learn about the positive impact of the SMS information service to the farmers resulting increased the bargain power in selling the commodity, making decision with the crop planting and harvesting, control the disease and pest in time and also carry out their daily activities based on the weather information. In order to increase those abilities, ICT service has been provided again in RMS program so that the farmers can benefit from it. SMS messages are being sent three times a week for information on market prices, weather forecast and technical knowhow to 5-6 farmers from each group in their mobile phones, who in turn circulate the messages to their members in the groups and other farming communities nearby.

3. CONCLUSION

Smart agriculture and safe vegetable production is the current national as well as international demand for the healthy and wealthy life of people. The technology and approaches should be speeded as the tools to conserve and sustainable use of our landraces and local cultivars to meet the national obligation of food and nutrition security. As Nepal is vulnerable to natural disasters and climate change's effect and impact, extensive use of climate resilient technology would be the sustainable way to cope them for the betterment of livelihood of Nepalese.

Thus, the best practices and learnings of CEAPRED through different projects implemented in Sindhupalchok, Sindhuli, Kavre, Udayapur and Dadeldhura such as climate change vulnerability assessment; participatory mapping of potential locations; identification of the varieties based on the production and marketing potential; market trial approach of those products; collection of the priority crops/local varieties for conservation and multiplication; establishment of climate smart agriculture model farms; identification of model farmers who follow excellent practices and award them; climate resilient technology (water smart, soil nutrient smart, cropping and weather smart, energy smart, IT smart); wider adoption of developed PoP; establishment of RMS Knowledge Park of climate resilient technology; strengthen the capacity of farmers; solar and dug-well irrigation; soil cement tank for waste water collection and irrigation; preparation and application of Jholmal 1, 2 and 3 promoting bio-insecticides, bio-pesticides and bio-fertilizers; Participatory Guarantee System (PGS); brand for safe products (like SINDHUKA); binding linkages between traders and producers; identification and adoption of gender friendly technology; and ICT services to farmers should be extended to other locations through collaboration and cooperation with concerned developmental partners.

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