Nepal-Denmark Development Cooperation
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Unlocking Public and Private Finance for the Poor

Role and Financing Opportunities of Energy Solutions in Selected Agriculture Value Chains

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This study was conducted by a consulting firm and the results are based within the limits of their study.

Forewords

UNNATI–Access to Finance (A2F) is a sub-component of UNNATI – Inclusive Growth Programme in Nepal funded by the Government of Denmark and implemented by Nepal Rastra Bank with technical support from UNCDF. The purpose of the UNNATI-A2F project is to support financial service providers to serve more effectively to the agricultural value chain actors providing appropriate financial products and services. The project is already partnering with several commercial banks and micro-finance institutions in this regard.

UNNATI specifically works in the four value chains i.e. dairy, large cardamom, ginger and orthodox tea for its interventions. There are ample opportunities to integrate energy and technologies at the various stages of the selected agriculture value chains to improve their efficiency and productivity. Many of the enterprises in these value chains use traditional energy sources or operate manually, which can be replaced with modern energy services leading to improved efficiency and productivity. In this context, UNNATI–A2F project conducted a study to understand the 'Opportunities of installing modern energy powered technologies in the selected agriculture value chains and their financing opportunities'. For this, a team consisting of expert consultants from an international consulting firm Practical Action Consulting (PAC) and experts from UNNATI–A2F project and Clean-start Project was formed to get the desired outcome of the assignment.

The specific objectives of the assignment were to conduct a desk study and consultations to prepare a long list of appropriate technologies in the value chains, use necessary selection criteria to identify the most relevant technologies through consultations and field visits, conduct indicative financial analysis of potential technologies (twelve), develop reference manuals for entrepreneurs, BFIs and service providers, validate the manuals and findings through workshop and finalize the materials.

The team embraced participatory approach of market system assessment for this assignment with information coming from primary as well as secondary information. This included a complete diagnosis of the selected commodities from production until the post-harvest activities from potential of utilizing modern energy. Measures were undertaken to ensure that the assessment in a fair representation of 35,000 beneficiaries through proper sampling. Special attention was given to 159 matching grantees selected by UNNATI through rigorous process based on their proposed business plan.

Consultations were done at central level mainly with organizations steering the UNNATI–A2F Component. This included institutional inputs from Nepal Rastra Bank, CleanStart- UNCDF, UNNATI implementing team, Banking and Financial Institution partners (BFIs), and Alternative Energy Promotion Centre (AEPC), National Agriculture Research Council (NARC), technology vendors among others. Further the team visited the eastern region of Nepal to understand the core beneficiaries as well as local level support and local contexts on energy usage in the selected value chains.

With the details of technologies available, the team conducted a participatory workshop. The workshop was arranged in Biratnagar by UNNATI–A2F team with participants from diverse background including BFIs, farmers, commodity associations, technology vendors and representatives from NRB and Regional Agriculture Development Office (RAD)- Biratnagar. The workshop brought together various actors across the value chain and brainstormed on the shortlisted technologies to validate the information collected through desk studies and consultations. The workshop also aided the study team to finalize the information on the technologies and was also a multi-stakeholder platform to initiate discussions for improved efficiency of the value chains.

After a primary and secondary research work, we now have finally come up with the report; "Role and financing opportunities of energy solutionsin selected agriculture value chains".

This includes a final report on potential of integrating appropriate technologies and energy solutions in the selected value chain in the context of UNNATI–A2F with four separate sections on four value chains, a simple indicative financial analysis of at least 12 appropriate modern energy powered technologies potential to be installed in the selected value chains in the project areas and three complete training curriculum (one for managers/loan officers, one for vendors and one for potential entrepreneurs). This study itself is the first of its kind in Nepal. In this context, I hope that the study will be a very useful reference material for the energy users, Financial Service Providers (FSPs), vendors and government/non-government initiatives working towards affordable, reliable, sustainable and modern energy for all.

Finally, I would like to thank all the concerned persons, who were involved directly or indirectly in the study process. My sincere thanks to the team of Practical Action Consulting for their effort to complete this study. Besides, I would also like to appreciate the hard work of all the staff of UNNATI-A2F project.

Last but not the least, I express my sincere gratitude to UNCDF for the support and guidance in the course of development of this document. Finally, I would like to sincerely thank Government of Denmark for their support in this course.

Thank you.

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Abbreviations

A2F	Access to Finance
AEPC	Alternative Energy Promotion Centre
AVC	Agriculture Value Chain
AVCF	Agriculture Value Chain Finance
BC	Benefit to Cost
BFI	Bank and Financial Institution
CHP	Combined Heat and Power
DADO	District Agriculture Development Office
DANIDA	Danish International Development Agency
DLSO	District Livestock Service Office
EDR	Eastern Development Region of Nepal
FGD	Focused Group Discussion
IRR	Internal Rate of Return
KII	Key Informant Interview
LCEAN	Large Cardamom Entrepreneurs Association of Nepal
MOAD	Ministry of Agriculture Development
NARC	Nepal Agriculture Research Council
NEA	Nepal Electricity Authority
NDA	Nepal Dairy Association
NGPTA	Nepal Ginger Producers and Traders Association
NPV	Net Present Value
NRB	Nepal Rastra Bank
NTCDB	National Tea and Coffee Development Board
PAC	Practical Action Consulting
PV	Photo Voltaic
SME	Small and Medium Enterprise
TOR	Terms of Reference
UNCDF	United Nations Capital Development Fund
VC	Value Chain

Potential of Integrating Appropriate Technologies and Energy Solutions in the Selected Value Chains

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1. Background and Scope of the Study

UNNATI-Access to Finance (UNNATI-A2F) appointed Practical Action Consulting (PAC) to undertake this study. This report is the final report of the assignment as an outcome of the consultations, desk reviews, field visits and feedbacks, relevant stakeholders as well as users of the technologies recommended. The report has four sections. The first section of the report sets the context in which the study is undertaken. The second section discusses on the methodology and process undertaken for the study. The third section gives a detailed description on the technologies identified per value chain while the fourth section gives context specific recommendations to UNCDF and UNNATI team as key way forward based on the findings and learnings from the assignment.

The study is conducted within the broader context of "UNNATI–Inclusive Growth Programme" in Nepal. The scope of the assignment was to access the role of energy solutions and technologies, and their financing opportunities in the UNNATI selected agriculture value chains. The specific objectives of the assignment were:

- Conduct a desk study and consultations to prepare a long list of appropriate technologies in the value chains
- Use necessary selection criteria to identify the most relevant technologies through consultations and field visits
- Conduct indicative financial analysis of potential 12 (twelve) technologies
- Develop reference manuals for entrepreneurs, BFIs and service providers
- Validate the manuals and findings through workshop and finalize the materials

Limitation:

Despite adequate planning, consultations, time and resources was a major constraint. Further, the team received highly valuable inputs from the feedback sharing workshop along with request for detailed operational assessment and business plan development across the value chain which unfortunately could not be appraised as this was outside the scope of the assignment. With the fact that business plan will be unique depending upon situation, our estimation is purely based on average of consultations and desk reviews. Further, the assumptions that we make for assessment might not hold true for all entrepreneurs. Hence, the study team recommends that operational and business plan at enterprise level is a must, should any technological interventions be focused on. Further, sticking with the objective of identifying technologies with interest for BFIs, developing accurate business plans with options analysis for introduction of each of the technology is important for the BFIs to appraise a fundable proposal.

2. Methodology and Findings

The PAC team embraced participatory approach of market system assessment for this assignment with information coming from primary as well as secondary information. This included a complete diagnosis of the commodities from production until the post-harvest activities from potential of utilizing modern energy. Measures were undertaken to ensure that the assessment is a fair representation of 35,000 beneficiaries through proper sampling. Special attention was given to 159 matching grantees selected by UNNATI through rigorous process based on their proposed business plan.

2.1 Assessment Framework

The specific aspects of accessibility, affordability, utility and functional appropriateness, ease of operation, utilization ratio and benefit return to farmers, maintenance and services, and potential of adoption of the technologies were the key areas of assessment.

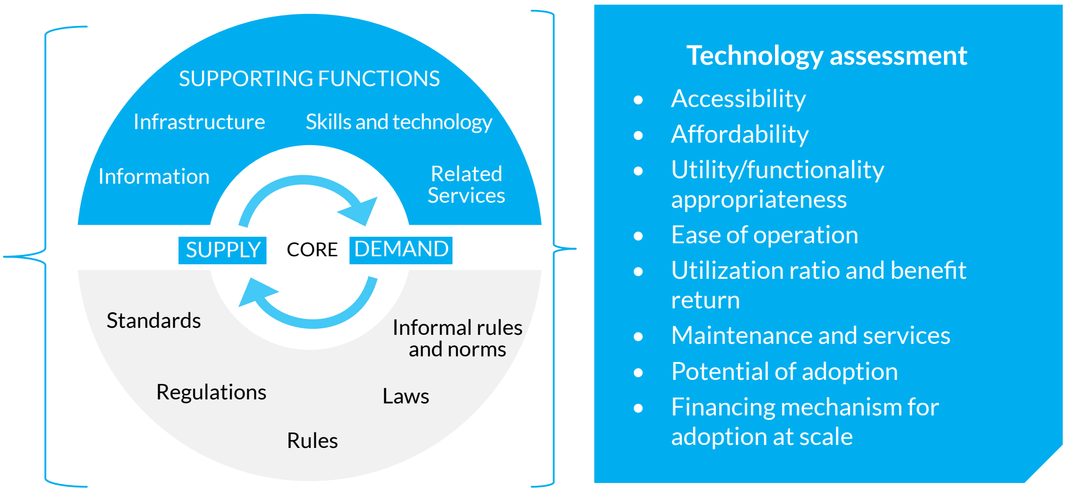


Figure 1: Modern energy assessment framework

2.2 Steps and Process of the Study

A consultative process was adopted to design the overall study. One of the key learning and recommendation is regarding conducting a multi-stakeholder workshop towards the mid-way of the project rather than towards the end as it happened in this assignment. Conducting the workshop mid-way gives team additional flexibility to explore technologies that would be requested by the value chain actors.

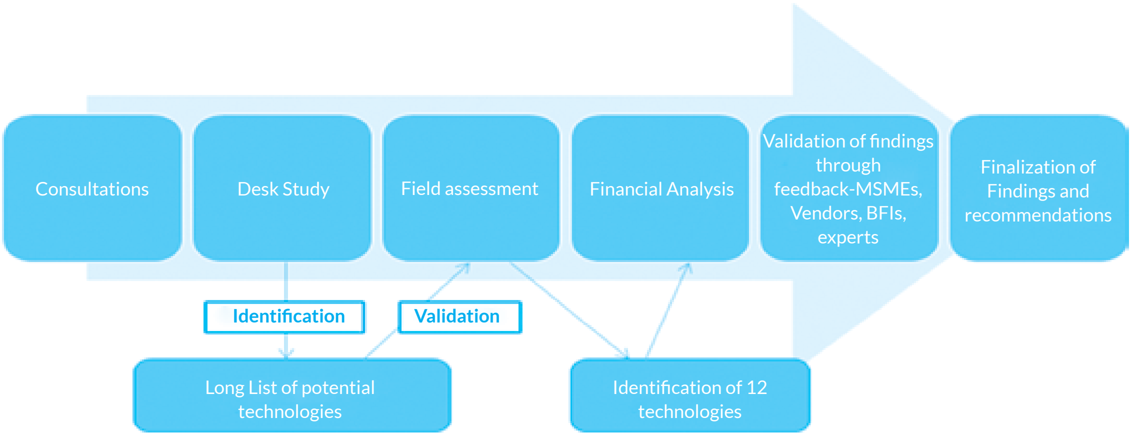


Figure 2: Steps followed to conduct the study

2.3 Defining Modern Technologies

The term modern energy is very broad, which includes clean energy technologies, renewable energy technologies, energy efficiency among others. The International Energy Agency (2015) defines 'modern energy powered technologies' as *technical solutions which provides energy access to everyone and improves living conditions of people and enhances productivity of enterprises without causing damage to the ecosystem (such as environment and biodiversity etc.)*. These modern energy powered technologies are defined as access to electricity, clean heating and cooking facilities (e.g. fuels and stoves that do not cause air pollution). Similar definition is also provided by the World Bank, *technologies that offer promise in addressing both climate change and energy access goals*.

"Modern" energy encompass a wide range of hardware and operational knowledge (such as solar PV), from the very large, complex, and knowledge-intensive to incremental, relatively low-tech improvements such as advanced-combustion cook-stoves. Some, like industrial efficiency technologies, are extensively used, although only in some markets. Some technologies are very widely applicable (e.g., efficiency in process and appliances), while others are highly specialized or location-specific (World Bank, 2011).

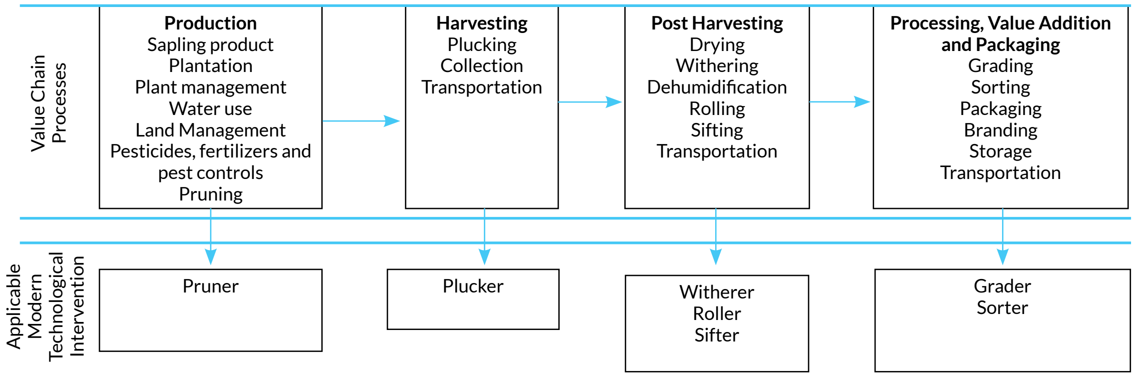
2.4 Desk Review and Consultations

Consultations were done at central level mainly with organisations steering the UNNATI–A2F Component. This included institutional inputs from Nepal Rastra Bank, CleanStart-UNCDF, UNNATI implementing team, Banking and Financial Institution partners (BFIs), Alternative Energy Promotion Centre (AEPC), National Agriculture Research Council (NARC), technology vendors amongst others. The preliminary consultations were helpful to understand the context while also having access (information) about various documents to be reviewed and key stakeholders to be met during field visits. The gist from the review and consultations is bulleted below:

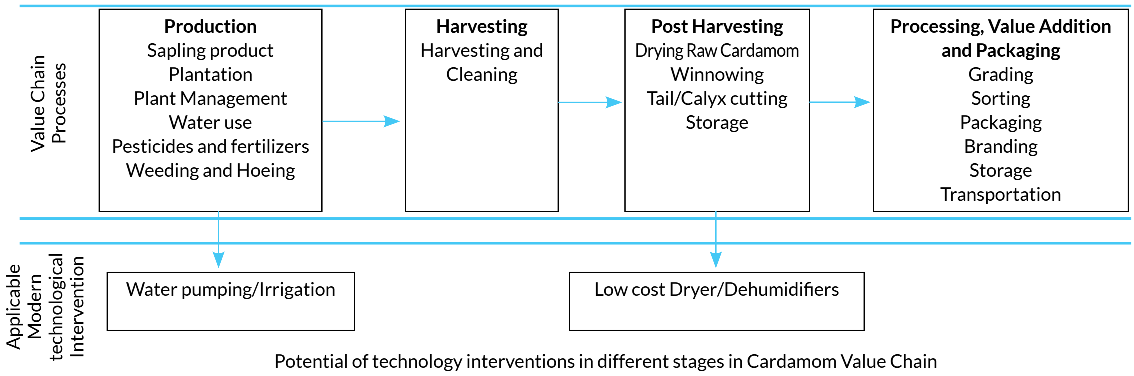
- Various local level service providers are supplying appropriate technologies in the value chains. Majority of them being based in Biratnagar and Birtamod.
- Despite the availability, the upfront cost of the technologies has been a major barrier for its adoption.
- Generally, the technologies thought to be attractive to farmers, vendors as well as financial institutions requires estimated capital injection of 15 to 25 million.
- However, with the fact that the cost for developing proposals for BFIs is very high when compared with the return, BFIs do not have motivate to be engaged in apprising such proposals.
- There is very less difference between normal commercial and agricultural loan products being offered by BFIs.
- The monetary policy of current fiscal year mandates the commercial banks to have 10% of its loan portfolio on agriculture sector. There are provisions related

to interest payback for non-default cases whose utilization remains low.

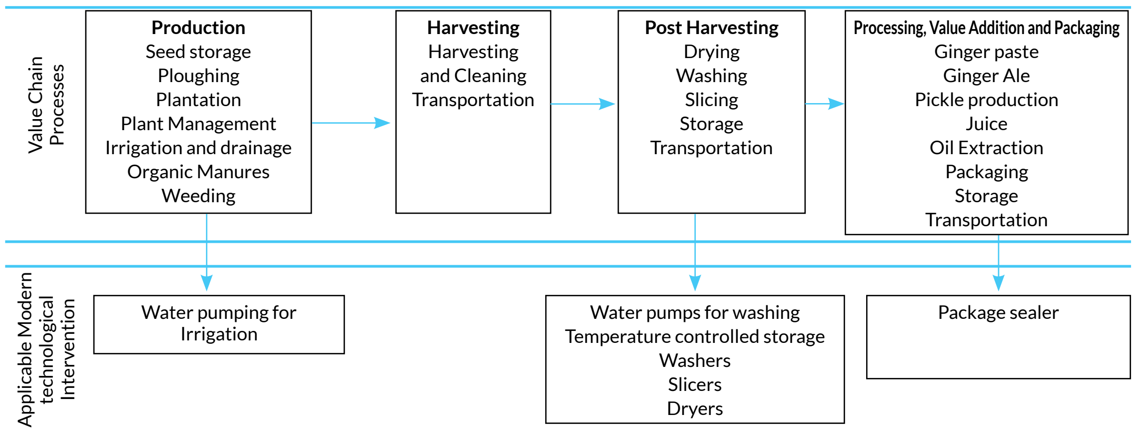
The desk reviews and consultation was successful in identification of long list of technologies applicable for the tea, large cardamom, ginger and dairy value chains. The below are the gist of the technologies as per the stages in various value chains.



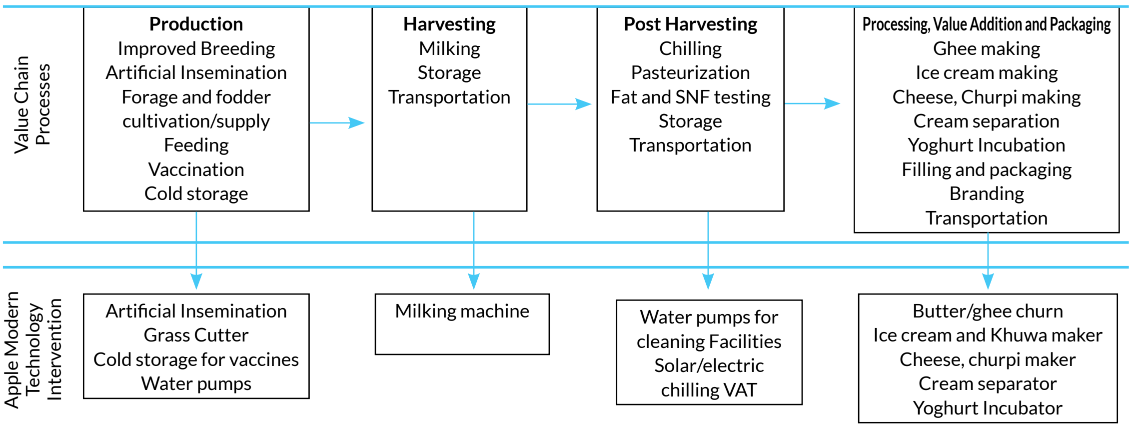
Potential of technology interventions in different stages in Orthodox tea Value Chain



Potential of technology interventions in different stages in Cardamom Value Chain



Potential of technology interventions in different stages in Ginger Value Chain



Potential of technology interventions in different stages in Dairy Value Chain

2.5 Field Visit

With the long list identified, the study team undertook a joint field visit to identify various aspects of technology. The visit was focused towards the core beneficiaries as well as local level support providers to understand the local context of energy usage in the selected value chains. The below is the sample for the assessment at beneficiary's level.

- Total 8 FGDs at farmer/MSME level (2 per value chain)- numbers of individual per FGD was between 10-15.
- 4-6 large traders of the commodities and their products (could be products like cheese for dairy) to understand the quantity and quality requirements from buyer perspectives.
- 12 KIIs at enterprise level (3 per value chains).
- Community enterprises like cold storage, washing units, drying units as applicable.

The observation and learnings from the field was useful for the team to identify various aspects of technology vis-à-vis the criteria for selection. The findings have hence helped the team to come up with the shortlist of technology for detailed assessment. The below are the gist of findings from the field visit.

- There is huge opportunity of modern energy powered technologies especially in the Dairy Value Chain. Majority of the matching grantees being considered by the implementation team for further engagement are also in the Dairy Value Chain.
- The demand for technologies at producer level is very huge. The producers are aware of various technologies which could ease the overall process, improve productivity, expand production area, however, its adoption level remains low due to many factors including the cost of installation.
- Value chain actors have already tested some technologies identified through the desk study. For instance, they are aware of automated tea plucker, but it has not been used further due to its complication during operation.
- Solar is a potential energy source barring to unreliable grid power and

increasingly expensive firewood.

- Artificial insemination has a huge potential in the area, however, the success rate of AI remains low due to improper handling of semen and/or during its application
- Lack of interconnected between the farmers, vendors, banking institutions is very well evident. Participatory events to bring these together to discuss on appropriate technology is a necessity.
- Most of the businesses among the grant recipients are proactive and have a growth plan in their mind. However, actually developing a roadmap to achieve the targeted their growth plan and implementing the same is a major constraint. A comprehensive business development service support would aid them in expanding their business and in turn adopting the modern technologies to increase energy use efficiency at scale, maintain quality and quantity consistently.

2.6 Shortlist of Technology

The team prepared a technology selection matrix to quantitatively compare the long list of technologies. This was done through weighted average score. The basis of scoring is as below. The outcome of the evaluation is provided in annex I.

	Accessibility	Affordability	Utility/Functionality appropriateness
5	Available in Neighbourhood/village/ward	Cost<10% of annual income	Operated in Full capacity as per the cycle requirement
4	Available in District level	Cost between 10-20% annual income	Operated in 75% of full capacity as per the cycle requirement
3	Available in Region	Cost between 20-30% annual income	Operated in 50% of full capacity as per the cycle requirement
2	Available only at National Level	Cost between 30-40% annual income	Operated in 50% of full capacity as per the cycle requirement
1	Available at international level	More then 50% of Yearly income	Unsure about technology functionality
	Ease of operation	Utilization ratio and benefit return	Maintenance and services
5	Self Operated and easy-no required	Cost recovery by 1 year/IRR above baning rate	Self Maintenance in sufficient and maintenance service readily available
4	Self operated but needs training	Cost recovery by 1 year/IRR below banking rate	Could be maintained in most case with most of the maintenance service available
3	Requires dedicated local level operator	Cost recovery by 2-3 year	General maintenance service available locally
2	Requires dedicated operator from outside local level	Cost recovery by 3-4 years	Maintenance service available at district level
1	Requires dedicated technical expertise	Cost recovery by 4 years	Maintenance service available at National/ International level
	Potential of adoption	Financing Mechanism (Bankable)	Demand of the output
5	High adaptability and impact at national level	Bankable by any BFIs	High and chance of increasing demand
4	Moderate Adaptability-national/high regional	Bankable by BFI partner of UNCDF	Moderate and steady projected demand
3	Adaptable and scalable	Bankable at local level	Moderate but unsure about future demand
2	Adaptable but unsure about scaling up	Unsure about bankability	Low current and unsure future demand
1	Difficult to adapt in local context and Scale up	Difficult financing mechanism	Both current and future demand are low

A total of 14 technologies were short listed. This was shared in a workshop between study team, UNNATI–A2F and UNNATI implementing team. The feedbacks were incorporated and final list of technologies for detailed technical and financial assessment were identified for wider feedback taking session. The technical and financial details of identified technologies are provided in next section.

2.7 Feedback Seeking Workshop

With the details of technologies available, the team conducted a participatory workshop. The workshop was organized with participants from diverse background including BFIs. The workshop brought together various actors across the value chain and brainstormed on the shortlisted technologies to validate the information collected through desk studies and consultations. The workshop also aided the study team to finalize the information on the technologies and was also a multi-stakeholder platform to initiate discussions for improved efficiency of the VCs.

The technical session on technology comprised of two sessions. The first session was conducted on plenary to share the criteria used for shortlisting as well as the simple indicative financial analysis. The discussions were helpful to understand the basis on which technology shortlisting has been done. The session was moreover beneficial to BFIs as they had better information about the potential of technology interventions in VCs and then start a thinking process on financial products to cater the technology needs.

The second session was conducted in groups, divided as per the value chains and the interest of participants present. Each of the technology was linked with at least one group and accordingly its detailed information was verified. The team then shared consolidated feedback to PAC. The major feedbacks, collected from the workshop are provided.

- The long list and short list of technology identification is well appreciated by the participants
- The request for brief information to include in specific technological details needs elaboration with additional points such as life cycle of technology, moratorium period- if any, mode of preferred payment system- bullet, others etc.
- Request for detailed analysis from banking perspective for at least technology- for banks to understand and refer to the format for other technologies

2.8 Reference Document on Technologies

The team conducted independent technical and financial analysis to provide adequate information to the stakeholders for informed decision making.

The technical assessment focused on identifying the energy demand as per the value chain. The specific points identified for elaboration of individual technologies which are available in reference manual are as below

- Technology being used currently for the process
- Current energy requirement for the process
- Type of energy required in modern technology
- Availability of energy required
- Availability and reliability of energy technology

- Efficiency of the selected modern technology
  - o Size and volume
  - o Quantity of energy usage for current volume
  - o Enhancement of productivity
- Ease of operation
  - o Skilled human resource
  - o Safety
- Potential of adoption
- Maintenance and after-sale services
- Market availability and transportation

Financial analysis of technology was a straightforward exercise. With the workshop aiding to verify the detailed cash flow for each of the technology, BC, NPV, and IRR were assessed. Upon request from the participants of the workshop, one technology's detailed financial workout has been developed which could be used as a reference by the banks to evaluate proposals from SMEs and vendors. The detail of each of the technology is provided in reference manual.

2.9 Training Manual

The objectives of the training manual is to orient financial institutions on the plausible options of modern energy powered technologies in the selected value chains and eventually adopt suitable pathways to design financial products for financing such energy technologies. The vendors and suppliers would have a list of suitable modern energy powered technologies in the selected value chains, which can be considered by vendors in their businesses. Lastly, the farmers/entrepreneurs are expected to be oriented on various technologies which could be considered for various stages in the value chain. The training manuals have been submitted separately.

2.10 Financial Assessment

Determining financial viability is concerned with such questions as the adequacy of funds, the financial viability of the project, the borrower's ability to service debt, procedures for recovering investment and operating costs, etc., and, ultimately, does the project return a profit? It is an essential part of the business case that needs to be presented to financial institutions/banks to secure financing.

Our assessment on financial viability involved collecting necessary input data during the field visit and follow-ups, validated through the workshop. The team collected the below information for financial analysis.

- Capital cost
- Operations and maintenance cost
- Operating parameters
- Unit selling price

- Interest rates
- Assumptions for assessment
- Benefit of adopting the technology over conventional system

The detail output of the exercise (with detailed assumptions) is clubbed together with technical details in below section.

2.11 Gender Proofing of the Selected Modern Energy Technologies

Women are recognized as key to family and community for well-being and food security. The findings from the study report revealed and substantiated the claim of value chain reports developed by UNNATI that women are predominantly involved in various farm activities (from tillage operations to harvesting to processing and storage). The study made diligent attempts to shortlist and select modern technologies which are useful for/can be easily handled by women as well as are instrumental in enhancing women's income generation, contribute to their empowerment and family well-being. The study also aimed to promote access to credit for women along with other co-benefits such as reducing in drudgery and enhancing productive time to women.

3. Value Chain Reports on Potential of Integrating Energy Solutions in Value Chains

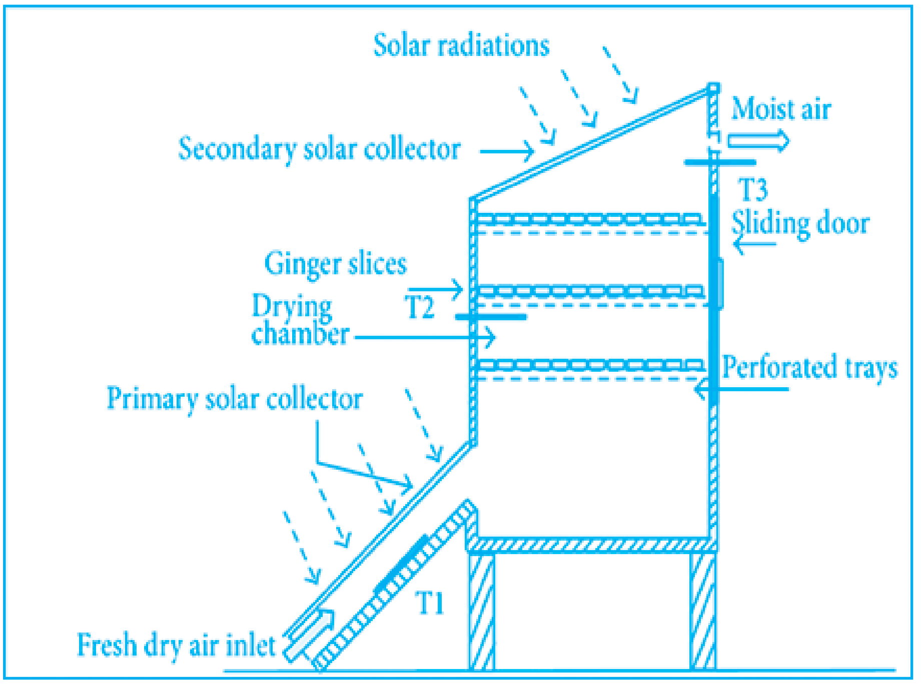
The study concludes that there is potential of integrating modern energy powered technologies in the UNNATI VCs. Below is the detailed value chain based report on potential of integrating energy solutions in various value chains.

3.1 Integration of Modern Energy Powered Technologies in Ginger

Ginger is cultivated mainly in the mid-hills and some plain areas of Nepal. Of the total production, 60 per cent is exported, while the rest is consumed within the domestic market. While India is the biggest market for Nepali Ginger, it is also exported to overseas countries, including Gulf countries. Raw Ginger and dried candies are the major exportable forms. Ginger is exported to India through the border areas of Kakarvitta in the east, Bhairahawa in the west and Nepalgunj in the mid-west. Due to favourable climatic conditions and increased demand in domestic and export markets, Ginger farming has gained popularity among farmers in mid hills on Nepal. Between 2008 and 2012, the world Ginger market grew at a speed of 10 per cent annually while the share of Nepal's Ginger in this world production stood at 12 per cent. Nepal's share of Ginger production in South Asia is 21.39 per cent. The statistics of the Trade and Export Promotion Centre shows that Ginger exports jumped significantly by 162.49 per cent to 62, 843 tonnes in 2012-13. Ilam, Panchthar, Tehrathum, Kavrepalanchowk, Palpa, Nawalparasi, Tanahu, Kaski, Dang, Salyan, and Pyuthan are the top districts in Ginger production in Nepal. The specific recommended technologies for Ginger value chain are:

3.1.1 Solar Powered Ginger Dryer

The solar powered Ginger Dryer works on thermal power using solar collectors. This dryer constitutes of a mixed mode box-cabinet with natural circulation. There is a primary solar collector with a transparent sheet is located over the collector and a secondary solar collector oriented North-South is covered with a single layer of thick UV stabilized polyethylene film and hinged at the top of the drying chamber. The fresh air is sucked in from under the primary collector and heated through the air duct and flows to the drying chamber. Secondary collector allows the solar radiations to drying chamber and further enhances the drying rate by greenhouse effect. The drying chamber is coated with black paint, thermally insulated with asbestos sheets to minimize the heat loss provided with the support for sample holding mesh trays having area 1 m^2. The general rule of thumb is that 1 m^2 of tray area is needed to lay 10 kg of produce; an average dryer can dry around 250 kg of Ginger with 3 days drying time.



Schematic diagram

3.1.2 Automated Ginger Washer

A Ginger washing machine is composed of stainless steel frame, speed motor, drum chamber, pipeline shower, sprinkler and water tank. Semi-automated or fully automated varieties of machines are available in market which utilise electric power. The required electric power can be supplied by grid electricity or from suitable solar PV system. However, it will be more viable to use grid-electricity if the size of the machine is large and requires significant quantity of electrical energy.

The machine uses surfing, bubbling and water spraying to wash ginger. During this process, it can completely clean the soil stuck in the gingers as well as use sterilization sprays to wash out the effect of pesticide residues on the surface.

The machine can also wash other vegetables in addition to ginger but will require calibration in speed and flow of water.

Sample Technical Parameters:

Dimension (mm)	Weight (kg)	Power (kW)	Capacity (kg/h)
3000*1200*1300	420	2.95	300-500
4000*1200*1300	400	4.1	800
5000*1200*1300	500	5.1	1500
6000*1200*1300	600	5.5	2000

Technical viability analysis	**Type of energy required in modern technology:** Grid electricity or solar PV **Availability and reliability of energy technology:** Grid electricity is mostly available, solar PV may be used as backup **Size and volume:** Different sizes are available, which may meet the requirements of medium and large size enterprises. **Enhancement of productivity:** Less manual work, efficient use of water, increase in speed of process. **Ease of operation:** As it is mostly automated, it is easy to operate **Skilled human resource:** Operator needs to be trained **Safety:** Proper safety standards need to be maintained **Market availability and transportation:** Can be imported from India or China
Financial feasibility analysis	**Capacity of the system:** 500 kg per hour. **Operating Life:** 15 years Although the system can be in operation whole year, it is assumed that the system will be in operation for 2 months only during the 2 crop cycles of Ginger where a crop cycle is generally a month long. **Energy consumption:** 18 kWh per day (3 kW system operating 6 hours per day) **Investment streams:** Total installation cost of the plant is of NPR 1.5 Million. Operating cost of the plant is NPR 168,000 which includes cost of human resource and electricity cost. The maintenance cost is NPR 40,000 per year.

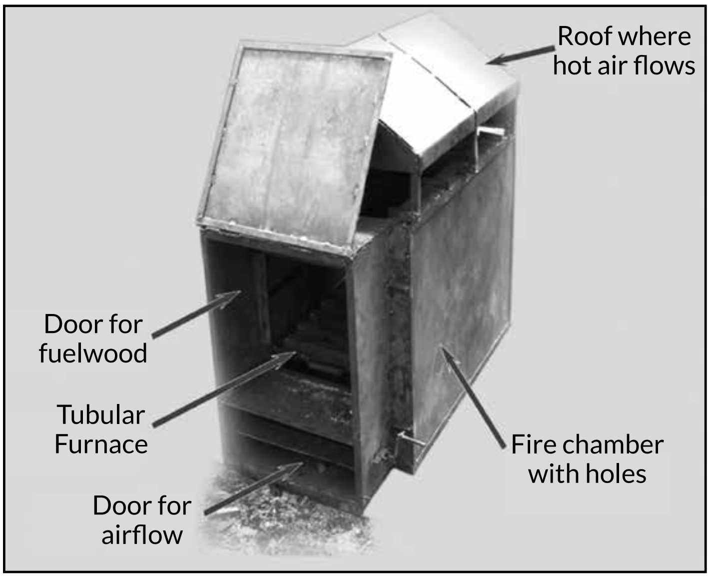
Financial feasibility analysis	**Income streams:** The income stream includes the incremental income of the washed Ginger. The incremental income will be NPR 5 kg per washed Ginger (field consultation). The system can process 180 tonnes of Ginger per year contributing to the yearly income of NPR 900,000. **Assumptions:** • The system will operate only 2 months during 2 crop cycles of Ginger production. • The system will operate 6 hours a day. • The operation of system will require an operator (at NPR 1,000 per day) and 3 labours (at NPR 500 per day). The detailed financial analysis is attached in the financial worksheet.
Profitability	IRR: 33% NPV: 25 Million Breakeven Point: 3 years
Recommendation	The average production of Ginger in project area is around 13 tonnes per hectare per year. The operational capacity of the machine is 180 tonnes of Ginger per year. To meet this demand of operational capacity, farmers will need to have ginger cultivation in minimum 14-hectare land area.
Limitations	• This is only a seasonal operation. • Maintenance of the plant needs to be a regular practice

3.2 Integration of Modern Energy Powered Technologies in Large Cardamom

Nepal is the third largest exporter of Large Cardamom (Amomum Sabulatum, Roxb) and is identified and listed by NTIS 2010 and ADS 2015 as a priority crop. The Eastern Development Region produced 4,907 MT (in 2015) which is 94 per cent of total production (5, 225 MT). It fetches high benefit to cost ratio for the farmers which is resulting in increasing trend of land under cultivation. The major constraint in production has been viral infestation coupled with buyer led price determination system. Often, the price of Large Cardamom is fixed before the harvesting and financial transaction is done with local traders in advance. From energy technology perspective, proper drying and storage facility would be a priority.

2.2.1 Improved Cardamom Dryer

Improved Cardamom dryer is an efficient drying method using fuelwood. These dryers are recently being piloted by Singhabahini Engineering Works Pvt. Ltd., Sunsari. An average improved dryer dries 1 kg of Cardamom utilising 1 kg of fuelwood whereas, traditional method requires 3 kg of fuelwood to dry similar capacity.



Improved Cardamom dryer

Technical viability analysis	**Type of energy required in modern technology:** Thermal energy using fuelwood **Availability of energy required:** Supply of fuelwood needs to be maintained **Efficiency of the selected moderntechnology:** Efficient and less carbon production than open fire **Size and volume:** 1.80 m x 0.7 m x 1.3 m for drying 200 kg; 1m x 0.7 m x 1.3 m for drying 150 kg **Quantity of energy usage**: 200 kg of fuelwood for drying 100 kg of cardamom **Ease of operation:** Easy to operate **Skilled human resource:** Requires orientation for using **Safety:** Needs necessary safety measures. **Maintenance and after-sale services:** Manufacturer provides **Market availability and transportation:** One manufacturer in Nepal
Financial feasibility analysis	**Capacity of the system:** 1500 kg per week (current operation is 1000 kg per week due to lack of inputs, the financial analysis is carried based on what capacity will make the system breakeven). **Operating Life:** 6 years **Investment streams:** Total installation cost of the plant is of NPR 35,000. Operating cost of the plant is NPR 2,100 which includes cost of human resource. At the end of third year operation, the base grate should be replaced which cost around NPR 3,000.

Financial feasibility analysis	**Income streams:** The income stream includes the saving of the fuelwood than the traditional method of drying. The system saves 2 kg of fuelwood per kg of cardamom than the conventional method. Thus, 3,000 kg of fuelwood will be saved contributing to the yearly income of NPR 15,000. **Assumptions:** • The annual operational days are one week. • The fuelwood cost is NPR 5 per kg. • The system requires 1 kg of fuelwood to dry 1 kg of cardamom compare to 3 kg of fuelwood for traditional method. (as per consultation with supplier) The detailed financial analysis is attached in the financial worksheet.
Profitability	IRR: 11% NPV: 15,000 Million Breakeven Point: 3 years
Recommendation	The dryer can be used for drying multiple crop harvest. The capital investment in the dryer will make economic sense if it is used for drying multiple crop harvest.
Limitations	Initial cost is high for small holding farmers.

3.3 Integration of Modern Energy Powered Technologies in Dairy

Dairy farming is the dominant activity of crop-livestock integrated farming practice among smallholder farmers in Nepal, with 80 per cent of farm households rearing Dairy animals (cows and buffaloes). In addition, the sector is the largest contributor of the livestock sector to Nepal's agricultural GDP.

Government along with many non-government organisations has given priority to develop this sector. Conventional farming practices have been a major challenge along with limited availability of veterinary service in the sector. Veterinary services are not available even in urban areas. Milk holidays in some parts of hilly region and new product design for Dairy industry is another challenge. There are dairies operating in many parts of country but the technologies used there are still traditional. The specific recommended technologies for Dairy value chain are:

3.3.1 Cream Separator

Cream separation machine can be operated using electricity from Solar PV hybrid with energy from Micro Hydro Project or national grid. About 0.4 kW electric powers is required to operate the machine that can separate cream from 500 litres of milk in an hour. In order to operate the proposed cream separator using solar PV, a 1.2 kWp sized solar PV system is needed to be installed.

The separators are abrasion and rust proof, therefore, can serve for long duration as per needs of entrepreneurs. As the machines are manufactured using high quality materials, they are durable and can also be customized as per the requirements. Sample Specifications for 500 Ltr/hr Electric Cream Separator:

- Machine Capacity: 500 Ltr/hr.
- Tank Cap.: 40 Ltr.
- No of S.S. Discs: 35
- Motor: 1425 RPM Single Phase Electric Motor 0.25 HP / 0.50 HP
- Separation Temperature: 35- 40 C/95-108 F
- Solid Removal Time: 1.5 Hour
- Machine Length: 660 mm X Width: 550 mm X Height: 1200 mm
- Machine Weight: Nett - 70 kg; Gross - 145 kg Approx.
- Bowl Material: M.S./S.S. 304
- Spout Set Material: CRCA Sheet/S.S. 304 Sheet
- Receiving Tank Material: Aluminium Sheet/S.S. 304 Sheet
- Useful in Dairy Plant

Electric Cream Separator – can be powered using solar PV

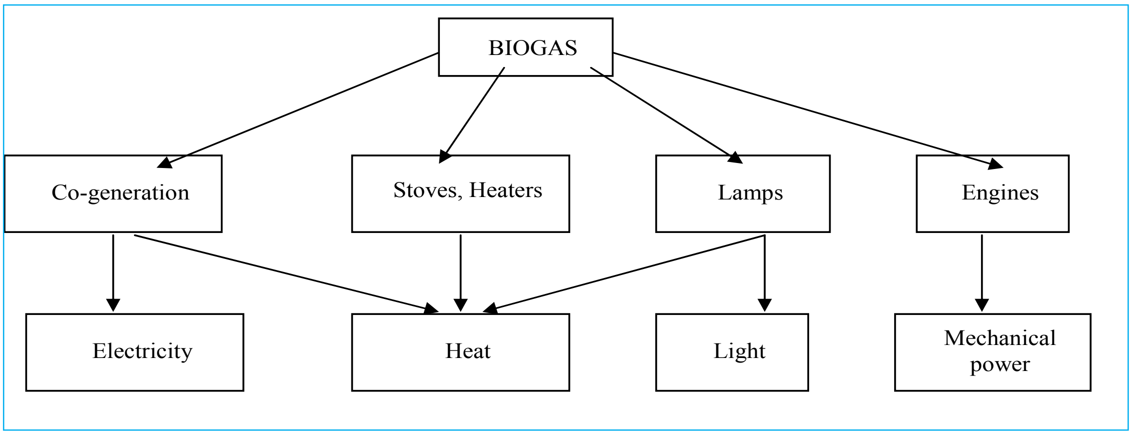
Technical viability analysis	**Type of energy required in modern technology:** Electricity from off-grid or on grid or from Solar PV **Availability and reliability of energy technology:** The energy system is reliable, but capacity depends on solar radiation and reliability of electricity supply from grid or off-grid. **Size and volume:** moderate in size **Type of energy used currently:** Manual separator or by heating in traditional cook-stoves **Ease of operation:** Easy to operate **Skilled human resource:** Training is required **Safety:** Safety procedures need to be implemented **Market availability and transportation:** The technology is available in Nepalese market and can be easily purchased from Biratnagar
Financial feasibility analysis	**Capacity of the plant**: 3,000 litres of milk processing per day (500 litres per hour with 6 hours of operation) **Energy consumption:** The total energy 0.4 kW will be supplied by solar system of 1.2 kWp. **Operating Life**: 10 years **Investment streams:** Total installation cost of the system is of NPR 415,000, machine cost is NPR 55,000 and NPR 360,000 for 1.2 kWp solar PV system (solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 50,000 which includes cost of human resource (system manned by single operator at NPR 5,000 per month). The annual maintenance cost of the plant is NPR 20,000, which includes solar plant and machine maintenance after 3 years of operation. **Income streams:** The plant will generate income primarily from production of cream which is used in ghee/butter production. The current (average) market price of ghee (may vary according to type of feeds) is NPR 750 per kg. We assumed around 5% increment due to enhance in quality of the production by the system i.e. NPR 37 per kg of cream of incremental rate. The total gross income from system is NPR 280,000 (from 7,500 kg of cream from 1% fat content 750,000 litres of milk the system is capable of processing). **Assumptions:** • The annual operational days are of 250. • The fat content in the milk is 1%.

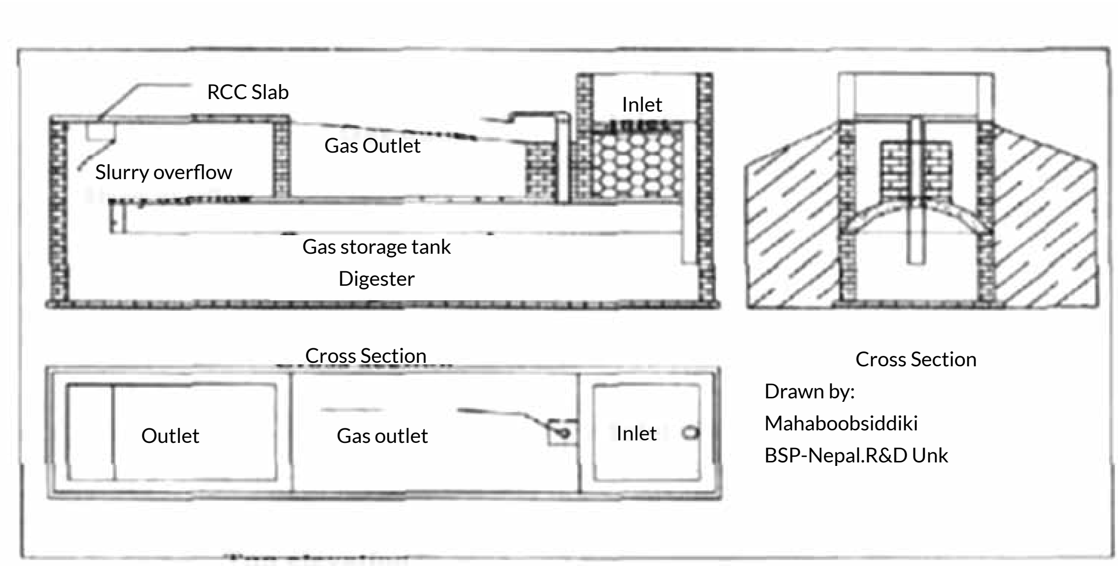
Profitability	IRR: 31% NPV: 550,000 Breakeven Point: 3 years
Recommendation	The system can be recommended for medium and large-scale operations and commercially viable.
Limitations	Initial training for operators is necessary.

3.3.2 Biogas Plant for Thermal and Electrical Power Generation

Biogas is a combustible fuel produced through anaerobic digestion process. Anaerobic means "in the absence of oxygen". Biogas consists of roughly 40%–70% methane, with the rest being CO_2 and trace amounts of H_2O, H_2S, H_2 and NH_3 produced by the microbiological process. The amount of methane in the biogas is largely a function of the organic input menu. Methane is odourless and is invisible in bright daylight. It burns with a clear blue flame without smoke and is non-toxic. It produces more heat than kerosene, wood, charcoal, cow-dung chips etc.

Organic wastes from Dairy processing units are ideally suited as inputs to a biogas plant. Biogas, when utilized in a combined heat and power (CHP) unit produces electrical energy for consumption and heat energy for further use. The heat produced by the CHP is used to heat the digestion process to improve biogas yield. Biogas can also be cleaned up for injection into boiler as a fuel substitute for conventional fuel. The remaining by-product of the digestion process is digestate which is a fermented organic material which may be used as high quality fertilizer. A farm with 15-17 cattle can feed a biogas plant of 50 m^3 that can produce 3 kW of electricity and 200 kg bio-slurry per day.





Tunnel type with gas storage on displacement principle

Technical viability analysis	**Type of energy required in modern technology:** Organic waste of biomass to produce bio-energy **Availability of energy required:** System can be designed for required energy output **Availability and reliability of energy technology:** Supply of feed needs to be maintained **Efficiency of the selected modern technology:** Highly efficient use of biomass (waste) **Size and volume:** As per required (can be designed for small or medium-scale) **Ease of operation:** Moderate **Skilled human resource:** Needs to be trained **Safety:** Considerable safe but safety procedures should be followed **Market availability and transportation:** Can be constructed by skilled masons and technical assistance is readily available. Construction materials can be transported easily.
Financial feasibility analysis:	**Investment streams:** Total installation cost of the plant is of NPR 1.5 Million, which covers cost of civil works, generator, equipment etc. Operating cost of the plant is NPR 300,000, which includes cost of feedstocks and human resource. The annual maintenance cost of the plant is NPR 10,000.

Financial feasibility analysis:	**Income streams:** There are two plausible income streams, viz., (i). Income from energy saving (such as thermal heat generation with conventional methods like fuelwood) and (ii). Bio-fertilizer production and sales. The anticipated annual income from energy saving is of NPR 750,000 and the income from bio-fertilizer is of NPR 250,000. • The energy saving from conventional source of energy (fuel wood) is of NPR 1,000 per day, amounting to NPR 24,000 (assuming 200 kg fuelwood per day at NPR 5 per kg of fuelwood). • It is assumed that the price of bio fertilizer is NPR 15 per kg and can generate 200 kg per day amounting to 720,000 NPR per year.
Financial feasibility analysis:	• It is assumed that feedstock required for the plant operation is 1,000 kg per year amounting to 120,000 NPR per year at NPR 500 per kg. • The plant will be manned by 3 operators, incurring an expenditure of NPR 180,000 per year at NPR 5000 operational cost per month. The detailed analysis is provided in the financial worksheet.
Profitability	IRR: 28% NPV: 2.5 Million Breakeven Point: 4 years
Recommendation	The plant is suitable for medium scale operations of below 5 kW, however, there is scope to increase it up to 10-15 kW based on availability of feedstock. The plant can be used for multiple usages in accordance to the demands of the dairy unit.
Limitations	• Continuous supply of feedstocks shall be ensured. • Maintenance of the plant needs to be a regular practice

3.3.3 Milk Chilling Vat

Chilling of milk is necessary after receiving milk at collection/chilling centre in order to control growth of microorganisms, minimize micro-induced changes and maximize its shelf life. Chilled milk can easily and safely be transported without further deteriorative changes due to microbial growth.

Bulk milk coolers are generally installed at chilling centres. Milk Chilling Vat can be operated using electricity from Micro Hydro Project or the national grid or solar PV. About 2.64 kW of electric power is required to operate the compressors of Chilling

Vat that can hold 500 litres of milk. The collected milk at a milk collection centre needs to be kept in the Chilling Vat for about 3 to 24 hours before the supplying to Dairy industry through milk tankers. The Chilling Vat consists of a double jacketed vat fitted with a mechanical agitator. It also has provision for circulation of chilled water which comes from the chilled water tank.

Chilling Vats range from 300-2000 litres capacity having productive life of 10-15 years and require electrical power of 3-15 kW.

Technical viability analysis	**Type of energy required in modern technology:** Electric power from grid/solar PV **Availability and reliability of energy technology:** For reliability solar PV with battery backup in hybrid with grid electricity **Size and volume:** Varies from small portable to large sizes. **Ease of operation:** Easy to operate **Skilled human resource:** Orientation required for operation and maintenance **Safety:** Requires appropriate safety measures. **Market availability and transportation:** Easily available in Biratnagar, Kathmandu.
Financial feasibility analysis	**Capacity of the system:** 500 litres per day **Energy consumption:** 72 kWh per day **Operating Life:** 15 years **Investment streams:** Total installation cost of the plant is of NPR 450,000, which covers cost of generator, equipment etc. Annual operating cost of the plant is NPR 160,000 which includes cost of electricity supply and human resource. The annual maintenance cost of the plant is NPR 22,500. **Income streams:** The milk chilling system will enhance the self-life of milk by 24 to 48 hours, which will provide an incremental income NPR 3 per litre (Ref: field consultation). That means, the annual income from the Milk chilling system will be of NPR 375,000. **Assumptions:** • The annual operational days are of 250. • The plant will be manned by 2 operators, incurring an expenditure of NPR 100,000 per year.

Profitability	IRR: 24% NPV: 580,000 Breakeven Point: 4 years
Recommendation	The plant is suitable for medium scale operations which may benefit up to 20 dairy farmers.
Limitations	• Continuous supply of electricity shall be ensured. • Maintenance of the plant needs to be a regular practice

3.3.4 Automated Milking Machine

The automated milking machines are an effective means of milking cow which operate from electric power. The machine includes teat cups that contact the cow's teats and remove the milk, a claw where milk pools as it is removed from the four teats, vacuum tubes that provide vacuum to the teat cups and a milk tube that removes milk away from the claw, a source of vacuum for the machine, and a pulsator that regulates the on-off cycle of the vacuum. Many milking machines today have an automatic take-off (ATO or detacher) device that removes the machine from the cow when milking is completed.

Automated milking machine can be operated from using electricity from Solar PV, Micro Hydro Project or the national grid. The machines are mobile fitted with wheel, portable and very suitable for small farms in any geography as well. A machine embedded with 1 bucket with capacity of 10 litres, can milk 1-10 cows/hour and have a liner life of 3000 milking life. It uses the electric motor of 0.5 HP (1440 RPM) with milking claw of 240 CC and pulsation ratio of 60:40 (60PPM 2+2 Type).

Technical viability analysis	**Type of energy required in modern technology:** Solar PV/ grid electricity **Availability of energy required:** Can be designed as per requirement **Size and volume:** Portable in size and moderate in volume. **Enhancement of productivity:** Saves time and efforts and ease in transportation as well. **Ease of operation:** Moderate **Skilled human resource:** Training required **Safety:** Yes, decreases the direct contact with animal, hence enhances safety **Market availability and transportation:** Available in Nepalese, Indian and Chinese markets and may require transportation.

Financial feasibility analysis	**Capacity of the system:** 100 litres per day (assuming the maximum capacity- 10 litres per cattle in a cattle farm comprising 10 cattle). **Energy consumption:** 0.4 kWh per day **Operating Life:** 10 years **Investment streams:** Total installation cost of the system is of NPR 100,000. Annual operating cost of the system is NPR 72,000 which includes cost of electricity supply and human resource. The annual maintenance cost of the plant is NPR 10,000, which includes liner replacement every year. **Income streams:** The system will enhance efficiency of milking by 1 litre per cattle. This efficiency will produce 10 litres of milk per day from a dairy farm (comprising 10 cattle). The anticipated income from the dairy farm will be of NPR 126,000. **Assumptions:** • The annual operational days are of 300. • The plant will be manned by 1 operator, incurring an expenditure of NPR 60,000 per year. • The unprocessed milk selling rate at the farm level is NPR 42 per liter (Ref: field consultation). • The electricity charges are NPR 10 per unit.
Profitability	IRR: 32% NPV: 305,000 Breakeven Point: 4 years
Recommendation	The machine is suitable for medium scale farm with minimum 10 cattle.
Limitations	• Initial training for operators is necessary. • Periodical calibration of machine is important.

3.3.5 Refrigeration for Sexing Technology and Vaccines

The storage of vaccines is very vital in Dairy value chain to retain their effectiveness. Most vaccines should be stored at 35 to 45° Fahrenheit. Also in Dairy value chain artificial insemination has become an efficient and cost-effective strategy to improve the genetics and reproductive performance of herd. An excellent method of storage of the vaccines and semen are through good freezers with uninterrupted power supply. A cattle farm/entrepreneur can easily store the vaccines and medicines of cattle in a normal refrigerator/ freezer, which operates using electricity from solar

PV, Micro Hydro project and/or National Grid.

If a cattle farm/entrepreneur has purchased a 100 litre refrigerator for storing vaccines and medicines then the farm/entrepreneur has to install a solar PV system of 600 Wp to fulfill the electricity demand.

Technical viability analysis	**Type of energy required in modern technology:** Electric power from grid/solar PV **Availability and reliability of energy technology:** Hybrid systems are recommended for increasing reliability. **Enhancement of productivity:** Yes, safe and effective method of storage. **Ease of operation:** Easy to operate **Skilled human resource:** Not required for storage but trained human resource is required for insemination process. **Safety:** Requires appropriate safety measures **Market availability and transportation:** Easily available in Nepalese market
Financial feasibility analysis	**Capacity of the system:** 10 litres **Energy consumption:** Solar PV system of 0.3 kWp. **Operating Life:** 15 Years **Investment streams:** Total installation cost of the solar PV system is of NPR 80,000, Cost of the cooling machine (Deep fridge -NPR 15,000) Annual operating cost of the system is NPR 36,000 which includes cost of manpower.

Financial feasibility analysis	The annual maintenance cost for machine and solar PV system is NPR 5,000. **Income streams:** The income of the system is through selling vaccines and other medicines. **Assumptions**: • The annual operational days are of 300. • Two operators at NPR 500 per day are required for operation. • Current price of one AI is at NPR 2000 per cattle and can store in the solar powered fridge of 10 litre should store at least 50 straws of AI semen for system to be in breakeven.
Profitability	IRR: 29% NPV: 158,000 Breakeven Point: 3 years
Recommendation	The technology is recommended at the rural context
Limitations	• The initial cost of solar PV is very high in the current context of Nepal. • Maintaining -100 degree Celsius for Semen might be a technical issue

3.3.6 Feed Processing Units

Generally, the feed industry is operating the plant using grid electricity with diesel generator as back-up. Instead of using diesel generator, the feed industry can make use of solar PV system as a back-up for the grid electricity.

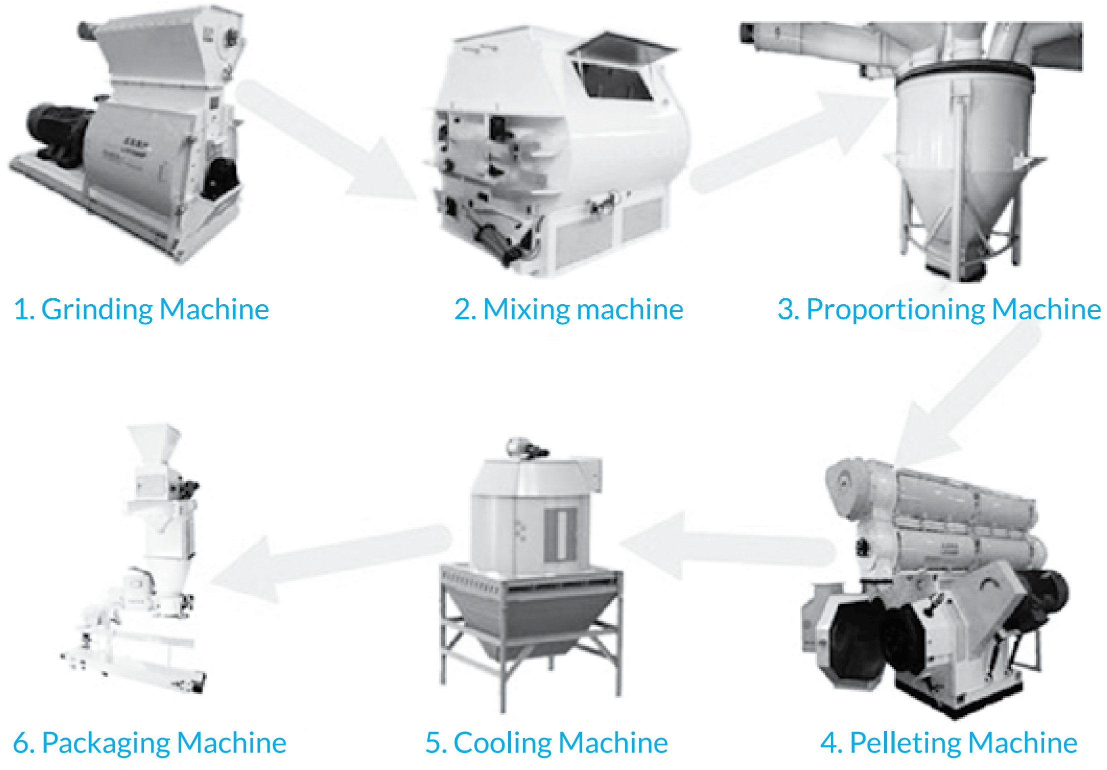
The process of feed making is:

- Grinding of cattle's feed ingredients such as Maize, Mustard Cake, Barn, Molasses, Straw, Urea etc.
- Elevation of the Grinding materials of Cattle's feed ingredients.
- Mixing of cattle's feed ingredients.
- Packaging of final product.

In order to deliver 10 tonnes cattle feed per day, the following units with specified capacity are needed:

- 22.4 kW Motor with Grinding unit
- 4.47 kW Motor with Elevator unit
- 14.92 kW Motor with Mixing unit
- 0.746 kW Motor with Packaging unit

If the plant operates of 8 hours in a day, the total electrical demand of the plant will be 45 kW, where 35 kW will be supplied through Grid electricity and rest 10 kW from Solar PV system (30kWp). The solar system will supplement the operation during the low voltage and power cuts.



Process flow for high capacity animal feed making machine

Technical viability analysis	**Type of energy required in modern technology:** Electricity from grid/solar PV **Availability and reliability of energy technology**: Hybrid systems are recommended for increasing reliability. **Enhancement of productivity:** Increases the productivity, multi-purpose with packaging. **Ease of operation:** Moderate **Skilled human resource:** Training is required **Safety:** Requires appropriate safety measures **Market availability and transportation:** Diesel operated system in existence in Nepali market which can be replaced with electric power, hence available but transportation due to its large size might be difficult.

Financial feasibility analysis	**Capacity of the plant:** 10 tonnes/day **Energy consumption:** The total energy requirement is 45 kW; out of which, grid electricity will contribute 35 kW and 10 kW will be supplied by solar system. Operating Life: 20 Years **Investment streams:** Total installation cost of the system is of NPR 22 Million (civil cost is NPR 7 million for the plant). The estimated investment for procuring machineries for feed processing is of NPR 6 million. The investment required for the solar system is NPR 9 Million (for 10 kW capacity a 30 kWp solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 1 million which includes cost of electricity supply and human resource. The annual maintenance cost of the plant is NPR 120,000, which includes solar plant and machine maintenance. **Income streams:** The plant will generate income primarily from animal feeds. The current (average) market price of animal feed (may vary according to type of feeds) NPR 32 per kg. The total gross income from animal feed is NPR 12.8 Million. **Assumptions:** • The annual operational days are of 240. • The plant will be manned by 10 human resource (2 operators and 8 labors), incurring an expenditure of NPR 480,000 per year. • The electricity charges are NPR 10 per unit. • The solar PV is considered as a back-up of power and not a substitute or alternative to grid.
Profitability	IRR: 36% NPV: 57 Million Breakeven Point: 3 years
Recommendation	This business proposition is for medium and large-scale operations and commercially viable.
Limitations	Initial training for operators is necessary.

3.3.7 Efficient Stoves for Cheese Making

Currently, most of the cheese and churpi production enterprises use traditional cook-stoves for heating milk. This not only hampers their health but also the environment. In order to replace traditional cook-stoves, efficient institutional rocket stoves are proposed.

The institutional rocket stove consists of a cylinder that surrounds the larger pot creating a 16mm gap which is especially effective in transferring heat because the pot is larger. Larger pots have more surface area so greater amounts of heat pass into the food. In fact, using larger pots decreases the amount of fuel used and helps to reduce the emissions made when cooking. When a chimney is attached to the stove, the hot gases are forced to flow down another gap on the outside of the inner cylinder. All of the heat has already scraped against the pot before it exits out of the chimney.

These stoves range from 100-300 litres capacity with increased thermal efficiency by 35% than that of traditional cook-stoves.

Technical viability analysis	**Type of energy required in modern technology:** Thermal power using fuelwood **Availability of energy required:** Can be designed as per requirement **Availability and reliability of energy technology:** Supply of fuelwood needs to be maintained **Efficiency of the selected modern technology:** Efficient than traditional cooking methods. **Size and volume:** Small to moderate in size **Ease of operation:** Easy **Skilled human resource:** No such skills required for operation **Safety:** Appropriate safety measures need to be implemented **Market availability and transportation**: Although the exact technology available in Indian market but availability of number of cook stoves companies allow possibility of local production. Easier to transport
Financial feasibility analysis	**Capacity of the system:** The system can process 300 litres of milk per day. **Energy consumption:** The total energy requirement is 150 kg of fuelwood per day (assuming 1 kg of fuelwood is required to heat 2 litres of milk for cheese making) **Operating Life:** 5 years **Investment streams:** Total installation cost of the system is of NPR 100,000. The annual maintenance cost of the plant is NPR 5000.

Financial feasibility analysis	**Income streams:** The system is 35% more efficient than traditional cook stoves resulting into savings of 10,500 kg of fuelwood per year resulting to savings of NPR 53,000 in a year. **Assumptions:** • The annual operational days are of 200. • The cost of fuelwood is NPR 5 per Kg • 1 kg of fuelwood can heat around 2 litres of milk to produce cheese (as per field consultation)
Profitability	IRR: 10% NPV: 33,000 Breakeven Point: 3 years
Recommendation	The intervention is not commercially viable without additional supports from government subsidy or donor supports. However, the improved stove will enhance efficiency of plant and dairy farmers can consider this technological option.
Limitations	Micro-scale technology and life time of stoves are less than 3 years.

3.3.8 Cold Storage

The Dairy products need a temperature controlled storage facility before they are dispatched to the market. The Dairy products need to be stored in a cold place to any damage from production to supply to a Dairy industry.

A 1000 m^3 cold storage facility requires around 65 kW of electricity to operate. Solar PV system of that scale will be highly expensive, hence, a grid connected cold storage system is proposed by the study.

Technical viability analysis	**Type of energy required in modern technology:** Electricity from grid **Availability and reliability of energy technology:** Mostly reliable but may implement a back-up facility for reliability **Size and volume:** Varies from small to large size **Enhancement of productivity:** Effective measures for bulk storage **Ease of operation:** Easy **Skilled human resource:** Training required for maintenance (not required for operation) **Safety:** Requires safety measures **Market availability and transportation:** Readily available in Nepalese market

Financial feasibility analysis	**Capacity of the plant:** 1000 Cubic Meter, storing around 120 tons in two cycles of 6 months each. **Energy consumption:** The total energy requirement is 60 kW; out of which, grid electricity will contribute 50 kW and 10 kW will be supplied by solar system. Operating Life: 25 years **Investment streams:** Total installation cost of the system is of NPR 3.75 Million (excluding the civil cost). The investment required for the solar system is NPR 9 Million (for 10 kW capacity, a 30 kWp solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 4 million which includes cost of electricity supply and human resource. The annual maintenance cost of the plant is NPR 20,000, which includes solar plant and machine maintenance. **Income streams:** The plant will generate income (i) the rental charge: NPR 100,000 atNPR 500 per quintal, (ii) Opportunity cost of storing: Current (average) market price of animal feed (may vary according to type of feeds) NPR 32 per kg. The total gross income from animal feed is NPR 12.8 Million. **Assumptions:** • The annual operational days are of 240. • The plant will be manned by 10 human resource (2 operators and 8 labours), incurring an expenditure of NPR 480,000 per year. • The electricity charges are NPR 10 per unit. • The solar PV is considered as a back-up of power and not a substitute or alternative to grid.
Profitability	IRR: 28% NPV: 31 Million Breakeven Point: 4 years
Recommendation	This business proposition is for large-scale operations and commercially viable.
Limitations	• Initial training for operators is necessary. • This is a capital investment venture.

3.3.9 Electric Heater

For pasteurization, milk should be heated to 63°C for 30 minutes. However, there are different temperature ranges for heating milk in order to produce different outputs such as cheese, lollypop, dog chew (churpi) or other dairy products.

A toilet connected biogas plant of 10 m^3 (also using cattle dung) can produce thermal power to heat 250 litres of milk (to make dog chew, cheese, lollypop and other dairy products etc.). Similarly, 10 kWh of electrical energy is required to heat same amount of milk using electricity from Micro Hydro Project or the national grid electricity. The heating tank should be made of stainless steel having gross volume of 250 litres with heater of 4 kW.

Technical viability analysis	**Type of energy required in modern technology:** Electricity from Grid/solar or thermal energy from biogas **Availability and reliability of energy technology:** If using thermal energy, then feed supply needs to be maintained; back-up or hybrid system with solar PV may be used for increasing reliability of electrical energy **Efficiency of the selected modern technology:** Efficient and less carbon production than using fuelwood **Size and volume:** Portable to large size **Enhancement of productivity:** Increment in production than traditional heating methods, reduces the time **Ease of operation:** Moderate **Skilled human resource:** Needs to be trained for operation and maintenance **Safety:** Requires appropriate safety measures **Market availability and transportation:** Available in Nepalese market
Financial feasibility analysis	**Capacity of the system:** The system can process 500 litres of milk per day. **Energy consumption:** The total energy requirement is 4 kW. **Operating Life:** 5 years **Investment streams:** Total installation cost of the system is of NPR 135,000. Annual operating cost of the system is NPR 32,000 which includes cost of electricity supply and human resource. The annual maintenance cost of the plant is NPR 7000. **Income streams:** The system will replace consumption of 50,000 kg of fuelwood per year resulting to a net income of NPR 200,000 per year.

Financial feasibility analysis	**Assumptions:** • The annual operational days are of 200. • The cost of fuelwood is NPR 5 per kg • 1 kg of fuelwood can heat around 2 litres of milk to produce cheese (as per field consultation) • The electricity per unit tariff is NPR 10.
Profitability	IRR: 77% NPV: 390,000 Breakeven Point: 2 years
Recommendation	The intervention is not commercially viable without additional supports from government subsidy or donor supports. However, the improved stove will enhance efficiency of plant and dairy farmers can consider this technological option.
Limitations	Micro-scale technology and life time of stoves are less than 3 years

3.4 Integration of Modern Energy Powered Technologies in Orthodox Tea

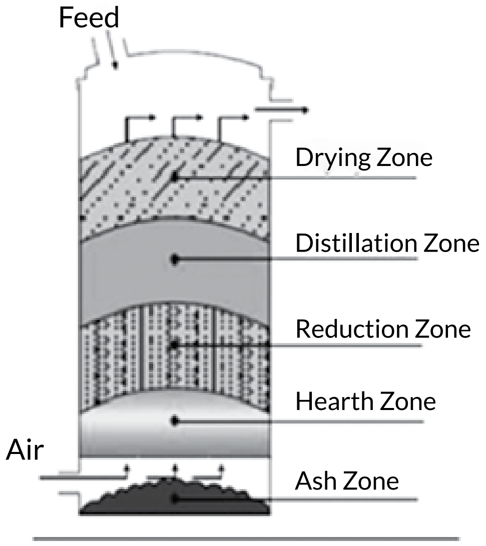
Nepal's Orthodox Tea has huge potential in the niche international markets as the demand for high end organic tea products are increasing rapidly around the global market. Nepal tea has comparative advantage as the bushes are younger than the famous Darjeeling tea. In Nepal, Orthodox Tea is produced and processed in the mountainous regions at an altitude ranging from 3,000–7,000 feet above the sea level. Ilam district alone produced approximately 75% to 80% of the total Orthodox Tea. Remaining is produced in Tehrathum, Panchthar, Dhankuta, etc. Nepal exports approximately 2,200 MT of Orthodox Tea annually (which is approximately 90 to 95% of total production), out of which approximately 85% assumed to be exported to India remaining to Germany, Japan, Russia and few other countries. Sales revenue from the Orthodox Tea is approximately USD 5.9 million.

3.4.1 Biomass Gasifier for Thermal Power in Orthodox Tea Processing

Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. The gas is a low-heating value fuel, with a calorific value between 1000-1200 kcal/Nm^3 (kilo calorie per normal cubic metre). Almost 2.5-3.0 Nm^3 of gas can be obtained through gasification of about 1 kg of air-dried biomass.

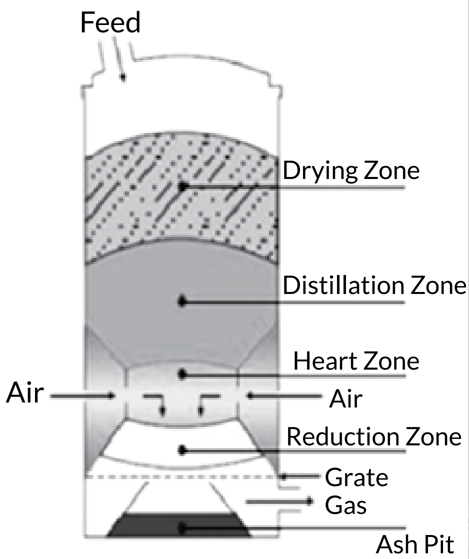
This technology is slowly replacing both traditional biomass use and gas-powered systems, as it provides an excellent de-centralized source of energy at an affordable cost. Apart from rural households, biomass fuels are the main source of energy to a large number of small, rural and cottage industries. The technology can be used in heat generation as well as electricity production which can be used for drying Orthodox Tea as well as use the electrical power to run the motor various Dairy appliances.

1. Updraft or counter-current gasifier



Updraft gasifiers are less sensitive to fuel size and moisture content as compared to a downdraft gasifier.

2. Downdraft or co-current gasifier



Downdraft gasifiers give relatively cleaner gas (low tar content) and are preferred for engine applications, niche applications demanding clean gas.

Schematic diagram

Technical viability analysis	**Type of energy required in modern technology:** Thermal energy using Biomass and/or farm waste **Availability of energy required:** System can be designed for required energy output **Availability and reliability of energy technology:** Supply of biomass or feed needs to be maintained **Efficiency of the selected modern technology:** Highly efficient use of biomass **Size and volume:** As per required (can be designed for small or medium-scale) **Ease of operation:** Moderate **Skilled human resource:** Operator needs to be trained **Safety:** Standard safety procedures need to be maintained **Market availability and transportation:** Can be manufactured in Nepal or in India; small sizes are easier to transport

Financial feasibility analysis	**Capacity of the system:** 3000 kg per day **Operating Life:** 20 years **Investment streams:** Total installation cost of the plant is of NPR 3.5 Million, which covers cost of civil works, generator, equipment etc. Operating cost of the plant is NPR 180,000, which includes cost of human resource. The annual maintenance cost of the plant is NPR 90,000. **Income streams:** The income of the system will be savings made from replacing diesel to fuelwood. A similar system will require 250 litres of diesel which will be replaced by system utilizing 3,000 kg fuelwood.
Financial feasibility analysis	The anticipated annual income from energy saving is of NPR 1.35 Million. **Assumptions:** • The annual operational days are of 300. • The 100 ml diesel is utilized to produce 1 kg of tea. • Around 1.5 kg of fuelwood to produce 1kg of tea.
Profitability	IRR: 22% NPV: 3.5 Million Breakeven Point: 5 years
Recommendation	The intervention is not commercially viable without additional supports from government subsidy or donor supports. The technology is recommended to the tea farmers at medium and large scale.
Limitations	The initial investment cost is high.

3.4.2 Hybrid Tea Withering

Normally withering is carried out by spreading the leaves thinly on banks of trays or "tats" made of tightly stretched jute hessian or wire-netting. The tats are kept 12 to 15 centimeters apart, to allow free access of air. There are two types of withering; open withering and closed withering. The open or "chung" type of withering accommodation admits of no control of rate of withering except by thickness of spread and the length of time of the withering phase. This is "natural withering" in its simplest form. The average time span for withering is 18 to 20 hours where "tats" are used. In modern trough withering system 16-18 hours is the duration of wither with normal ambient air. In rainy season, to remove the surface moisture, heaters are used along with fans for two hours.

Sample Technical parameters:

Capacity	Power	Weight	Size
60 kg/h	13 kW	1500 kg	5000x1250x800 mm

The required electric power can be supplied through electricity from grid/micro-hydro or by suitable solar PV system.

Technical viability analysis	**Type of energy required in modern technology:** Electric power from Grid/solar PV **Availability of energy required:** Required energy can be supplied from grid **Availability and reliability of energy technology:** Solar PV with battery backup hybrid with grid electricity makes the system reliable **Size and volume:** Small to moderate in size **Quantity of energy usage for current volume:** Moderate **Ease of operation:** Easy to operate **Skilled human resource:** Training is required **Safety:** Will require appropriate safety measures **Market availability and transportation:** Available in Indian and Chinese markets, will need transportation **Capacity of the system:** 60 kg per hour. **Energy consumption:** The total energy requirement is 13 kW supplied by Solar PV system of 40 kWp. **Operating Life:** 20 years **Investment streams:** Total installation cost of the system is of NPR 13.5 Million, 1.5 million for the machine and the investment required for solar PV system is NPR 12 Million (for 13 kW capacity, a 40 kWp solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 200,000 which includes cost of human resource. The annual maintenance cost for machine and solar PV system is NPR 75,000.

Financial feasibility analysis	**Income streams:** The income of the system is through contribution in production of Orthodox Tea. The system will contribute to produce 72 tonnes of Orthodox Tea per year at 200 days operation with 6 hours of withering, the incremental income being NPR 80 per kg resulting to a net income of NPR 785,000 per year. **Assumptions:** • The annual operational days are of 200. • Two operators at NPR 500 per day are required for operation. • Current selling price of orthodox tea is around NPR 640 per kg, a general orthodox tea processing includes 8 steps (Tea leaf acquisition, steaming, withering, rolling, drying, storage, packaging and marketing/transportation). We have assumed each step to have equal contribution in the final product. Hence, NPR 80 per kg is incremental rate for each process.
Profitability	IRR: 30% NPV: 1.8 million Breakeven Point: 4 years
Recommendation	The intervention is not commercially viable without additional supports from government subsidy or donor supports as the initial cost of solar PV installation is high.
Limitations	The initial cost of solar PV is very high in the current context of Nepal.

4. Recommendations

While the final technology recommendations are distributed across various stages of the value chain, the team throughout its overall process identified that proper use of clean/efficient and modern energy powered technologies offer various benefits such as improved health, time saving, reduced drudgery, water savings, improved soil quality and nutrient values, biodiversity protection, food security, and better livelihoods and quality of life. There is hence a higher incentive to use energy wisely (by improving efficiencies) as well as by developing local renewable energy resources for use by small and medium enterprises processing the food.

PRODUCTION	POST-HARVEST AND STORAGE	PROCESSING	COMMERCIALIZATIONS
• Solar, wind-powered water pumping	• Solar, geothermal food drying for storage	• Solar, wind, hydro milling, pressing, cooking, drying, etc.	• Biofuel for transportation and distribution
• Biofuel-powered machinery	• Solar cooling and refrigeration	• Renewable electricity and heating application	• Solar cooling and refrigeration (retail)
• Solar Desalination, heating cooling	• Minimized/efficient packaging	• Modern biomass for cooking	• Truck design and operation
• Efficient machinery/ maintenance	• Food loss reductions	• Efficient processing for cooking	• Improved efficient Infrastructure
• Low-pressure, efficient irrigation	• Efficient drying	• Smart Integration into existing fossil fuel-based power systems	• Efficient market Information through modern ICTs
• Biomass residue energy generation	• Improved Insulation for cool storage		• Capacity building for farmers, traders, etc. to improve understanding of value.

The study team identifies that there are various other operational level issues when technologies are actually adopted. Introduction or adoption of one stand alone technology rarely rips out the desired benefits and hence calls for an intervention from systemic perspective.

The below are the key recommendations which we argue will aid in overall modernisation of the value chains.

Policy level recommendations	Minimum procurement prices: There is a need of strengthening the existing agriculture policies for fixing minimum procurement price of crops. In case of ginger and cardamom, farmers are not getting the best market prices owing to the business interests of traders. Government shall design appropriate pricing mechanism and shall protect the interest of farmers. Support for adoption of modern energy powered technology: The relevant ministries and departments of agriculture can accelerate the process of adoption of modern energy powered technologies by offering financial incentives to the farmers. These financial incentives could be in the form of one time subsidy for procuring technologies or providing a small grant (10 to 20% of the total cost of tech) for adopting technologies with own funding.

Policy level recommendations	Promoting cluster-based farming: Farmers are still practicing subsistence nature of agriculture which is mainly due to the small holding farming. The Government can promote cluster-based farming by providing high yielding varieties of crops/cattle to farmers. The cluster -based farming will reduce the financial risk of small holding farmers and increase farm income. Promoting advanced crop husbandry practices: The government needs to improve the agriculture extension system of Nepal and ensure that timely supply of agriculture inputs such as fertilizers, pesticides, efficient irrigation etc. are supplied to farmers to enhance crop productivity. One must understand that enhance crop productivity and production can only make agriculture value chain commercially viable, provided such agriculture is linked to the market.
Technology-linked recommendations	**Vocational and skills development training on modern energy powered technology:** Farmers also need to be trained in modern energy powered technologies in their crop value chain. Farmers should be educated with the economics of adoption of modern energy powered technologies and the economic loss which they have been making by practicing only conventional cultivation and post-harvest technologies. This type of training will also produce a locally available pool of human resources, who can work as technicians after installation of modern energy powered technologies. **Agriculture-technology innovation:** There is also a need of an agriculture -technology innovation centre in Nepal. This centre will be a platform that will seek to identify specific agri-technological issues and bring innovators together to develop solutions for agri-related challenges, starting from reducing post harvest loss to increasing crop productivity by applying modern energy powered technologies. The Centre can also aim to promote entrepreneurship in the agri-sector, leading to innovation, economic development and job creation.
Financing modern energy powered technologies	**Agriculture loan:** Nepal Rastra Bank can encourage financial institutions to design customised loan products for promoting modern energy powered technologies in agriculture sector. The loan products can offer lower rate of interest under the agriculture sector lending.

In addition to the above mentioned matrix of recommendation, the below recommendations from the systemic change of the sector would be also important to consider.

4.1 Intervention at Policy Level for Systemic Change/Sectoral Development

4.1.1 Warehouse Concept

There are few private cold storage facilities in eastern Nepal-for instance Royal Cold Storage in Birtamod. These warehouses are operating under capacity (60% of business break-even[1]) as supply of electricity (power) is not reliable as well as not suitable to meet the increasing demands of farmers.

By considering the increasing demands of farmers for cold storage for storing their high value crops harvest such as ginger, cardamom, potato etc., there is a business case for promoting cold storage in Eastern Nepal. This process of cold-chain logistics activities that is primarily used to service the market connectivity of perishable produce from harvest to consumers, will be benefiting the farmers of most of the Eastern Province of Nepal. Based on a thorough demand assessment, there is also scope of introducing packaging as part of the cold-chain system.

A cold-chain system relies primarily on a supply based approach, using both cooling and packaging techniques, cold-chain counters immediate perishability and makes it feasible to deliver perishable produce to where it could not otherwise have reached. This business model thereby empowers farmers by expanding access to multiple and distant markets.

4.1.2 Sexing technology and AI promotion

Artificial Insemination is a pretty common technology in the target districts. However, the farmers reported low success rate (25-30%). Of this low success rate, the chances of having a she-calf is theoretically 50% thus reducing the total chance of having a she-calf from AI to 12.5-15%. In this context, a bigger systemic intervention is envisioned with introduction of sexing technology which argues for 80% success rate in she-calf birth. Some vet providers in the district also informed that some 500 semen tubes were provided through District Livestock Service Office (DLSO) and was consumed very swiftly but further initiatives and follow-ups have not taken place. While none were able to comment on the success rate, the service providers expressed that the demand for sex semen is high. The service providers like agro veterinary trading centre (Birtamod), Barbote Livestock Medicine Centre (Ilam) expressed that they initiated to procure sex semen on their own which could not materialize as it demanded huge investment cost to safeguard semen from damage. Nepal Livestock Breeding Centre (NLBC) is the only producer/ importer/ multiplier of livestock semen in Nepal till date. However, liquid nitrogen is produced by various private organizations.

The supply of quality sex semen is the proposed recommendation. Practical Action

1 Shyam Kumar Ray, loading master, royal cold storage

in its earlier initiative has worked with NLBC who have expressed their interest and ability to invest should they have a business contract with regular procurers of semen provided the consolidated demand is of sizeable quantity. On the other hand, there is also a possibility of sex semen importing and trading. For instance, a social private enterprise Nepal Agribusiness Innovation Centre with an objective to promote agribusiness sector has expressed its interest to be engaged with a viable cost recovery business model. The recommendation from the project team is thus to coordinate with these stakeholders mentioned as sexing technology is high in demand in Nepal.

4.2 Intervention for Immediate Piloting and Possible Upscaling

4.2.1 Self-sufficient Dairy Farm and Processing Plant

Due to unreliable energy, enterprises in the target districts run on diesel power or firewood. This increases the cost of doing business and reduces competitiveness of business in addition to higher environmental cost. During the field visit, the team observed and consulted with many dairy farms who were facing challenges in terms of ensured power supply as well livestock waste management. This recommendation is targeted towards dairy farms of 15-20 cattle size having a dairy processing plant or with an intention to do so. The proposed recommendation is to have an effective biogas system wherein the system generates energy required for general operation of the farm. The energy requirement during low consumption time can be used for general household consumption too. On the other hand, the bio slurry can be used as a fertilizer for production of forage for the livestock.

The technology

Bio gas is not a new technology neither the biogas electrification. What is really new is the powering of the dairy industry with the Biogas with tunnel feeder. Experiences from similar initiative by Practical Action establish that the system would require slight departure from the conventional design of the biogas. It constitutes 2 units of 25 m^3 tunnel model Plug flow digester. The departure from dome type digester to the tunnel type is to allow increasing the capacity of the digester without changing the cross section of the digesters. The size of the digester can be increased by increasing its longitudinal length by adding extras section. This type of digester makes the biogas feasible at high water table locations as in the case of target districts.

Description of tunnel type biogas technology:

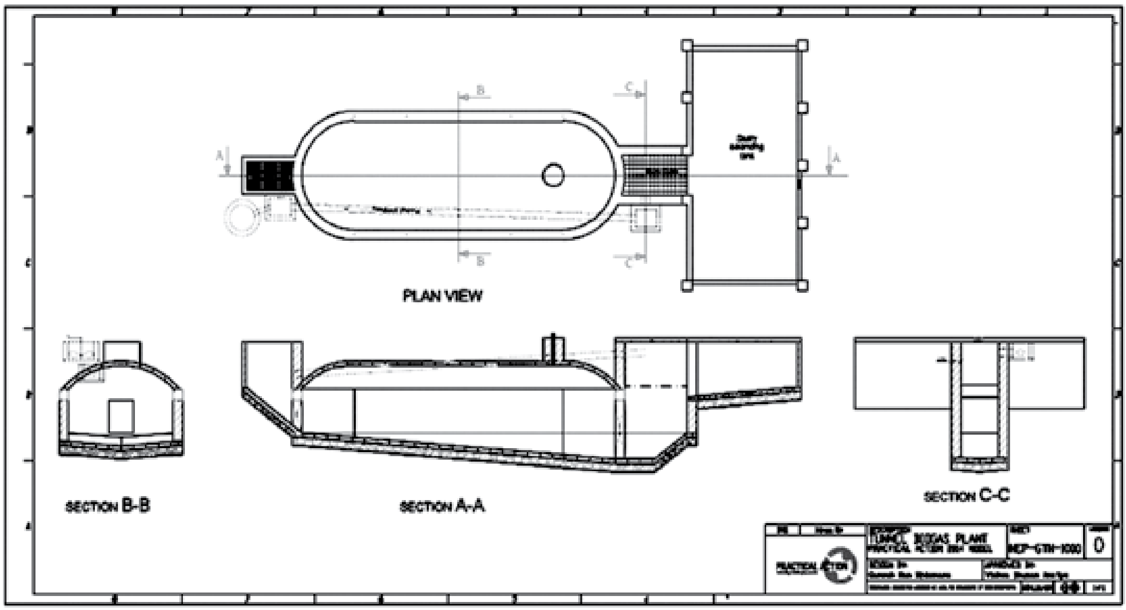


Figure: Tunnel Biogas Plant of 25 m^3 capacity

Tunnel type biogas plant works on the proven principle of a plug-flow mechanism. The plug-flow digester is a long rectangular chamber, semi-circular shape at its ends, with a curve-shaped air-tight reinforced concrete cement cover. Cattle manure is fed into the digester through inlet flows to outlet and then reservoir (system balancing tank) linked to digester. The digested (effluent) is discharged to slurry pit through the overflow end of the system. The biogas is stored in curved surface of tunnel plant using displacement principle which means there is movement of slurry between the balancing tank and the digester. A certain portion of effluent feeds back to the inlet for rapid digestion of the cattle manure. When the slurry level goes down i.e., less feeding material, the slurry automatically comes to digester to make the system balance. It is to be noted here that inlet level and outlet openings are in same level to function the principle of plug flow.

Tunnel Model Biogas Plant Characteristics:

- Fixed Dome (Practical Action 2014 model)
- Size 25 cubic meters
- Feeding material: Cattle dung, urine and water
- Feasible even in high water table locations
- Practical Action 2014 Tunnel model Biogas plant could be built in sizes of 30, 35 and 40 cubic meters with only increment of length

Technical specifications of the proposed biogas

Parameters	Specification
Plant size, m^3	25 m^3
Initial Dung feed, Kg	12,000
Daily Dung feed, Kg (at9-10 Kg dung/ m^3 plant size)	225 – 250
No. of Cattle required (at15 Kg dung/ cattle)	15 – 17
Daily Water feed including urine, litres	225 – 250
Daily gas produced, m^3 (at0.04 m^3/ Kg dung)	9 – 10
Daily generator running with 3 Kw load, hrs (at0.6 m^3/ Kwh) Or Daily stove burning for pasteurization of milk, hrs (at1.5 m^3/ hr)	5- 5.5 Or 6 - 6.5
Fertilizer output kg/day	250

With above specifications and designs, the 2 units of 25 cubic meter biogas plant produces 33 kWh of electricity per day from 20 m^3 of daily gas production. The electricity can be used for running chaff cutter, water pumping, and exhaust fan operation, lightening, heating purposes for products like churpi. The excess gas can be used for the pasteurization of the milk.

The plant can also produce significant amount of digested effluent per day which is an excellent fertiliser. It can be dried to make compost fertilizer. Likewise, it can be used for window composting in which the slurry is mixed with carbon feedstock.

Cost-Benefit

A simple calculation as shown below shows that the payback period of the technology is less than 3 years.

- *Investment (Cash outflow)*
  - o Costs of 2 units of 25 m^3 AD plant: NPR 800,000
  - o Costs of Biogas generator with gas purification unit: NPR 500,000
  - o Total initial investment: NPR 1,300,000
  - o Repair and maintenance cost: NPR 10,000/year
- *Revenue (Cash inflow)*
  - o Electricity: 33 kWh*NPR 30/unit*365 days = NPR 361,350 per annum (the per unit cost comparing to electricity from diesel engine)
  - o Fertilizer: 250 kg*NPR 1/kg*365 days = NPR 91,250/year by selling fertilizer

The proposed recommendation offers a cost-effective solution to one of the most pressing problem the dairy sector is currently facing. The increasing size of the dairy herds in the commercial firms has made it possible to generate electricity from the biogas.

4.2.2 Agribusiness Capacity Building Through Business Service Development

UNNATI has made significant investments to agribusinesses for their growth through challenge funds. However, there are other prevailing issues and challenges among finance, which are hindering the growth of agribusinesses in Nepal. Lack of knowledge and skills on business management and operations; market (branding, packaging, pricing) and market linkages (distribution networks); technologies and technical services; financial management and record keeping; and limited networks are key bottlenecks faced by agribusinesses. There are adequate learnings from past and current programmes that providing finance (grants/subsidies) supports are not only the solutions for promoting agribusinesses. After completion of the programmes many such agribusinesses were closed down due to aforementioned issues.

Despite of realization of gaps, many agribusinesses especially SMEs are unable to address themselves by recruiting fulltime competent staffs due to the size of their businesses and low/slow return in agriculture sector. In many cases, agribusinesses do not have any one to share their issues and get right counselling. Many of them are even unaware that they could get solutions for their issues from the market. Hence, linking and providing business services through specialized business service providers would be crucial for growth of agribusinesses. There are few such specialized service providers in the market, who are competent and providing services to agribusinesses. The idea of providing services through specialized service providers will not only ensure the proper utilization of provided grants but also ensure the sustainability of the agribusinesses. They could be a good exist strategy for the programme to ensure sustainability and growth after programme ends.

Of the 159 grant recipients, UNNATI could select around 40-50 SMEs who have business development plant related with better organisational efficiency, backward and forward linkages etc. These recipients could be served by business development services at a very nominal (at cost) rate. With admission into these business development services, we can expect 10-20% increase in business revenue of the SMEs along with increased job opportunities for about 100 individuals directly and above 1000 indirectly.

The work plan for the selected 40-50 SMEs would be as below

SN	Activity	Feb	Mar	Apr	May	June
1	Client admission into agribusiness BDS centre	X				
2	Business growth assessment by business development experts and presentation of draft growth plan to SMEs	X				

3	Endorsement of the plan by SMEs	X				
4	Identification and roadmap development of 3 key intervention in the SME that would substantially improve overall business efficiency		X			
5	Undertaking research and proofing of the proposed interventions		X	X		
6	Implementation at pilot scale				X	
7	Measurement of results					X
8	Develop a long-term plan					X
9	Knowledge capture and reporting					X

4.3 Intervention to Increase Demand/Supply Side of Recommended Technologies

4.3.1 Training and Capacity Development Events

It was realised that capacity building and orientation events is in dire need especially for the vendors and SMEs to understand the overall market constraints. At the present, the actors are moreover working in silos and concentrating on their own bit only. For instance, the ginger producers have no idea about the added benefit of washed and sorted ginger etc. This finding was further reinforced during the consultation workshop where participants claimed that a "participatory" of this nature was the first of its king being attended. With training manuals in place, UNNATI is now well placed to conduct events and orient to capacitate actors in the modern technologies being proposed or also new technologies that could be explored. In this context, it is recommended that at least 16 such events be organised targeting the 159 grantees (10 per event) who would prove to be early adopters of technologies. The details on locations of the workshop might vary but this would ensure that these 10 GRs get in contact with at least 5 other vendors who could provide the technologies and after sales services and the BFIs where they could approach for financial support. A proper planning of the event can only be done once details of all the vendors, GRs, BFIs are maintained in a database and analysed. This event can be completed within a span of 3 months and is of urgent necessity.

5. Annex

5.1 Annex I: Technology selection

Selection Criterion (weightage and scoring on 1-5 marking scale)																						
	Criteria			Accessibility		Affordability		Utility/ functionality appropriateness		Ease of operation		Utilization ratio and benefit return		Maintenance and services		Potential of adoption		Financing mechanism (bankable)		Demand of the output		Total Score
	Weightage			2		3		4		3		5		3		2		4		5		
				S	WS	S	WS	S	WS	S	WS	S	WS	S	WS	S	WS	S	WS	S	WS	
Orthodox Tea	1	Mechanical Tea Pruner	Farmer	1	2	3	9	2	8	3	9	3	15	2	6	3	6	2	8	5	25	112
	2	Mechanical Tea Plucker	Farmer	1	2	3	9	2	8	2	6	3	15	3	9	3	6	2	8	5	25	112
	3	Biomass gasifier for heating	Entrepreneur	4	8	4	12	5	20	4	12	4	20	5	15	5	10	4	16	5	25	178
	4	Hybrid Withered with Axial Flow Fan	Entrepreneur	1	2	3	9	2	8	2	6	3	15	3	9	3	6	4	16	5	25	122
	5	Electric Roller	Entrepreneur	2	4	2	6	2	8	3	9	3	15	4	12	2	4	3	12	5	25	95
	6	Roll breaker and Sifter	Entrepreneur	2	4	4	12	2	8	2	6	3	15	3	9	2	4	3	12	5	25	95
	7	Mechanical sorting machine	Entrepreneur	3	6	4	12	3	12	2	6	2	10	2	6	3	6	5	20	5	25	103
	8	Portable Electric Bag packaging	Entrepreneur	3	6	4	12	2	8	3	9	2	10	3	9	2	4	3	12	5	25	95
Large Cardamom	9	Electric Winnower	Farmer	3	6	4	12	3	12	2	6	2	10	2	6	3	6	1	4	5	25	87
	10	Solar Dryer	Cooperative	3	6	3	9	3	12	5	15	4	20	4	12	3	6	2	8	5	25	113
	11	Biomass gasifier for Drying	Cooperative	5	10	4	12	4	16	5	15	4	20	5	15	5	10	4	16	5	25	139

Dairy	12	Hybrid powered Feed processing	Cooperative	4	8	5	15	4	16	5	15	4	20	4	12	4	8	4	16	4	20	130
	13	Bio gas	Cooperative	4	8	5	15	5	20	4	12	5	25	4	12	4	8	5	20	5	25	145
	14	Automated Milking Machine	Cooperative	5	10	5	15	5	20	5	15	3	15	5	15	5	10	4	16	5	25	141
	15	Household Chilling Vats	Farmer	4	8	5	15	4	16	3	9	3	15	3	9	3	6	3	12	5	25	115
	16	Solar powered refrigeration	Support	3	6	5	15	5	20	3	9	3	15	3	9	3	6	5	20	5	25	125
	17	Hybrid Milk Chillers	Farmer	5	10	5	15	5	20	5	15	3	15	5	15	5	10	4	16	5	25	141
	18	Hybrid pasteurizers	Cooperative	5	10	5	15	5	20	5	15	3	15	5	15	5	10	4	16	5	25	141
	19	FAT and SNF testing Machine	Cooperative	2	4	3	9	2	8	2	6	5	25	3	9	3	6	3	12	5	25	104
	20	Milk Packaging machine	Cooperative	3	6	3	9	2	8	2	6	3	15	3	9	3	6	3	12	5	25	96
	21	Solar powered cream separator	Entrepreneur	4	8	4	12	4	16	5	15	4	20	3	9	3	6	4	16	4	20	122
	22	Ice-cream maker	Entrepreneur	3	6	4	12	4	16	2	6	3	15	3	9	3	6	3	12	2	10	92
	23	Khuwa making machine	Entrepreneur	4	8	4	12	3	12	5	15	4	20	4	12	3	6	4	16	3	15	116
	24	Hybrid cold storage	Entrepreneur	4	8	3	9	4	16	4	12	4	20	5	15	4	8	4	16	4	20	124
	25	Hybrid electric heater	Entrepreneur	4	8	4	12	4	16	5	15	4	20	4	12	3	6	2	8	5	25	122
	26	Institutional rocket stove	Entrepreneur	4	8	5	15	4	16	4	12	2	10	4	12	4	8	4	16	5	25	122
	27	Butter churn	Entrepreneur	2	4	3	9	3	12	5	15	2	10	4	12	4	8	3	12	3	15	97
	28	Automatic Ghee maker	Entrepreneur	3	6	4	12	3	12	4	12	4	20	5	15	5	10	3	12	3	15	114
	29	Yoghurt Incubator	Entrepreneur	2	4	4	12	3	12	3	9	4	20	5	15	3	6	2	8	3	15	101

Ginger	30	Power Harvesters	Cooperative	1	2	3	9	4	16	4	12	3	15	3	9	3	6	3	12	5	25	106
	31	Power weeder	Farmer	2	4	5	15	4	16	4	12	3	15	3	9	3	6	2	8	5	25	110
	32	Temperature controlled storage	Cooperative	3	6	3	9	5	20	4	12	4	20	3	9	4	8	3	12	5	25	121
	33	Automated washer cum peeler	Entrepreneur	3	6	4	12	5	20	4	12	4	20	3	9	3	6	4	16	5	25	126
	34	Solar Powered Dryer	Farmer	4	8	5	15	5	20	3	9	4	20	4	12	4	8	4	16	5	25	133
	35	Peeler, Slicer and grinder	Entrepreneur	3	6	4	12	5	20	4	12	5	25	4	12	3	6	3	12	3	15	120
	36	Juice Expresser	Entrepreneur	3	6	3	9	5	20	4	12	4	20	2	6	3	6	3	12	3	15	106
General	37	Hybrid ware house local level		2	4	2	6	4	16	3	9	2	10	4	12	1	2	5	20	5	25	104
	38	hybrid ware house district level		2	4	2	6	4	16	3	9	2	10	4	12	1	2	5	20	5	25	104

Opportunities of Installing Modern Energy Powered Technologies in the Selected Agriculture Value Chains and Their Financing Opportunities

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1. Background and Scope of the Study

As a part of Practical Action Consulting (PAC)'s study on "Opportunities of installing modern energy powered technologies in the selected agriculture value chains and their financing opportunities" for United Nations Capital Development Fund (UNCDF) to support UNNATI - Access to Finance (UNNATI - A2F) initiative from 7 August 2017 to 31 December 2017. This report consists of indicative financial analysis of 14 proposed modern technologies to be induced into selected value chain. These technologies were analysed along with the perceived income, expected expenditure, installation cost and their financial viability against various financial parameters respectively.

Information on initial investment, detail cash flow, financial parameters as well as direct benefits is presented in the report. In addition, various assumptions on income, expenses, productions and value addition of using these techs are also listed likewise. Based on the analysis recommendation on usage scale either at farmer level or at enterprise level (small, medium and large) are suggested with limitations of using these technologies.

2. Methodology and Limitations

2.1 Methodologies

Some of the technologies have been currently used in the intervening districts as well as other parts of the country; the rest have been in operation in India and China. The team gathered the number of information on:

- Installation cost.
- Capacity of the system.
- Energy consumption.
- Current use of energy, trend, prices, extent etc.
- Current trend of production.
- Manpower cost etc., through field consultation, supplier manuals and data collection from similar projects which are being implemented currently or in past.

Based on this information the calculations were made on:

Cash Inflow

The income from the technologies was calculated on basis of:

- Income due to replacing traditional energy system (fuelwood, diesel).
- Income due to increment in selling rate of the product due to value addition.

Cash Outflow

The expenditure of the technologies was calculated on basis of:

- Cost of energy system required to operate the system (Grid electricity, Solar PV system, fuelwood consumption).

- Manpower cost and maintenance cost.

Analysis

Financial viability analysis was carried against Internal Rate of Return (IRR), Breakeven and Net Present Value (NPV). In majority of cases the current production trend was the basis of operation for the system and their financial benefits but the team also carried a situational analysis on what will be the anticipated income if the technologies are operated in their full capacities.

2.2 Limitations

The analysis for the 14-selected modern energy powered technologies provides only indicative financial feasibility. The analysis is made based on assumptions, which are derived from consultations from filed visits and secondary sources of data/ information on anticipated capacity of technologies, annual operational day, pricing on farm products and revenue estimation etc. However, there is significant scope of improving on the quality of these data.

It is expected that users can customize their analysis based on their contextual data/ inputs by feeding into the generic excel sheets of the financial analysis.

3. Indicative Financial Analysis

3.1 Financial Analysis of Technologies for Large Cardamom Value Chain

3.1.1 Improved Cardamom Dryer

Application in the Value chain	The cardamom dryer will be used for multiple usages such as drying cardamom as well as ginger, mushrooms etc. The dryer utilizes thermal energy using fuelwood, it is efficient and produces less carbon than open fire. The dryer is available in two sizes 1.80 m x 0.7 m x 1.3 m for drying 200 kg and 1m x 0.7 m x 1.3 m for drying 150 kg.
Financial feasibility analysis:	Capacity of the system: 1500 kg per week (current operation is 1000 kg per week due to lack of inputs, the financial analysis is carried based on what capacity will make the system breakeven). Operating Life: 6 Years Although the system can be in operation whole year, currently, it is in operation only for a week in an entire year. **Investment streams:** Total installation cost of the plant is of NPR 35,000. Operating cost of the plant is NPR 2100 which includes cost of manpower. At the end of third year of operation, the base grate should be replaced which cost around NPR 3000. **Income streams:** The income stream includes the saving of the fuelwood than the traditional method of drying. The system saves 2 kg of fuelwood per kg of cardamom in comparison to the conventional method. Thus, 3000 kg of firewood will be saved contributing to the yearly income of NPR 15,000. **Assumptions:** - The annual operational days are one week. - The fuelwood cost is NPR 5 per kg. - The system requires 1 kg of fuelwood to dry 1 kg of cardamom compare to 3 kg of fuelwood for traditional method. (as per consultation with supplier) The detailed financial analysis is attached in the financial worksheet.
Profitability:	Internal Rate of Return (IRR): 11% Net Present Value (NPV): 15,000 Million Breakeven Point: 3 years

Recommendation:	The dryer can be used for drying multiple crop harvest. The capital investment in the dryer will make economic sense if it is used for drying multiple crop harvest rather than for just large cardamom.
Limitations:	- Initial cost is high for small holding farmers.

3.2 Financial Analysis of Technologies for Ginger Value Chain

3.2.1 Solar Powered Ginger Dryer

Application in the Value chain	The modern energy powered technology will be used for ginger drying. This is a mixed mode box-cabinet natural circulation solar dryer. The dryer consists of a primary solar collector (1×0.5 m). A transparent sheet was located over the collector. The fresh air is sucked and heated through the air duct and flows to the drying chamber. A secondary solar collector (0.75 × 0.5 m) oriented north-south was covered with a single layer of 0.15 × 10−6 thick UV stabilized polyethylene film and hinged at the top of the drying chamber. It allows the solar radiations to drying chamber and further enhances the drying rate by greenhouse effect.
Financial feasibility analysis:	Capacity of the system: 250 kg of ginger drying in 3 days cycle. Operating Life: 10 Years Although the system can be in operation for the whole year, it is assumed that the system will be in operation for 4 months (2 months each during 2 crop cycles of Ginger where a crop cycle is generally a month long.) **Investment streams:** Total installation cost of the plant is of NPR 100,000. Operating cost of the plant is NPR 12,000 which includes cost of manpower. The maintenance cost is NPR 5000 per year. **Income streams:** The income stream includes the incremental income of the dried Ginger. Although the supply of dried ginger in not undertaken at commercial scale at the moment, citing to the trend in Indian market and consultation in field, an incremental income of NPR 5 kg per dried Ginger is assumed in the calculation. As the system will generate 10,000 Kg of dried Ginger per year contributing to the yearly income of NPR 50,000.

Financial feasibility analysis:	**Assumptions:** - The system will operate only for 4 months, 2 months each during Ginger crop cycle. (2 crop cycle a year of Ginger) The detailed financial analysis is attached in the financial worksheet.
Profitability:	Internal Rate of Return: 2% Net Present Value: 28,000 Breakeven Point: 5 years
Recommendation:	The plant is suitable in small enterprise and farmer level.
Limitations:	There is possibility of decay and loss of ginger in the event of prolonged rain and less availability of solar radiation.

3.2.2 Automated Ginger Washer

Application in the Value chain	A Ginger washing machine is composed of stainless steel frame, speed motor, drum chamber, pipeline shower, sprinkler and water tank. Semi-automated or fully automated varieties of machines are available in market which utilizes electric power. The machine uses surfing, bubbling and water spraying to wash ginger. During this process, it can completely clean the soil stuck in the gingers as well as use sterilization sprays to wash out the effect of pesticide residues on the surface. The machine can also wash other vegetables in addition to ginger but will require calibration in speed and flow of water.
Financial feasibility analysis:	Capacity of the system: 500 kg per hour. Operating Life: 15 Years Although the system can be in operation for the whole year, it is assumed that the system will be in operation for 2 months only during the 2-crop cycle of Ginger where a crop cycle is generally a month long. Energy consumption: 18 kWh per day (3 kW system operating 6 hours per day) **Investment streams:** Total installation cost of the plant is of NPR 1.5 Million. Operating cost of the plant is NPR 168,000 which includes cost of manpower and electricity. The maintenance cost is NPR 40,000 per year.

Financial feasibility analysis:	**Income streams:** The income stream includes the incremental income of the washed Ginger. The incremental income will be NPR 5 per kg of washed Ginger (field consultation). The system can process 180 tonnes of Ginger per year contributing to the yearly income of NPR 900,000.
Profitability:	Internal Rate of Return: 33% Net Present Value: 25 Million Breakeven Point: 3 years
Recommendation:	As the average production of Ginger in intervening area is around 13 tonnes per hectare per year, to feed the system with 180 tonnes of Ginger requires Ginger from 14-hectare area. Thus, the system is more suitable at medium enterprise level.
Limitations:	- This is only a seasonal operation. - Maintenance of the plant needs to be a regular practice.

3.3 Financial Analysis of Technologies for Diary Value Chain.

3.3.1 Cream Separator

Application in the Value chain	Cream separation machine can be operated using electricity from Solar PV hybrid with energy from Micro Hydro Project or national grid. About 0.4 kW electric powers is required to operate the machine that can separate cream from 500 litres of milk in an hour. The separators are abrasion and rust proof, therefore, can serve for long duration as per needs of entrepreneurs. As the machines are manufactured using high quality materials, they are durable and can also be customized as per the requirements.
Financial feasibility analysis:	Capacity of the plant: 3000 litres of milk processing per day (500 litres per hour with 6 hours of operation) Energy consumption: The total energy 0.4 kW will be supplied by solar system of 1.2 kWp. Operating Life: 10 Years **Investment streams:** Total installation cost of the system is of NPR 415,000, machine cost is NPR 55,000 and NPR 360,000 for 1.2 kWp solar PV system (solar system with batteries is provided with average per kWp of solar system being NPR 300,000).

Financial feasibility analysis:	Annual operating cost of the system is NPR 50,000 which includes cost of manpower (system manned by single operator at NPR 5000 per month). The annual maintenance cost of the plant is NPR 20,000, which includes solar plant and machine maintenance after 3 years of operation. **Income streams:** The plant will generate income primarily from production of cream which is used in ghee/butter production. The current (average) market price of ghee (may vary according to type of feeds) is NPR 750 per kg. We assumed around 5% increment due to enhance in quality of the production by the system i.e. NPR 37 per kg of cream of incremental rate. The total gross income from system is NPR 280,000 (from 7500 kg of cream from 1% fat content 750,000 litres of milk the system is capable of processing). **Assumptions:** 1. The annual operational days are 250. 2. The fat content in the milk is 1%.
Profitability:	Internal Rate of Return: 31% Net Present Value: 500,000 Breakeven Point: 3 years
Recommendation:	The system can be recommended for medium and large-scale operations and commercially viable.
Limitations:	Initial training for operators is necessary.

3.3.2 Bio-gas Plant for Heating and Electric Power Generation

Application in the Value chain	The modern energy powered technology will be used for multiple usages such as powering water pump, cleaning, lighting and chilling.
Financial feasibility analysis:	Capacity of the system: 50 CUM Operating Life: 15 Years The plant will require 250 Kg dung per day, which could produce 10 CUM purified biogas and 3 kW of electricity per day. This plant capacity can be achieved with 10-15 numbers of cattle (Reference: Biogas Plant in Chitwan, implemented by Practical Action, 2016). **Investment streams:** Total installation cost of the plant is of NPR 1.5 Million, which covers cost of civil works, generator, equipment etc.

Financial feasibility analysis:	Operating cost of the plant is NPR 300,000, which includes cost of feedstocks and manpower. The annual maintenance cost of the plant is NPR 10,000. **Income streams:** There are two plausible income streams, viz., (i). Income from energy saving (such as thermal heat generation with conventional methods like firewood) and (ii). Bio-fertilizer production and sales. The anticipated annual income from energy saving is of NPR 750,000 and the income from bio-fertilizer is of NPR 250,000. **Assumptions:** The annual operational days are 240. The anticipated electrical generation is of 3,600 kWh per year (assuming 5 hours of generation per day, amounting to 36,000, at NPR 10/Unit). The energy saving from conventional source of energy (fuel wood) is of NPR 1000 per day, amounting to NPR 24,000 (assuming 200 kg fuelwood per day at NPR 5 per kg of fuelwood). It is assumed that the price of bio fertilizer is NPR 15 per kg and can generate 200 kg per day amounting to 720,000 NPR per year. It is assumed that feedstock required for the plant operation is 1000 kg per year amounting to 120,000 NPR per year at NPR 500 per kg. The plant will be manned by 3 operators, incurring an expenditure of NPR 180,000 per year at NPR 5000 operational cost per month. The detailed analysis is provided in the financial worksheet.
Profitability:	Internal Rate of Return: 28% Net Present Value: 2.5 Million Breakeven Point: 4 years
Recommendation:	The plant is suitable for medium scale operations of below 5 kW, however, there is scope to increase it up to 10-15 kW based on availability of feedstock. The plant can be used for multiple usages in accordance to the demands of the dairy unit.
Limitations:	- Continuous supply of feedstocks shall be ensured. - Maintenance of the plant needs to be a regular practice.

3.3.3 Milk Chilling Vat

Application in the Value chain	The Milk Chilling technology will be applied for cooling of milk before transporting it to the processing unit. The milk Chilling device will be powered either with electricity from grid or mini-grid/off-grid micro hydro plants.
Financial feasibility analysis:	Capacity of the system: 500 litres per day Energy consumption: 72 kWh per day Operating Life: 15 Years **Investment streams:** Total installation cost of the plant is of NPR 450,000, which covers cost of generator, equipment etc. Annual operating cost of the plant is NPR 160,000 which includes cost of electricity supply and manpower. The annual maintenance cost of the plant is NPR 22,500. **Income streams:** The Milk chilling system will enhance the self-life of milk by 24 to 48 hours, which will provide an incremental income NPR 3 per litre (Ref: field consultation). That means, the annual income from the Milk chilling system will be NPR 375,000. **Assumptions:** The annual operational days are 250. The plant will be manned by 2 operators, incurring an expenditure of NPR 100,000 per year.
Profitability:	Internal Rate of Return: 24% Net Present Value: 580,000 Breakeven Point: 4 years
Recommendation:	The plant is suitable for medium scale operations which may benefit up to 20 dairy farmers.
Limitations:	- Continuous supply of electricity shall be ensured. - Maintenance of the plant needs to be a regular practice.

3.3.4 Automated Milking Machine

Application in the Value chain	The automated milking machines are an effective means of milking cattle which operate from electric power. The machine includes teat cups that contact cow's teats and extract milk. There is a claw where milk pools as it is removed from the four teats, vacuum tubes that provide vacuum to the teat cups and a milk tube that removes milk away from the claw, a source of vacuum for the machine, and a pulsator that regulates the on-off cycle of the vacuum. The milking machines today have an automatic take-off (ATO) or detacher device that removes the machine from the cow when milking is completed. Automated Milking Machine operated from hybrid system of Solar andenergy from Micro Hydro Project or the national grid.
Financial feasibility analysis:	Capacity of the system: 100 litres per day (assuming the maximum capacity- 10 litres per cow from a cattle farm, comprising 10 cattle). Energy consumption: 0.4 kWh per day Operating Life: 10 Years **Investment streams:** Total installation cost of the system is of NPR 100,000. Annual operating cost of the system is NPR 72,000 which includes cost of electricity supply and manpower. The annual maintenance cost of the plant is NPR 10,000, which includes liner replacement every year. **Income streams:** The system will enhance efficiency of milking by 1 litres per cattle. This efficiency will produce 10 litres of milk per day from a dairy farm (comprising 10 cattle). The anticipated income from the dairy farm will be of NPR 126,000. **Assumptions:** The annual operational days are 300. The plant will be manned by 1 operator, incurring an expenditure of NPR 60,000 per year. The unprocessed milk selling rate at the farm level is NPR 42 per litres (Ref: field consultation). The electricity charges are NPR 10 per unit.

Profitability:	Internal Rate of Return: 32% Net Present Value: 305,000 Breakeven Point: 4 years
Recommendation:	The machine is suitable for medium scale farm with minimum 10 cattle.
Limitations:	- Initial training for operators are necessary. - Periodical calibration of machine is important.

3.3.5 Refrigeration for Sexing Technology and Vaccines

Application in the Value chain	Refrigeration system powered by electricity through grid/ micro-hydro/solar system utilized in storing vaccines, temperature sensitive medicine, Artificial Insemination straws
Financial feasibility analysis:	Capacity of the system: 10 litres Energy consumption: Solar PV system of 0.3 kWp Operating Life: 15 Years **Investment streams:** Total installation cost of the solar PV system is of NPR 80,000, Cost of the cooling machine (Deep fridge-NPR 15,000) Annual operating cost of the system is NPR 36,000 which includes cost of manpower. The annual maintenance cost for machine and solar PV system is NPR 5,000. **Income streams:** The income of the system is through selling vaccines and other medicines. **Assumptions:** - The annual operational days are 300. - Two operators at NPR 500 per day are required for operation. - Current price of one Artificial Insemination (AI) is NPR 2000 per cattle and can be stored in the solar powered fridge of 10 litres which should store at least 50 straws of AI semen for system to be in breakeven.
Profitability:	Internal Rate of Return: 30% Net Present Value: 158,000 Breakeven Point: 3 years

Recommendation:	The technology is recommended for the rural context.
Limitations:	- The initial cost of solar PV is very high in the current context of Nepal. - Maintaining -100 degree Celsius for Semen might be a technical issue.

3.3.6 Feed Processing Units

Application in the Value chain	Generally, the feed industry is operating the plant from the energy of National Grid with back-up power from Diesel Generator. The energy required for the feed industry can be supplied from the hybrid system of Solar and energy from National Grid. The technology to make the feed of cattle is just to collect the ingredients of cattle feeds such as Maize, Mustard Cake, Barn, Molasses, straw, Urea etc. and grind with energy from hybrid system of solar and energy from National grid. After Grinding, the ingredients are mixed and packed for the delivery to the dealers or customers.
Financial feasibility analysis:	Capacity of the plant: 10 tonnes/Day Energy consumption: The total energy requirement is 45 kW; out of which, grid electricity will contribute 35 kW and 10 kW will be supplied by solar system. Operating Life: 20 Years **Investment streams:** Total installation cost of the system is of NPR 22 Million (civil cost is NPR 7 million for the plant). The estimated investment for procuring machineries for feed processing is NPR 6 million. The investment required for the solar system is NPR 9 Million (for 10 kW capacity a 30 kWp solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 1 million which includes cost of electricity supply and manpower. The annual maintenance cost of the plant is NPR 120,000; which includes solar plant and machine maintenance. **Income streams:** The plant will generate income primarily from animal feeds. The current (average) market price of animal feed (may vary according to type of feeds) is NPR 32 per kg. The total gross income from animal feed is NPR 12.8 Million.

Financial feasibility analysis:	**Assumptions:** - The annual operational days are 240. - The plant will be manned by 10 manpower (2 operators and 8 labors), incurring an expenditure of NPR 480,000 per year. - The electricity charges are NPR 10 per unit. - The solar PV is considered as a back-up of power and not a substitute or alternative to grid.
Profitability:	Internal Rate of Return: 36% Net Present Value: 57 Million Breakeven Point: 3 years
Recommendation:	- This business proposition is for medium and large-scale operations and commercially viable.
Limitations:	- Initial training for operators is necessary.

3.3.7 Efficient Stoves for Cheese Making Replacing Traditional Cook-stoves.

Application in the Value chain	Cheese and Churpi making needs thermal heat for boiling and processing of milk. Based on field consultation, it is found that approximately 1 kg of dry firewood is necessary for processing 2 litres of milk. Efficient stove will reduce the fuelwood consumption due to the increase in thermal efficiency.
Financial feasibility analysis:	Capacity of the system: The system can process 300 litres of milk per day. Energy consumption: The total energy requirement is 150 kg of fuelwood per day (assuming 1 kg of fuelwood is required to heat 2 litres of milk for cheese making) Operating Life: 5 Years **Investment streams:** Total installation cost of the system is of NPR 100,000. The annual maintenance cost of the plant is NPR 5000. **Income streams:** The system is 35% more efficient than traditional cookstoves resulting into savings of 10,500 kg of fuelwood per year resulting to savings of NPR 53,000 in a year.

Financial feasibility analysis:	Assumptions: - The annual operational days are 200. - The cost of fuelwood is NPR 5 per Kg. - 1 kg of fuelwood can heat around 2 litres of milk to produce cheese (as per field consultation).
Profitability:	Internal Rate of Return: 10% Net Present Value: 33,000 Breakeven Point: 3 years
Recommendation:	The intervention is not commercially viable without additional support from government subsidy or donors. However, the improved stove will enhance efficiency of plant and dairy farmers can consider this technological option.
Limitations:	- Micro-scale technology and life of stoves are less than 5 years.

3.3.8 Cold Storage

Application in the Value chain	Generally, the cold storage industry is operating the plant from the energy of National Grid with back-up power from Diesel Generator. The energy required for the cold storage can be supplied from the hybrid system of Solar and energy from micro hydro power plant. It is planned that the project will install 10 kW solar PV (captive consumption) and 50 kW will be powered from the existing grid. The total installed capacity of the plant will be 60 kW. The cold storage will be used for storage of ginger, large cardamom and based on availability even dairy products can be stored.

Financial feasibility analysis:	Capacity of the plant: 1000 Cubic Meter, storing around 120 tonnes in two cycles of 6 months each. Energy consumption: The total energy requirement is 60 kW; out of which, grid electricity will contribute 50 kW and 10 kW will be supplied by solar system. Operating Life: 25 Years **Investment streams:** Total installation cost of the system is NPR 3.75 Million (excluding the civil cost). The investment required for the solar system is NPR 9 Million (for 10 kW capacity a 30 kWp solar system with batteries is provided with average per kWp of solar system being NPR 300,000). Annual operating cost of the system is NPR 4 million which includes cost of electricity supply and manpower. The annual maintenance cost of the plant is NPR 20,000, which includes solar plant and machine maintenance. **Income streams:** The plant will generate income (i) the rental charge: NPR 100,000 at NPR 500 per quintal, (ii) Opportunity cost of storing: Current (average) market price of animal feed (may vary according to type of feeds) is NPR 32 per kg. The total gross income from animal feed is NPR 12.8 Million. **Assumptions:** • The annual operational days are 240. • The plant will be manned by 10 manpower (2 operators and 8 labors), incurring an expenditure of NPR 480,000 per year. • The electricity charges are NPR 10 per unit. • The solar PV is considered as a back-up of power and not a substitute or alternative to grid.
Profitability:	IRR: 28% NPV: 31 Million Breakeven Point: 4 years
Recommendation:	This business proposition is for large-scale operations and commercially viable.
Limitations:	- Initial training for operators are necessary. - This is a capital investment venture.

3.3.9 Electric Heater Replacing Fuelwood

Application in the Value chain	Electric heater can be used in boiling the milk as part of pasteurization as well as in making cheese, lollypop, dog chew or any other dairy products. The heater is a stainless-steel pot of gross volume 250 litres which requires 4 kW of electricity supplied through grid/micro-hydro or through bio-gas plants.
Financial feasibility analysis:	Capacity of the system: The system can process 500 litres of milk per day. Energy consumption: The total energy requirement is 4 kW. Operating Life: 5 Years **Investment streams:** Total installation cost of the system is of NPR 135,000. Annual operating cost of the system is NPR 32,000 which includes cost of electricity supply and manpower. The annual maintenance cost of the plant is NPR 7000. **Income streams:** The system will replace consumption of 50,000 kg of fuelwood per year resulting to a net income of NPR 200,000 per year. **Assumptions:** - The annual operational days are 200. - The cost of fuelwood is NPR 5 per Kg. - 1 kg of fuelwood can heat around 2 litres of milk to produce cheese (as per field consultation). - The electricity per unit tariff is NPR 10.
Profitability:	Internal Rate of Return: 77% Net Present Value: 390,000 Breakeven Point: 2 years
Recommendation:	The intervention is not commercially viable without additional support from government subsidy or donors. However, the improved stove will enhance efficiency of plant and dairy farmers can consider this technological option.
Limitations:	- Micro-scale technology. - Life of stoves is less than5years.

3.4 Financial Analysis of Technologies for Orthodox Tea Value Chain

3.4.1 Bio-gasifier for Heating Orthodox Tea

Application in the Value chain	Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. The gas is a low-heating value fuel, with a calorific value between 1000-1200 kcal/Nm3 (kilo calorie per normal cubic meter). Almost 2.5-3.0 Nm3 of gas can be obtained through gasification of about 1 kg of air-dried biomass.
Financial feasibility analysis:	Capacity of the system: 3000 Kg per day Operating Life: 20 Years **Investment streams:** Total installation cost of the plant is of NPR 3.5 Million, which covers cost of civil works, generator, equipment etc. Operating cost of the plant is NPR 180,000, which includes cost of manpower. The annual maintenance cost of the plant is NPR 90,000. **Income streams:** The income of the system will be savings made from replacing diesel with fuelwood. A similar system will require 250 litres of diesel which will be replaced by system utilizing 3000 kg fuelwood. The anticipated annual income from energy saving is of NPR 1.35 Million. **Assumptions:** - The annual operational days are 300. - The 100ml diesel is utilized to produce 1 kg of tea. - Around 1.5 kg of fuelwood to produce 1kg of tea.
Profitability:	Internal Rate of Return: 22% Net Present Value: 3.5 Million Breakeven Point: 5 years
Recommendation:	The intervention is not commercially viable without additional support from government subsidy or donors. The technology is recommended to the tea farmers at medium and large scale.
Limitations:	- The initial investment is high.

3.4.2 Hybrid Tea Withering

Application in the Value chain	The tea witherer utilizes low-temperature hot air for dehydrating fresh tea leaves. It is a type of closed tea withering process which is operated through electricity from grid/micro-hydro or Solar PV system.
Financial feasibility analysis:	Capacity of the system: 60 kg per hour. Energy consumption: The total energy requirement is 13 kW supplied by Solar PV system of 40 kWp. Operating Life: 20 Years **Investment streams:** Total installation cost of the system is of NPR 13.5 Million. The required investment for machinery is NPR 1.5 million. The investment required for the solar system is NPR 12 Million (for 13 kW capacity a 40 kWp solar system with batteries would be necessary. The average cost per kWp of solar system is NPR 300,000). Annual operating cost of the system is NPR 200,000 which includes cost of manpower. The annual maintenance cost for machine and solar PV system is NPR 75,000. **Income streams:** The income of the system is through contribution in production of Orthodox tea. The system will contribute to produce 72 tonnes of Orthodox tea per year at 200 days operation with 6 hours of withering, the incremental income being NPR 80 per kg resulting to a net income of NPR 785,000 per year. **Assumptions:** - The annual operational days are 200. - Two operators at NPR 500 per day are required for operation. - Current selling price of orthodox tea is around NPR 640 per kg, a general orthodox tea processing includes 8 steps (Tea leaf acquisition, steaming, withering, rolling, drying, storage, packaging and marketing/transportation). We have assumed each step to have equal contribution in the final product. Hence, NPR 80 per kg is incremental rate for each process.

Profitability:	Internal Rate of Return: 77% Net Present Value: 390,000 Breakeven Point: 2 years
Recommendation:	The intervention is not commercially viable without additional support from government subsidy or donors as the initial cost of solar PV installation is high.
Limitations:	The initial cost of solar PV is very high in the current context of Nepal.

4. Annexes

4.1 Cardamom Dryer

INPUTS	Units		Remarks
Capacity of the machine	kg/week	**1500**	**At the current trend the machine is operated only a week**
Total Installation Cost	NPR	**35000**	
Operating life	Years	6	
Firewood cost	NPR/kg	5	Average in the intervening area
Conventional Drying firewood consumption	kg/ kg of cardamom	3	A base example from Taplejung
Cardamom Dryer firewood consumption	kg/ kg of cardamom	1	A base example from Taplejung
Labour charge per day	NPR/per day per labour	200	Assumed
Maintenance cost	NPR	3000	after 3 years of operation, the base grate needs to be replaced
Current production trend of Cardamom	kg/hectare	1.474	Average production in intervening areas, farmers interview during site visit
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	35000	NPR	
Capacity of the Machine	1500	Kg/week	
Labour cost per year	1400	NPR/year	Single labour per day plus operator cost
Assumed Maintenance cost after 3 years	3000	NPR/year	
Annual expenditure cost	1400	NPR	Labour cost
One time maintenance cost at end of year 3	4400	NPR	Labour cost+ maintenance cost

INPUTS	Units		Remarks
Income: based on firewood saving			
Firewood saving per kg of cardamom	2	Kg/kg of cardamom	
Firewood saving as per capacity of machine	3000	kg/Year	
Income due to saving of firewood	15000	NPR / year	Assuming 5 NPR per kg of firewood

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Cash Inflow						
Incremental revenue 1	15000	15000	15000	15000	15000	15000
Incremental revenue 2						
Total Inflow	15000	15000	15000	15000	15000	15000
Cash Out flow						
Investment	35000					
Annual operational cost 1 (excluding maintenance)	1400	1400	1400	1400	1400	1400
Annual operational cost 2 (Including maintenance)			3000			
Machine Depreciation		3500	3150	2835	2551.5	2296
Total Outflow	36400	4900	7550	4235	3951.5	3696
Net Cash flow	-21400	10100	7450	10765	11048.5	11304
Incremental cash flow	-21400	-11300	-3850	6915	17963.5	29267.15
NPV	15083					
FIRR	**11%**					
Break Even point						

4.2 Solar Ginger Dryer

INPUTS	Units		Remarks
Capacity of the machine	Kg	**250**	**in 3 days of drying**
Total Installation Cost	NPR	**100000**	
Operating life	Years	10	
Incremental rate for dried Ginger	NPR/kg	5	In current practice the dried ginger cost 5-7 NPR higher than undried.
Operation in a year	Month per year	4	Although ginger has 2 crop cycle of 2 months we assumed drying process to be carried 4 months in a year
Operator cost	NPR/per day	3000	
Maintenance cost		5%	Assumed
Current production trend of Ginger	kg/hectare	13000	Average production in intervening areas, farmers interview during site visit.
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	100000	NPR	
Capacity of the Machine	250	Kg	
Labour cost per year	12000	NPR/ year	Operator cost
Assumed Maintenance cost	5000	NPR/ year	Assumed is 5% of initial investment
Total Annual Expenditure	17000	RNPR	Labour cost+ maintenance cost

INPUTS	Units		Remarks
Income:			
Required Ginger per Year for an economical operation	10000	kg/Year	Assuming 30 working days in a month with 3 days drying cycle for 4 months year
Crop income with modern energy powered technology from 1 Ha of Land	65000	NPR/ Crop cycle	Assuming 5 NPR per kg (dried Ginger price in Market)
Anticipated income from Total capacity of Ginger dryer	50000	NPR/ year	
Anticipated area of land as per capacity of the equipment	0.77	Hectare	Hence, the equipment can be implemented in Farmer level or small enterprise.

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Cash Inflow										
Incremental revenue 1		50000	50000	50000	50000	50000	50000	50000	50000	50000
Total Inflow	0	50000	50000	50000	50000	50000	50000	50000	50000	50000
Cash Out flow										
Investment	100000									
Annual operational cost	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000
Machine Depreciation		10000	9000	8100	7290	6561	5905	5314	4783	4305
Total Outflow	117000	27000	26000	25100	24290	23561	22905	22314	21783	21305
Net Cash flow	-117000	23000	24000	24900	25710	26439	27095	27686	28217	28695
Incremental cash flow	-117000	-94000	-70000	-45100	-19390	7049	34144.1	61829.7	90047	118742
NPV	28421									
FIRR	**-2%**									
Break Even point										

4.3 Automated Ginger Washer

INPUTS	Units		Remarks
Capacity of the machine	Kg/hour	**500**	
Total Installation Cost	NPR	**1500000**	
Operating life	Years	15	
Incremental rate for washed Ginger	NPR/kg	5	In current practice the washed ginger cost 5-7 NPR higher than unwashed.
Operation in a year	days per year	60	2 months of operation
Operation in a day	hours per day	6	Assumed
Electrical Capacity	kW	5	Includes the pumping the water into the system and conveyor belt movement.
Per Unit Cost of Electricity	NPR	10	NEA rate for industrial units in average
Labour charge per day	NPR/per day per labour	500	Assumed
Operator cost	NPR/per day	1000	
Maintenance cost		3%	

INPUTS	Units		Remarks
Dollar to Nepali Exchange rate		103	
Current production trend of Ginger	kg/ hectare	13000	Average production in intervening areas, farmers interview during site visit.
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	1500000	NPR	
Capacity of the Machine	500	Kg/hour	
Labour cost per year	150000	NPR/year	Three labours per day plus operator cost
Electrical Cost per year	18000	NPR/year	
Assumed Maintenance cost after 3 years	37500	NPR/year	Assumed is 3% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	168000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	205500	NPR	Labour cost+ electricity cost+ maintenance cost
Income:			

INPUTS	Units		Remarks
Required Ginger per day for an economical operation	3000	Kg/Day	Assuming 6 hour working hours per day
Required Ginger per Year for an economical operation	180000	kg/Year	Assuming 60 working days in year
Crop income with modern energy powered technology from 1 Ha of Land	65000	NPR/Crop cycle	Assuming 5 NPR per kg (washed Ginger price in Market)
Anticipated income from 180 tonnes of Ginger -Total capacity of Ginger for the Washing plant	900000	NPR/year	
Anticipated area of land for 180 Tonnes of Ginger	14	Hectare	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6		Year 12	Year 13	Year 14
Cash Inflow											
Incremental revenue		900000	900000	900000	900000	900000	900000		900000	900000	900000
Total Inflow	0	900000	900000	900000	900000	900000	900000		900000	900000	900000

Cash Out flow											
Investment	1500000										
Annual operational cost 1 (excluding maintenance)	168000	168000	168000	168000							
Annual operational cost 2 (Including maintenance)					205500	205500	205500		205500	205500	205500
Machine Depreciation		150000	135000	121500	109350	98415	88574		47072	42364	38128
Total Outflow	1668000	318000	303000	289500	314850	303915	294074		252572	247864	243628
Net Cash flow	-1668000	582000	597000	610500	585150	596085	605927		647428	652136	656372
Incremental cash flow	-1668000	-1086000	-489000	121500	706650	1302735	1908662		5702144	6354280	7010652
NPV	2578730										
FIRR	**33%**										
Break Even point											

4.4 Cream Separator

INPUTS	Units		Remarks
Capacity of the machine	Liter/hour	**500**	
Total Installation Cost	NPR	**55000**	Machine cost.
Solar system cost	NPR/kWp	**300000**	
Operating life	Years	10	
Electrical Capacity Solar PV system	kWp	1.2	0.4 kW of power to be drawn from solar system
Incremental rate for cream	NPR/kg	37	The cream is assumed to develop Ghee price whose average price in Nepal is around NPR 750, we have assumed 5% increment cost for cream as remaining skimmed milk is also sold in the market.
Operation in a year	months per year	10	Assumed
Operation per month	Days per month	25	
Operation in a day	hours per day	6	Assumed
Labour charge per month	NPR/per month per labour	5000	Assumed
Maintenance cost		5%	
Current production trend of milk	Liter per farmer per day	25	Average production from an individual farmer in intervening areas, a farmer has 2 cows in average
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	415000	NPR	

INPUTS	Units		Remarks
Capacity of the Machine	500	Lt/Hr	
Labour cost per year	50000	NPR/year	Single labour per day
Assumed Maintenance cost after 3 years	20750	NPR/year	Assumed is 3% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	50000	NPR	Labour cost
Total Annual Expenditure for after three years	70750	NPR	Labour cost and maintenance cost
Income:			
Required Milk per day for an economical operation	3000	Lt/Day	Assuming 6 hrs working hrs per day
Required Milk per Year for an economical operation	750000	Lt/Year	Assuming 200 working days in year
Cream production per year.	7500	Kg/year	Assuming 1% fat content in the milk
Crop income with modern energy powered technology from 1 single farmer	62.5	Kg / year	
Anticipated income from 7500 kg of cream -Total capacity of plant	277500	NPR/year	
Anticipated volume of production for 7500 Kg of cream	120	Farmers	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Cash Inflow										
Incremental revenue 1		277500	277500	277500	277500	277500	277500	277500	277500	277500
Incremental revenue 2										
Total Inflow	0	277500	277500	277500	277500	277500	277500	277500	277500	277500
Cash Out flow										
Investment	415000									
Annual operational cost 1 (excluding maintenance)	50000	50000	50000	50000						
Annual operational cost 2 (Including maintenance)					70750	70750	70750	70750	70750	70750
Machine Depreciation		41500	37350	33615	30253.5	27228	24505	22055	19849	17864
Total Outflow	465000	91500	87350	83615	101003.5	97978	95255	92805	90599	88614
Net Cash flow	-465000	186000	190150	193885	176496.5	179522	182245	184695	186901	188886
Incremental cash flow	-465000	-279000	-88850	105035	281531.5	461053.4	643298	827993.2	1014894	1203780
NPV	548976									
FIRR	**31%**									
Break Even point										

4.5 Bio-gas Plant for Heating and Electric Power Generation

INPUTS	Units		Remarks
Capacity of the machine	Lt/day	**400**	**50m^3 bio-gas plant**
Total Installation Cost	NPR	**1500000**	
Operating life	Years	15	
Electrical generation	kW	3	Assuming 5 hours of operation
Firewood consumption per day	Kg per day	200	Assumption is 1 kg of firewood can boil 2 litres of milk to heat to make cheese, churpi etc.
Firewood Rate	NPR/Kg	5	Average for the intervening areas.
Fertilizer production per day	Kg/day	200	Practical Action's multipurpose Bio-gas plant build at Chitwan district.
Fertilizer rate	NPR/kg	15	
Incremental rate/Value addition	NPR/day	1000	The equipment will directly contribute in heating as well as lighting and electrification will be value addition. We are assuming it will replace firewood/kerosene directly. So the firewood cost for heating 400 litres of milk is accounted as an incremental income.
Operation in a year	months per year	12	Assumed
Operation per month	Days per month	20	
Feedstock cost	NPR/kg	500	
Feedstock required	Kg/day	1000	
Labour cost	NPR/month	5000	
Maintenance cost	NPR/year	10000	Practical Action's reference from Chitwan plant
Electrical rate	NPR/kWh	10	NEA grid electricity cost for small enterprises.

INPUTS	Units		Remarks
Current production trend of milk	Lt per farmer per day	25	Average production from an individual farmer in intervening areas, a farmer has 1-2 cows in average
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	1500000	NPR	
Capacity of the Machine	400	Lt/Hr	
Feedstock cost	120000	NPR/year	
Labour cost	180000	NPR/year	3 operators cost
Assumed Maintenance cost per year	10000	NPR/year	
Total Annual Expenditure	310000	NPR	Operation cost+ maintenance cost
Income:			
Required Milk per day for an economical operation	400	Lt/Day	
Required Milk per Year for an economical operation	96000	Lt/Year	Assuming 12 months of operation in 20 working days in year
Electricity savings	36000	NPR/year	
Firewood savings	240000	NPR/year	
Income from Fertilizers sales	720000	NPR/year	Firewood savings+ Selling fertilizers+electricity saving if connected to grid
Total income	996000	NPR/year	

INPUTS	Units		Remarks
Required number of cattle for anticipated milk production	16		

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6		Year 13	Year 14
Cash Inflow								----		
Incremental revenue 1		996000	996000	996000	996000	996000	996000		996000	996000
Incremental revenue 2										
Total Inflow	0	996000	996000	996000	996000	996000	996000		996000	996000
Cash Out flow										
Investment	1500000									
Annual operational cost 1 (excluding maintenance)	310000	310000	310000	310000	310000	310000	310000		310000	310000
Machine Depreciation		150000	135000	121500	109350	98415	88574		86104	87335
Total Outflow	1810000	460000	445000	431500	419350	408415	398574		396104	397335
Net Cash flow	-1810000	536000	551000	564500	576650	587585	597427		599896	598665
Incremental cash flow	-1810000	-1274000	-723000	-158500	418150	1005735	1603162		5867090	6465754
Net Present Value	**2260219**									
FIRR	**28%**									
Break Even point										

4.6 Milk Chilling Vat

INPUTS	Units		Remarks
Capacity of the machine	Lt/day	**500**	
Total Installation Cost	NPR	**450000**	
Operating life	Years	15	
Incremental rate for chilled cream	NPR/kg	3	Reference rate as per field consultation
Operation in a year	Months per year	10	Assumed
Operation per month	Days per month	25	
Operation in a day	Cycle per day	1	Chilled milked to store in the Vat for 3-24 hours before transportation
Electrical Capacity	kW	3	
Per Unit Cost of Electricity	NPR	10	NEA rate for industrial units in average
Labour charge per month	NPR/per month per labour	5000	Assumed
Maintenance cost		5%	
Current production trend of milk	Lt per farmer per day	25	Average production from an individual farmer in intervening areas, a farmer has 2 cows in average
Depreciation		10%	Assumed
Calculations			
Cost			

INPUTS	Units		Remarks
Upfront Investment	450000	NPR	
Capacity of the Machine	500	Lt/Hr	
Labour cost per year	100000	NPR/year	Two labours per month
Electrical Cost per year	60000	NPR/year	
Assumed Maintenance cost after 3 years	22500	NPR/year	Assumed is 5% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	160000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	182500	NPR	Labour cost+ electricity cost+ maintenance cost
Income:			
Required Milk per day for an economical operation	500	Lt/Day	
Required Milk per Year for an economical operation	125000	Lt/Year	Assuming 10 months of operation in 25 working days in year
Income with modern energy powered technology	375000	NPR/ year	Assuming 3 NPR per litre incremental price of chilled milk
Production milk of farmer per year	6250	Litres/year	
Number of farmers to fulfill the capacity of equipment	20	Farmers	Hence, the machine is well suited for small co-op level or enterprise level.

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5		Year 12	Year 13	Year 14
Cash Inflow										
Incremental revenue 1		375000	375000	375000	375000	375000		375000	375000	375000
Incremental revenue 2										
Total Inflow	0	375000	375000	375000	375000	375000		375000	375000	375000
Cash Out flow										
Investment	450000									
Annual operational cost 1 (excluding maintenance)	160000	160000	160000	160000						
Annual operational cost 2 (Including maintenance)					182500	182500		182500	182500	182500
Machine Depreciation		45000	40500	36450	32805	29525	---	25056	25831	26201
Total Outflow	610000	205000	200500	196450	215305	212025	--	207556	208331	208701
Net Cash flow	-610000	170000	174500	178550	159695	162976		167444	166669	166299
Incremental cash flow	-610000	-440000	-265500	-86950	72745	235720.5		1421058	1587727	1754026
NPV	578954									
FIRR	**24%**									
Break Even point										

4.7 Automated Milking Machine

INPUTS	Units		Remarks
Capacity of the machine	Lt/day	**100**	Assumption is 10 cows farm, although machine has capacity to milk 10 cows/hour. A cow can provide 10 litres of milk a day.
Total Installation Cost	NPR	**100000**	
Operating life	Years	10	The liner life is 3000 milking life i.e. if we assume 10 cycle each day to 300 days of operation then liner replacement after each year of operation.
Increase in milking capacity per cow per day	Liter/cow	1	Compared to manual milking
Milk selling rate from the farmer	NPR/liter	42	Average rate through consultation
Operation in a year	months per year	12	Assumed
Operation per month	Days per month	25	
Operation in a day	Hrs per day	1	A cow can be milked in around 5 mins, 10 cows in around an hour.
Electrical Capacity	kW	0.4	
Per Unit Cost of Electricity	NPR	10	NEA rate for industrial units in average
Labour charge per month	NPR/per month per labour	5000	Assumed
Maintenance cost		10000	As assumed liner replacement after each year of operation which roughly cost 5000 and another 5000 for yearly maintenance.

INPUTS	Units		Remarks
Current production trend of milk	Lt per farmer per day	25	Average production from an individual farmer in intervening areas, a farmer have 2 cows in average
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	100000	NPR	
Capacity of the Machine	100	Lt/Hr	
Labour cost per year	60000	NPR/year	One labourer per day.
Electrical Cost per year	1200	NPR/year	
Assumed Maintenance cost	10000	NPR/year	
Total Annual Expenditure for first three years	71200	NPR	Labour cost+ electricity cost+maintenance cost
Income:			
Required Milk per day for an economical operation	100	Lt/Day	
Required Milk per Year for an economical operation	30000	Lt/Year	Assuming 10 months of operation in 25 working days in year
Increase in production per day	10	Lt / day	
Anticipated income from increased production	126000	NPR/year	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Cash Inflow										
Incremental revenue 1		126000	126000	126000	126000	126000	126000	126000	126000	126000
Total Inflow	0	126000	126000	126000	126000	126000	126000	126000	126000	126000
Cash Out flow										
Investment	100000									
Annual operational cost 1 (excluding maintenance)	71200	71200	71200	71200						
Machine Depreciation		10000	9000	8100	7290	6561	5905	5314	4783	4305
Total Outflow	171200	81200	80200	79300	7290	6561	5905	5314	4783	4305
Net Cash flow	-171200	44800	45800	46700	118710	119439	120095	120686	121217	121695
Incremental cash flow	-171200	-126400	-80600	-33900	84810	204249	324344.1	445029.7	566246.7	687942
NPV	305080									
FIRR	**32%**									
Break Even point										

4.8 Refrigeration for Sexing Technology and Vaccines

INPUTS	Units		Remarks
Storage Capacity of the machine	Lt	**10**	
Assumed Semen specimen that can be stored in the refrigerator	Straws	**50**	
Cost of the Refrigerator	NPR.	**15000**	Machine cost
Solar system cost	NPR/kWp	**300000**	
Operating life	Years	10	
Electrical Capacity Solar PV system	kWp	0.3	80 w of power to be drawn from solar system
Incremental rate for cream	NPR/straws	2000	The semen is kept in a form of straws.
Operation in a year	months per year	12	Assumed
Operation per month	Days per month	30	
Operation in a day	hours per day	6	Assumed
Labour charge per month	NPR/per month per labour	3000	Assumed
Maintenance cost		3%	
Current production trend of milk	Lt per farmer per day	25	Average production from an individual farmer in intervening areas, a farmer has 2 cows in average
Depreciation		10%	Assumed

INPUTS	Units		Remarks
Calculations			
Cost			
Upfront Investment	105000	NPR	
Capacity of the Machine	10	Lt	
Labour cost per year	36000	NPR/year	single labour per day
Assumed Maintenance cost after 3 years	3150	NPR/year	Assumed is 3% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	36000	NPR	Labour cost
Total Annual Expenditure for after three years	39150	NPR	Labour cost+maintenance cost
Income:			
Anticipated income from 50 straws of semen	100000	NPR/year	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Cash Inflow										
Incremental revenue 1		100000	100000	100000	100000	100000	100000	100000	100000	100000
Total Inflow	0	100000	100000	100000	100000	100000	100000	100000	100000	100000
Cash Out flow										
Investment	105000									
Annual operational cost 1 (excluding maintenance)	36000	36000	36000	36000						
Annual operational cost 2 (Including maintenance)					39150	39150	39150	39150	39150	39150
Machine Depreciation		10500	9450	8505	7654.5	6889	6200	5580	5022	4520
Total Outflow	141000	46500	45450	44505	46804.5	46039	45350	44730	44172	43670
Net Cash flow	-141000	53500	54550	55495	53195.5	53961	54650	55270	55828	56330
Incremental cash flow	-141000	-87500	-32950	22545	75740.5	129701.5	184351.3	239621.2	295449.1	351779.2
NPV	157633									
FIRR	**29%**									
Break Even point										

4.9 Feed Processing Units

INPUTS	Units		Remarks
Capacity of the machine	kg/day	**10000**	**10 ton per day**
Machinery Cost	NPR	**6000000**	This cost is solely the machinery cost which excludes the land cost, building setup cost.
Civil cost	NPR	**7000000**	
Solar system cost	NPR/kWp	**300000**	
Operating life	Years	20	
Selling rate of feed	NPR/kg	8	The average selling rate from Santulit dana is NPR 32 /kg, we assumed the industry caps around 25% margin in the final product.
Operation in a year	months per year	8	Assumed
Operation per month	Days per month	20	
Electrical Capacity	kW	45	
Capacity drawn through grid	kW	35	
Capacity drawn through solar	kWp	30	10 kW of remaining power to be drawn from solar system
Operation in a day with grid	Hours	8	
Per Unit Cost of Electricity	NPR	10	NEA rate for industrial units in average
Labour charge per month	NPR/per month per labour	5000	Assumed
Operator cost	NPR/per month	10000	
Maintenance cost		3%	

INPUTS	Units		Remarks
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	22000000	NPR	
Capacity of the Machine	10000	Kg/day	
Labour cost per year	480000	NPR/year	8 labourers per day plus two operator cost
Electrical Cost per year	448000	NPR/year	
Assumed Maintenance cost after 3 years	150000	NPR/year	Assumed is 2.5% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	928000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	1078000	NPR	Labour cost+ electricity cost+ maintenance cost
Income:			
Required feeder per day for an economical operation	10000	Kg/Day	
Required feeder per Year for an economical operation	1600000	Kg/Year	
Anticipated income from 10000 kg of feeder-Total capacity of plant	12800000	NPR/year	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	---	Year 17	Year 18	Year 19
Cash Inflow							--			
Incremental revenue		12800000	12800000	12800000	12800000	12800000	--	12800000	12800000	12800000
Total Inflow	0	12800000	12800000	12800000	12800000	12800000		12800000	12800000	12800000
Cash Out flow										
Investment	22000000									
Annual operational cost 1 (excluding maintenance)	928000	928000	928000	928000						
Annual operational cost 2 (Including maintenance)					1078000	1078000		1078000	1078000	1078000
Machine Depreciation		2200000	1980000	1782000	1603800	1443420		1249467	1219223	1204533
Total Outflow	22928000	3128000	2908000	2710000	2681800	2521420		2327467	2297223	2282533
Net Cash flow	-22928000	9672000	9892000	10090000	10118200	10278580		10472533	10502777	10517467
Incremental cash flow	-22928000	-13256000	-3364000	6726000	16844200	27122780		153511481	164014258	174531725
NPV	57403860									
FIRR	**36%**									
Break Even point										

4.10 Efficient Stoves for Cheese Making Replacing Traditional Cook-stoves.

INPUTS	Units		Remarks
Capacity of the machine	Lt/day	**300**	
Total Installation Cost	NPR	**100000**	
Operating life	Years	5	
Firewood consumption	Kg per day	150	As per filed consultation 1 kg of firewood can boil 2 litres of milk to prepare Churpi
Operation in a year	days per year	200	Assumed
Firewood Rate	NPR/Kg	5	Average for the intervening areas.
Maintenance cost		5%	
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	100000	NPR	
Capacity of the Machine	300	Lt/day	
Assumed Maintenance cost per year	5000	NPR/year	Assumed is 5% of initial investment required every year
Total Annual Expenditure	5000	NPR	Labour cost+ firewood
Income:			
Firewood Savings per year	10500	Kg/year	The machine has 35% efficiency than traditional cookstoves.
Firewood saved income	52500	NPR/Year	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Cash Inflow						
Incremental revenue		52500	52500	52500	52500	52500
Total Inflow	0	52500	52500	52500	52500	52500
Cash Out flow						
Investment	100000					
Annual operational cost 1 (excluding maintenance)	5000	5000	5000	5000	5000	5000
Machine Depreciation		10000	10000	10000	10000	10000
Total Outflow	105000	15000	15000	15000	15000	15000
Net Cash flow	-105000	37500	37500	37500	37500	37500
Incremental cash flow	-105000	-67500	-30000	7500	45000	82500
NPV	33777					
FIRR	**10%**					
Break Even point						

4.11 Cold Storage

INPUTS	Units		Remarks
Capacity of the machine	m3	**1000**	**500 m^2 area with 2 m height.**
Machinery Cost	NPR	**3750000**	This cost is solely the machinery cost which excludes the land cost, building setup cost.
Solar system cost	NPR/kWp	**300000**	
Operating life	Years	25	
Storage capacity	Kg	120000	Taking reference of potato of 90 mm diameter and weighing 150 gm each, the number of potato that can be stored in 50 m^3 area.
Rental rate of crop storage	NPR/quintal	600	Reference of Indian Market
Opportunity cost of the storage	NPR/kg	20	

INPUTS	Units		Remarks
Operation in a year	Months per year	12	Assumed
Operation per month	Days per month	30	
Electrical Capacity	kW	50	
Capacity drawn through national grid	kW	30	NEA tariff rate for industry.
Capacity drawn through solar	kWp	30	10 kW of remaining power to be drawn from solar system
Operation in a day with grid	Hours	24	
Per Unit Cost of Electricity	NPR	10	Per unit cost from micro-hydro system
Labour charge per month	NPR/per month per labour	5000	Assumed
Maintenance cost		1%	
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	12750000	NPR	
Capacity of the Machine	1000	Kg/day	
Labour cost per year	120000	NPR/ year	2 labours per day
Electrical Cost per year	2592000	NPR/ year	
Assumed Maintenance cost after 3 years	18750	NPR/ year	Assumed is 1% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	2712000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	2730750	NPR	Labour cost+ electricity cost+ maintenance cost

INPUTS	Units		Remarks
Income:			
Required feeder per day for an economical operation	1200	Quintal/ season	Season defined as 6 months period
Required feeder per Year for an economical operation	12000	Quintal/ Year	5 stacks of ginger
Anticipated income from renting Total capacity of plant	9600000	NPR/ year	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5		Year 22	Year 23	Year 24
Cash Inflow										
Incremental revenue		9600000	9600000	9600000	9600000	9600000		9600000	9600000	9600000
Total Inflow	0	9600000	9600000	9600000	9600000	9600000		9600000	9600000	9600000
Cash Out flow										
Investment	12750000									
Annual operational cost 1 (excluding maintenance)	2712000	2712000	2712000	2712000						
Annual operational cost 2 (Including maintenance)					2730750	2730750		2730750	2730750	2730750
Machine Depreciation		1275000	1147500	1032750	929475	836528		700584	704760	708625
Total Outflow	15462000	3987000	3859500	3744750	3660225	3567278		3431334	3435510	3439375
Net Cash flow	-15462000	5613000	5740500	5855250	5939775	6032723		6168666	6164490	6160625
Incremental cash flow	-15462000	-9849000	-4108500	1746750	7686525	13719247.5		118725267	124889756	131050382
NPV	31714031									
FIRR	**28%**									
Break Even point										

4.12 Electric Heater Replacing Fuelwood

INPUTS	Units		Remarks
Capacity of the machine	Lt/cycle.	**250**	
Total Installation Cost	NPR	**135000**	
Operating life	Years	5	Will require periodic maintenance after 5 years of operation.
Operating cycle per day	cycle per day	2	2 times a day the machine will operate around 4 hours
Operation in a year	days per year	200	Assumed
Firewood Rate	NPR/Kg	5	Average for the intervening areas.
Electrical Capacity	kW	4	
Electrical Rate	NPR/unit	10	
Maintenance cost		5%	
Depreciation		10%	Assumed
Calculations			
Cost With New Technology			
Upfront Investment	135000	NPR	
Capacity of the Machine	500	Lt/day	
Electricity cost per year	32000	NPR/year	
Assumed Maintenance cost per year	6750	NPR/year	Assumed is 5% of initial investment required every year
Total Annual Expenditure	38750	NPR	Electricity cost + maintenance cost
Cost With Firewood for same capacity			
Capacity of the Machine	500	Lt/day	Assuming same capacity as new technology

INPUTS	Units		Remarks
Firewood Consumption per year	50000	Kg/year	Assuming 1kg of firewood is required to heat 2 litres of milk to prepare churpi
Firewood cost per year	250000	NPR/year	
Total Annual Expenditure	250000	NPR	Firewood cost
Income			
Savings per year	211,250	NPR/Year	Firewood cost minus the operational cost of the machine.

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Cash Inflow						
Incremental revenue		211250	211250	211250	211250	211250
Total Inflow	0	211250	211250	211250	211250	211250
Cash Out flow						
Investment	135000					
Annual operational cost 1 (excluding maintenance)	38750	38750	38750	38750	38750	38750
Machine Depreciation		13500	13500	13500	13500	13500
Total Outflow	173750	52250	52250	52250	52250	52250
Net Cash flow	-173750	159000	159000	159000	159000	159000
Incremental cash flow	-173750	-14750	144250	303250	462250	621250
NPV	389986					
FIRR	***77%***					
Break Even point						

4.13 Bio-gasifier for Heating Orthodox Tea

INPUTS	Units		Remarks
Capacity of the plant	Kg/day	**3000**	
Total Installation Cost	NPR	**3500000**	
Operating life	Years	15	
Operation in a year	Days per year	300	2 months of operation
Operation in term of month	month per year	12	
Operation in a day	hours per day	8	Assumed
Diesel required to processing per day	Liter/day	250	200 ml of diesel required for 1kg of production (https://www.thegef.org/sites/default/files/project_documents/2500_UNDP_TE_Terminal_Evaluation_REPORT_-_TEA__final__0.pdf)
Firewood required to operate the bio-mass of same capacity	Kg/day	3000	1.5 kg of firewood for 1 kg of made tea for overall process.(http://ieeexplore.ieee.org/document/7280268/?reload=true)
Cost of diesel	NPR/liter	78	Current rate
Cost of firewood	NPR/kg	5	Average in intervening area.
Labour charge per day	NPR/per day per labour	5000	Assumed
Maintenance cost		3%	
Current production trend of orthodox tea	kg/hectare	9800	Average production in intervening areas, farmers interview during site visit.
Depreciation		10%	Assumed
Calculations			

INPUTS	Units		Remarks
Cost			
Upfront Investment	3500000	NPR	
Capacity of the Machine	3000	Kg/day	
Labour cost per year	180000	NPR/ year	Two labourers per day plus operator cost
Assumed Maintenance cost after 3 years	87500	NPR/ year	Assumed is 5% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	180000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	267500	NPR	Labour cost+ electricity cost+ maintenance cost
Income:			
Diesel usage per year for generation	75000	Kg/year	Assuming 200 working days in year
Cost of Diesel usage per year for generation	5850000	NPR / year	
Firewood usage as diesel replacement per year	900000	kg/Year	Assuming 200 working days in year
Cost Firewood usage as diesel replacement	4500000	NPR / year	
Net income (diesel cost-firewood cost)	1350000	NPR / year	
Anticipated area of land for 180 Tonnes of tea	92	Hectare	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	-------	Year 18	Year 19
Cash Inflow										
Incremental revenue		1350000	1350000	1350000	1350000	1350000	1350000		1350000	1350000
Total Inflow	0	1350000	1350000	1350000	1350000	1350000	1350000		1350000	1350000
Cash Out flow										
Investment	3500000									
Annual operational cost 1 (excluding maintenance)	180000	180000	180000	180000						
Annual operational cost 2 (Including maintenance)					267500	267500	267500		267500	267500
Machine Depreciation		350000	315000	283500	255150	229635	206672		160430	167351
Total Outflow	3680000	530000	495000	463500	522650	497135	474172		427930	434851
Net Cash flow	-3680000	820000	855000	886500	827350	852865	875829		922070	915149
Incremental cash flow	-3680000	-2860000	-2005000	-1118500	-291150	561715	1437544		12807721	13722871
NPV	3459302									
FIRR	**22%**									
Break Even point										

4.14 Hybrid Tea Withering

INPUTS	Units		Remarks
Capacity of the machine	Kg/hr	**60**	
Total Installation Cost	NPR.	**1500000**	
Solar system cost	NPR/kWp	**300000**	
Operating life	Years	20	
Incremental rate for dried tea leaves	NPR/kg	80	Current selling price of orthodox tea is around NPR 640 per kg, a general orthodox tea processing includes 8 steps (Tea leaf acquisition, steaming, withering, rolling, drying, storage, packaging and marketing/transportation). We have assumed each step to have equal contribution in the final product. Hence, NPR 80 per kg is incremental rate for each process.
Operation in a year	Days per year	200	
Operation in a day	hours per day	6	Assumed
Capacity drawn through solar	kWp	40	13 kWsystems.
Labour charge per day	NPR/per day per labour	500	Assumed
Maintenance cost		5%	
Current production trend of orthodox tea	kg/hectare	9800	Average production in intervening areas, farmers interview during site visit.

INPUTS	Units		Remarks
Depreciation		10%	Assumed
Calculations			
Cost			
Upfront Investment	13500000	NPR	
Capacity of the Machine	60	Kg/Hr	
Labour cost per year	200000	NPR/year	Two labours per day
Assumed Maintenance cost after 3 years	75000	NPR/year	Assumed is 5% of initial investment required after 3 years of operational yearly
Total Annual Expenditure for first three years	200000	NPR	Labour cost+ electricity cost
Total Annual Expenditure for after three years	275000	NPR	Labour cost+ electricity cost+ maintenance cost
Income:			
Required tea per day for an economical operation	360	Kg/Day	Assuming 6 hrs working hrs per day

INPUTS	Units		Remarks
Required tea per Year for an economical operation	72000	kg/Year	Assuming 200 working days in year
Crop income with modern energy powered technology from 1 Ha of Land	784000	NPR/ year	Assuming NPR 80 per kg
Anticipated income from 72 Tonnes of Tea -Total capacity of witherer	5760000	NPR/year	
Anticipated area of land for 72 Tonnes of tea	7	Hectare	

Cash Flow (NPR)

Particular	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5		Year 12	Year 13	Year 14
Cash Inflow										
Incremental revenue		5760000	5760000	5760000	5760000	5760000		5760000	5760000	5760000
Total Inflow	0	5760000	5760000	5760000	5760000	5760000		5760000	5760000	5760000
Cash Out flow										
Investment	13500000									
Annual operational cost 1 (excluding maintenance)	200000	200000	200000	200000			----			
Annual operational cost 2 (Including maintenance)					275000	275000	----	275000	275000	275000
Machine Depreciation		1350000	1215000	1093500	984150	885735		423644	381280	343152
Total Outflow	13700000	1550000	1415000	1293500	1259150	1160735		698644	656280	618152
Net Cash flow	-13700000	4210000	4345000	4466500	4500850	4599265		5061356	5103720	5141848
Incremental cash flow	-13700000	-9490000	-5145000	-678500	3822350	8421615		42657799	47761519	52903367
NPV	18681297									
FIRR	**30%**									
Break Even point										

Address:

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