Completion Report

Biomass Pellet industry: a clean energy solution for Nepal, Nepal, NCF8, project no. NCF-C8-289

Grantee: Arbonaut Ltd.

Local Partner: Bakas Renewable Energy Ltd.

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1. EXECUTIVE SUMMARY

This project has been a collaboration between the grantee Arbonaut Ltd. (Finland) and the local partner BAKAS Renewable Energy (Nepal), with the financial support of the Nordic Climate Facility (NCF).

The project objectives can be summarized as follows:

- Production of biomass pellets from sustainably harvested forest shrub biomass to provide a clean energy solution for Nepal,
- Reduction of fire risk during the dry summer season by removing the highly inflammable shrub layer,
- Reduction of carbon dioxide emissions by introducing biomass pellets to local industries to replace fossil fuels and by reducing the forest fire risk,
- Income generation and livelihood improvement for the local communities by generating jobs and offering equity sharing in the pellet production,
- Supporting the sustainable harvest of forest shrubs and forest fire management via an online service and mobile app based on up-to-date forest inventory data.

Rapid growth in population, thriving industrial sector and increasing infrastructure development have led to increased demand for energy consumption. As the demand increases in a developing country like Nepal, the country has to surge its power-generating capacity by encouraging players in the energy sector. To control carbon emissions and tackle climate change, companies will be inclined towards usage of renewable energy for power requirement. Owing to the increasing price of primary fuel in the country, pellet industry using local raw materials and low production cost provide industries with low-cost alternative for fossil fuel.

In this context, the project has established a pellet factory next to the Sagarnath community forest area which is one of the oldest forest plantations in Nepal. The area is located in an underdeveloped region of the Madhesh province (Province No. 2) in the Southern part of Nepal. The plantation is managed by the Sagarnath Forest Development Project (SFDP) under the Ministry of Forestry since 1978.

The pellets are mainly produced from by-products of traditional forest operations such as saw dust, wood chips, shrubs etc. The local partner Bakas Renewable Energy has entered into a lease agreement for the Sagarnath forest to ensure an uninterrupted supply of raw materials required for pellet manufacturing. Bakas Renewable Energy is a pioneer in this sector in the country since it is the first company that has started pellet manufacturing at an industrial scale in Nepal.

The project started with the design and construction of the pellet factory during autumn 2020. In Parallel to the factory construction, the project set up the raw material collection process. Besides delays caused by the Covid-19 pandemic, the production of briquettes and pellets successfully started in April and October 2022, respectively. The project created 230 jobs for local people, out of which 80 are

women, to handle the shrub harvest and transport, collection of other raw materials, and the operations at the factory premises.

As project coordinator, Arbonaut Ltd. has been closely working with Bakas, following and monitoring the progress at the factory site. To support the shrub harvest planning and forest fire management activities, Arbonaut Ltd. conducted a detailed forest inventory using airborne laser scanning of the entire Sagarnath plantation area, and additional field measurements of shrubs and trees. From the inventory data, the project has created high-resolution maps describing the forest parameters such as tree height, diameter, basal area, volume, tree biomass, shrub biomass and shrub height. Furthermore, maps for fire risk management such as the canopy fuel weight, canopy bulk density, canopy base height and fire breaks were generated from the inventory data. A web map platform with a mobile application was implemented that provides a user-friendly access to the inventory results. The application offers different functionalities for shrub harvest planning, monitoring and tracking as well as for forest fire management, in order to support the sustainable forest.

To support the sales process, the marketing team of Bakas is intensely working to promote the pellets on the Nepalese market and to create awareness about die advantages of pellet usage. Currently, Bakas is in contact with various potential customers, and has supplied samples to various industries resulting in overall positive feedback. The produced densified biomass pellets have also been supplied to different brick industries for test runs. Nepalese SMEs mostly depend on liquid petroleum gas (LPG) and diesel/petrol for their energy requirement. Production of biomass pellets at industrial scale could substitute the use of petroleum products in SMEs with green energy to some extent. The marketing survey conducted by Bakas identified the need for a certain modification in the firing chamber when using pellets instead of fossil fuels, or alternatively the SMEs can acquire a pellet burner. Bakas is actively addressing this issue by consulting the industries for the required switch-over. The team believes that many new industries will transition to pellet instead of fossil fuel, resulting in a continuous increase in biomass pellets in the near future.

While the pellet production was successfully initiated, the project did not reach the initially set targets related to the quantity of the pellet production by the end of the project lifetime. This was caused by the delayed production start (due to Covid-19), technical problems with the biomass drying machine resulting in a longer drying process, and the usage of traditional manual shrub harvesting methods which showed not to be efficient enough for a biomass supply of high quantity. As a result, only a fraction of the initially planned pellet amount has been produced during the project period. However, the production is continuing also beyond the project with improved harvesting methods and the technical problem being resolved by now.

The project was completed within the initially scheduled time frame and in line with the available budget under this contract. Beyond the NCF grant and co-financing from BAKAS and Arbonaut Ltd. as part of this contract, the project was supported by the Nepalese investment bank *Business Oxygen (BO_2).*

2. ACHIEVEMENT OF RESULTS

2.1 Achievement of outcomes and outputs

Expected outcomes and outputs	Indicator(s):	Achievement of outcomes and outputs:
Outcome 1: Production and sales of 20 000 tons of pellets	15 000 tonnes of fossil fuels are replaced by pellets	576.5 tonnes of coal have been replaced.
	Emissions reduction of 28 519 tonnes of CO_2-equivalent through usage of pellets instead of fossil fuels	The pellets and briquettes produced amount have been used to replace coal, resulting in emission reductions of 797 t CO_2e by project completion. In the longer term, the expected emission reductions by the project amounts to about 110 000 tonnes of CO2e. This estimate includes the project duration and 9 years following project completion.
	190 new jobs created (permanent and seasonal)	230 new jobs (80 female, 150 male).
	10 000 EUR annual income for communities	24 680 EUR have been received by the local communities for their work especially in biomass harvesting and transportation.
Output 1.1: Pellet factory established and running	Biomass pellet production of 20 000 tonnes/year	1 000 tonnes of pellets and 800 tonnes of briquettes have been produced by the end of the project. Production is continuing and planned to increase to a standard production rate of 64 tonnes of pellets and 20 tonnes of briquette per day.
Output 1.2: Raw material supply chain established	15 000 tonnes of dried biomass and agricultural waste used for pellet production (10 000 tonnes/year)	1 140 tonnes of shrub biomass were collected during the project.

	6 000 tonnes of bagasse and ply waste used for pellet production (5 000 tonnes/year)	1 585 tonnes of ply waste and bagasse peel waste used for production.
	6 000 tonnes of sawmill by-products used for pellet production (5 000 tonnes/year)	1 530 tonnes of sawmill by-products such as saw dust were collected.
Output 1.3: Pellets are marketed and sold	20 000 tonnes of biomass pellets sold	768.4 tonnes of pellets and briquettes have been sold.
	3 private companies replace at least 10% of their annual energy need by biomass pellets	A refinery in Janakpur has replaced 100% of their fossil fuels by briquettes. Kathmandu Dairy has replaced diesel fuel to 100% with biomass pellet, and Bhaktapur Itta has replaced 10% of coal fuel with pellets.
	3 agencies/outlets are distributing the pellets	One online outlet (www.daraz.com) and 2 physical outlets (at pellet factory site and at Gaidakot, East Nawalparasi).
Output 1.4: Local people are engaged in raw material collection, production and marketing of pellets	140 new jobs for biomass collection	181 new jobs (131 seasonal full-time jobs for harvesting, of which 49 are female and 82 are male. 50 part-time jobs for material collection and handling), of which 30 are female and 20 are male
	10 new jobs for biomass transport	12 new jobs of which 12 are male (part-time).
	20 new jobs in the pellet factory	30 new jobs of which 30 are male. (8 full-time, 22 part-time).
	10 new jobs for office work	5 new jobs, of which 1 is female and 4 are male.(full-time).
	10 new jobs for marketing	2 new jobs (full-time), of which 2 are male
Output 1.5: Income generation for the community and SFDP	15 000 EUR income for SFDP through royalty payments by Bakas	Around 3,500 EUR have been paid to the Sagarnath Forest Development Project (SFDP) as royalty payment. As extraction of biomass from Sagarnath continues, additional amounts will be paid to SFDP as per the agreed terms.

	Signed agreement with the local government on payments for the usage of understory biomass from Sagarnath forest	As the project only used understory biomass from the Sagarnath plantation forest which is managed by the SFDP (which is a government entity), it was sufficient to make royalty payments only to the SFDP. Additional payments to the local government were not applicable in this case.
	Signed agreement on equity sharing with the local communities	This is prospective planning. Signing of the agreement will take place only after the project period. The reason is that as per rule, equity sharing with local people can only start once the production is profitable. We expect it will take place a few years after the healthy running of the pellet production.
Outcome 2: Forest fire risk reduced at least by 50% measured in terms of frequency and extent at SFDP by removal of understory biomass	Yearly frequency of forest fires reduced by 50%	Fire frequency has been lower during 2022 compared to pre-project years, but this is most likely linked to natural fluctuation. It is expected that the fire risk has reduced in all areas where shrubs have been harvested during the project, i.e. on 200 hectares. Fire risk reduction will become more effective during the coming years as shrub harvesting continues at larger scale.
	Yearly area affected by forest fires reduced by 50%	It is expected that the fire risk has been reduced in all areas where shrubs have been harvested during the project (ca. 200 hectares). Fire risk reduction will become more effective during the coming years as shrub harvesting continues at larger scale.
Output 2.1: Up-to-date inventory data of Sagarnath forest biomass available	Detailed maps of forest understory and tree biomass available	Digital maps of 16m resolution have been created for relevant forest inventory parameters (shrub height, shrub biomass, tree height, tree diameter, tree volume, tree biomass). Data was shared with Bakas and SFDP. Data is also available from the web and mobile application to all registered users.

Output 2.2: Mobile map application is introduced to plan sustainable biomass harvest and track understory extraction	20 persons at Bakas and SFDP are trained to use the app	Three user trainings held for more than 20 persons (1 female, others male). Participants included Bakas staff, SFDP representatives, forestry students and local + provincial stakeholders. User guides for the application were shared with Bakas and SFDP.
	5 weekly users of the app	10 user accounts have been created, but only 3 of them have used the system by the end of the project. In total, the system has been used on 14 days after introduction of the beta version (last 6 months of the project).
	Service agreement signed between Arbonaut and Bakas	Memorandum of understanding signed between Bakas and Arbonaut for continued cooperation. A licensing agreement has not been signed yet.
Output 2.3: Removal of easily inflammable understory biomass	30 locals are trained in sustainable harvest of understory biomass	36 locals (26 female, 10 male) are trained and skilled for harvesting understory.
	Collection of 15 000 tonnes of understory biomass	Collection of 1,140 tonnes during project. Full-fledged understory collection will start from the winter of 2023.
Output 2.4: Mobile Fire Risk Management application is introduced to plan forest fire management activities	20 persons at Bakas and SFDP are trained to use the app	Three user trainings held for more than 20 persons (1 female, others male). Participants included Bakas staff, SFDP representatives, forestry students and local + provincial stakeholders. User guides for the application were shared with Bakas and SFDP.
	5 weekly users of the app	10 user accounts have been created on request, but only 3 of them have used the system by the end of the project. In total, the system has been used on 14 days after introduction of the beta version (last 6 months of the project).
	Service agreement signed between Arbonaut and Bakas	Memorandum of understanding signed between Bakas and Arbonaut for continued cooperation. A licensing agreement has not been signed yet.

2.2 Deviations from the planned outputs and activities

The production of pellets did not reach the targeted quantity due to technical faults of the drier machine that became evident following the commissioning of the device. The problem was identified during the handover process of the dryer. The dryer was unable to dry the feedstock to the optimum level, which slowed down the pellet production. Because of that, also less shrubs were collected from the forest. The dryer manufacturer has rectified the design fault, but the proper functioning of the machine was achieved only after project end. At the time point of preparation of this report, the machine is functioning normally.

Another deviation is related to the activity 'Travel to China for pre-inspection of pellet-production machine' which could not take place due to the Corona pandemic. During the last milestone, the budgeted travel cost for this activity has been reallocated and two office managers from BAKAS visited Finland in October 2022 to present the project progress at the NCF/NDF, and to attend different meetings at Arbonaut and with potential future donors (Finnfund) related to project upscaling opportunities and next steps.

2.3 Achievement of NCF indicators

NCF core indicator	Results (quantitative)			Clarifications/Means of verification
Number of beneficiaries reached	women		460	Derived from the number of people with increased resilience to climate change.
	men		460	
	total		920	
Number of people with increased resilience to climate change	women		460	Includes number of people with improved livelihoods and their household members. Average household size is 4 persons.
	men		460	
	total		920	
Number of people with improved livelihoods	women		80	Based on the number of people that got decent jobs through this project.
	men		150	
	total		230	
New decent jobs created	full-time	women	1	- Harvesting (seasonal full-time): 49 (F), 82 (M) - Raw material collection and handling (part-time): 30 (F), 20 (M) - Machine operation and maintenance: 8 (M) full-time, 22 (M) part-time - Transport of biomass (part-time): 12 (M) - Marketing (full-time): 2 (M) - Office work (full-time): 1 (F), 4 (M)
		men	14	
		total	15	
	part-time	women	30	
		men	54	
		total	84	
	seaso-nal	women	49	
		men	112	
		total	131	

3. CLIMATE CHANGE

Climate change mitigation

- Replacement of fossil fuels by pellets: Consumption of 576.5 tonnes of fossil fuels has been avoided. 1,000 tonnes of biomass pellets and 800 tonnes of biomass briquettes have been produced. 60.4 tonnes of biomass pellet and 708.2 tonnes of biomass briquettes have been sold. 3 agencies/outlets are engaged in the sale and distribution of the pellets. 3 companies/industries (Janakpur Refinery, Kathmandu Dairy and Bhaktapur Itta Udhyog) have replaced more than 10% of their annual energy need by biomass pellets.

- Establishing the supply chain for biomass raw materials: 1,140 tonnes of fast re-growing and to a large extent invasive forest shrub biomass have been harvested. In addition, ca. 1,530 tonnes of agricultural waste products and ca. 1,585 tonnes of ply waste and bagasse have been collected.

- Awareness raising on biomass energy as a clean renewable energy source: The awareness on biomass pellets has increased in the region through dissemination activities and by directly involving the local communities in the pellet production and raw material collection process. Various events in neighbouring cities and communities were organised for demonstrating the usage of biomass pellets to local industries such as restaurants, large kitchens and brick factories.

- CO2 emission reduction (see also Table below): 110 000 tonnes of CO2-equivalent are estimated to be avoided by replacing fossil fuels through biomass pellets and by reducing the forest fire risk through the collection of highly inflammable forest understory biomass for pellet production. This estimate includes also the reductions that are expected to happen during the 9 years following project completion. Detailed maps on the forest fire risk in the project area have been prepared and are accessible to Bakas and the Sagarnath forestry officials through a mobile map application to facilitate forest fire prevention management.

- Monitoring sustainability of shrub biomass harvest: Detailed digital maps of the tree and shrub biomass have been created that are accessible to Bakas and the Sagarnath forestry officials via a web-map platform and a mobile map application. Using the app, the shrub harvest can be better planned and the harvested areas, harvest progress and harvest amounts can be tracked. 20 persons have been trained in using the app for harvest management. Furthermore, 23 permanent soil sampling locations have been established which are monitored twice a year for their soil physico-chemical parameters including soil organic carbon.

- Wider impact: Since the establishment of the factory, pellets start to be more and more considered as a viable and less costly alternative to fossil fuels across Nepal. The demand for pellets in the region is currently higher than the availability. Production and sale of pellets will continue and increase after the project lifetime, therefore it is expected that the climate mitigation impact will rise in the future.

Overview of GHG emission reductions

	Project year 1	**Project year 2**	**Project year 3**	**Annual reductions after reaching full capacity**	**Total over 12 years**
Emission reductions from usage of pellets/briquettes instead of fossil fuels (tCO2)			794,4	17 085	110 083
Emission reductions from reduced forest fire risk through shrub harvest (tCO2)			2,2	19,7	135
Total emission reductions (tCO2)			**797**	**17 104**	**110 218**

Climate change adaptation

- Reduction of forest fire risk: 1140 tonnes of the highly inflammable forest understory (shrubs) have been harvested, thus reducing the forest fire risk especially during the dry season. More than 30 local people have been trained in the sustainable harvest of the shrubs. As annual harvesting continues also after project lifetime, the frequency of forest fires will be lower than before project implementation.

- Supporting forest fire management activities: Detailed digital maps on forest fire risk, canopy fuel amount, canopy bulk density, canopy base height and existing fire breaks have been created that are accessible for the Sagarnath forestry officials to better plan fire prevention and fire fighting activities. The maps are available through a web-map platform and a mobile map application. 20 persons have been trained in using the app for fire management.

4. DEVELOPMENT IMPACTS AND CROSS-CUTTING ISSUES

The project has contributed to the economic development of the involved municipality and districts. The project activities are generating income at different levels. The area has received sectoral and national attention thanks to the operationalization of the first pellet factory at industrial scale in Nepal. So far, more

than 300 people from federal government agencies, provincial government agencies, local government agencies, students from university, and Indian investors have visited the factory site. Similarly, different potential customers from Nepali industries have visited the factory and have followed the project progress. Representatives of local sawmill and sugarcane factories have also taken keen interest to supply their by-products to the factory.

The pellet factory has been established with a yearly production capacity of 20,000 tonnes of pellets which is planned to be tripled in the future through further investment into the factory and premises. Income has been generated for the local communities by creating 230 jobs. In addition, it is planned to start equity sharing with the communities once production runs stable (expected by the end of 2023). Also the local government has been (and will be) financially supported by the project through yearly royalty payments by Bakas for the use of the forest shrubs for pellet production. Also the work of the Sagarnath Forestry Development Program is supported by the project through leasing payments by Bakas and through cost savings on fire control, fire prevention and fire fighting as the highly inflammable shrub layer is reduced each year before the start of the dry summer season. During the 20 years for which the Sagarnath plantation area has been leased for understory extraction, 600,000 tonnes biomass shall be harvested.

The project has actively promoted green climate-friendly energy. As a result, the awareness of pellets as an alternative source of energy for industrial and domestic use instead of fossil fuels has increased. More local industries have gotten interested in changing their energy source to pellets (marketing campaign and demonstration events to industries). Also the awareness on sustainable use of non-timber forest resources (shrubs) has increased through the information sessions on shrub collection and the training of local people on sustainable shrub harvest. Discussions with the workers revealed that the local people have an increased feeling of responsibility towards the forest and its sustainable use as it has now become a source of income for their community.

The project has focused on the long-term goal of creating sustainable employment opportunities for the locals. During the biomass collection from the forest floor of Sagarnath, a wider participation of local people, the majority of them women, was realized. Similarly, for the operation of the plant, local people are being trained and receive on-the-job training in the factory premises with manufacturers of the plant (Andritz). These trained personnels are gradually taking over the responsibility of daily operation and maintenance of the plant. Such technical transfer of skill will have a long-term impact for the professional career of these persons as well as for the Nepalese society. Women and marginalized people have been taken equally into account during the recruitment process. 80 of the created jobs have been given to women. The jobs also enable young women to finance their further education/studies, as discussions with the field workers have shown.

During the hiring process, the applied minimum standard wage was in accordance with the minimum district wage rate endorsed by the Chief District Officer. The personnel wages of skilled and semi-skilled staff have been fixed through negotiation based on experience and skill level. The safety of the workers has been ensured by providing safety equipment, depending on the nature of work. This includes for example hand gloves, spectacles, ear plugs, breathing masks, helmets and forest-proof boots. First aid kits are available at the work sites, both at the factory premises and at the harvest locations.

To ensure environmental sustainability of the pellet production process, the project has prepared an Environmental Management Action Plan for the factory establishment and operationalization which needs to be followed. For example, not all the shrubs are allowed to be harvested in one season. About 50% of the shrub vegetation is kept to provide sufficient amount of habitat and shelter for animals. Areas that are used by local people for firewood collection are not touched by the harvest operations. The condition of the soil is monitored at permanent sampling plots twice a year.

5. ASSESSMENT OF THE RESULTS AND IMPACTS OF THE PROJECT

5.1 Relevance

The expected positive impacts of the project have been achieved to a large extent. The establishment of the first pellet production plant at industrial scale in Nepal sets a benchmark for the alternative energy sector in the country. Selected industries in Madesh and Bagmati provinces have started replacing fossil fuels with pellets which is in line with the National Determined Contributions (NDC) targets and the national commitment of the country to become carbon neutral by 2045. The NDC 2020 has explicitly mentioned that “by 2030, ensure 15% of the total energy demand is supplied from clean energy sources [….] and 1,500MW equivalent energy will be generated from various sources including bioenergy”. Along with supporting the NDC target, the project has enhanced general awareness on clean energy sources largely within the province. Industries using fossil fuel are voluntarily switching towards the use of pellets. Few among them, particularly the brick sector, have started experimenting the use, first with a mix of coal and pellet and gradually moving towards use of only pellets for firing the bricks.

BAKAS has noted a substantial gap on the biomass policy frontier. The existing policies are largely focused on hydro power and solar energy. Biomass energy is less in focus and interest of the policy makers. BAKAS has intervened on it and proposed some essential amendments as they are the key steps towards supporting the sector. For example, the export of pellets from Nepal to any third world country was until recently connected with a 200% custom duty rate and therefore not feasible. This is contrary to the standard protocol of the country which provides even cash benefits to the industries that produce goods and services worth exporting. BAKAS has

continuously communicated this hurdle with the Ministry of Finance, and by the time of report preparation these negotiations have resulted in a lowering of the export duty down to 10% effective from 15th July 2023. Further dialogue and negotiation is still required to bring the rate down to 0% in the future which would be comparable to the export rate for other forest products.

The company has undertaken several interaction sessions with the provincial and local government bodies. Competent authorities from three tiers of governments (federal, provincial and local level) and teachers and students as well as researchers from academia have visited the factory site and provided their support and feedback on feedstock collection and marketing. The project site being the first of its kind in the country is attracting more and more people from Nepal as well as from India, too.

The targeted beneficiaries from the relatively poor local communities have been provided with jobs (very likely long-term employment). Local people, especially women and marginalised groups have been given priority during the recruitment process, and salary payments are equal for women and men of a similar skill level. The Sagarnath Forestry Development Program (SFDP) is receiving continuous income from Bakas for leasing the plantation forest for the extraction of the shrub biomass. SFDP is also benefitting from the removal of shrubs through the project as that saves efforts and cost on SFDP's side on forest fire prevention and invasive species control. In addition, the local government is financially benefiting from yearly royalty payments that Bakas is paying for the use of the forest shrubs.

5.2 Effectiveness

The expected outcomes and objectives of the project have been achieved to a large extent. Though the pellet production has not yet entered a profitable scale and therefore the agreement on equity sharing with the local communities has not been signed yet, Bakas has successfully commissioned the first commercial pellet factory in Nepal. The raw material supply chain has been established, the commercial production is running, pellets are being marketed and sold, income is being generated for the local people in form of employment and for the SFDP in form of royalty payments for the forest lease, and the forest fire risk is better controlled by removing the highly inflammable shrubs.

The major enabling factor for these achievements has been the international recognition of the project through the grant by the Nordic Climate Facility which has increased the trust of the local investment banks to provide the required additional financing for factory construction. Furthermore, the continuous efforts of Bakas on interacting with local representatives, networking with various local, regional and national stakeholders, raising awareness among the local communities and industries and working collaboratively with Arbonaut and the SFDP on sustainable harvest management, have made the project implementation successful. Arbonaut's

expertise on lidar-based forest inventory and information services for forest management have complemented the project efforts by providing updated forest inventory data/maps for the plantation area and mobile apps for sustainable harvest management and forest fire prevention management.

A major hindering factor has been the Corona pandemic which caused a delay in the factory construction process. This delay has lead to a late start of the commercial pellet production, i.e. during last 2 months of the project. Therefore the planned agreement on equity sharing with the local communities could not be signed yet and is expected to take place about one year of stable production.

An additional hindering factor has been the technical fault that was identified in the dryer machine during commissioning of the pellet production plant. Due to this technical problem, the drying of raw materials from the forest floor has been significantly slowed down with subsequent impact on the produced quantity of pellets. As a consequence, also the shrubs collection amount had to be reduced.

Another very crucial factor influencing the project outcomes has been the cost intensive establishment of the factory and production process which has been a challenge for the cash flow management. Setting up the factory has required significant investment in equipment, transportation, and storage facilities. Despite unprecedented hurdles due to increased set-up cost caused by sudden rise in price of construction material, BAKAS was able to set up the factory and start commercial production during the project period. In addition, the industry must manage the cash flow carefully to maintain profitability and to meet up its obligation for vendor payment and payment of EMI and interest. Raw material costs can fluctuate depending on the type of raw material and season, impacting profit margins and requiring the industry to maintain flexible pricing strategies. Furthermore, for effective cash flow management, regular monitoring and forecasting is being done by BAKAS. It helps the factory to ensure that the business has sufficient liquidity to cover expenses, invest in new equipment and technology, maintain adequate working capital and ensure sustainability.

5.3 Efficiency

The project managed to establish the pellet factory and raw material supply chain in sufficient time for starting the commercial pellet production still during the project lifetime. However, due to delays in the construction process caused by the Corona pandemic and challenges with cash-flow management, the commercial production started later than planned, only during the last milestone. During the project lifetime the pellet production has not yet reached a profitable level due to the slow biomass harvest process and technical problems with the dryer machine. The harvest process will be mechanized in the future to be more efficient in order to achieve a more competitive price for the pellets in comparison to the market price of coal and oil.

During the project the efficiency of the shrub chipping process was increased by utilizing a tractor in the forest at the harvest site that had a cutter mounted on it. This saved time and reduced cost by about 30% as the bulky shrubs did not have to be transported to the factory site but were processed right at the harvest location. However, the total budget of the pellet factory construction has been higher than initially planned, mainly due to a price increase during the COVID-19 pandemic. To cover the increased cost, BAKAS was arranging an additional loan from the BO2 investment bank.

5.4 Impact

Social impact: The project has brought employment and development to an area that is characterised by underdevelopment and poverty. The established pellet production is planned to be long-term and will provide stable employment for the local people also in the future while at the same time fostering the economic development of the area. The opportunity for equity sharing with the local communities sets an example of how the private sector can help to improve livelihoods of such regions.

Gender impact: Women have been given priority during the recruitment process, and salary payments are equal for women and men of a similar skill level. Some of the young women that were recruited use the salary to finance their studies.

Environmental impact: The project has established the first biomass pellet factory in Nepal which is expected to boost the usage of renewable energy sources also in other parts of Nepal. Awareness of pellets as a clean and affordable energy source has increased throughout the region. It is too early to conclude on a strong impact already now as the project duration was relatively short, but a few changes can be seen already which indicate the impact of this project: At least two similar plant constructions have by now been initiated in other parts of the country, following the example of the pellet factory at Sagarnath. Furthermore, at the divisional forest offices of the provincial government the approach for handling forest fire risk has changed – shrub removal is now part of the annual forest management planning. Finally, the Forest Regulation issued by the federal government in 2022 has made a provision stating that a royalty value should be paid for the extraction of understory shrubs, therefore providing an incentive for forest offices to make shrub biomass available for pellet production.

Economic impact: The project has introduced pellet production at industrial scale in Nepal. It will certainly lead to additional investments in the same field as it already has attracted interest by Nepalese investment banks. The demand on pellets in the region is rising. The project has also contributed to the national effort of developing this part of Nepal. This goes hand in hand with the construction of the Nepalese East-West highway that passes along the project area with the objective to attract more investment to the region.

5.5 Sustainability

As a crucial outcome of the successful project implementation, Bakas has been able to attract Nepalese investment banks to continue financing the activities also in the future. This will make it possible to increase the efficiency and profitability of the production process so that an agreement on equity sharing can be signed with the local communities.

Arbonaut has been able to provide information services for sustainable harvest management for Bakas and for fire risk management by the SFDP, potentially leading into a license agreement for the applications at later stage. Both partners, Bakas and Arbonaut, have established a cooperation that will continue beyond the project lifetime.

There is a high likelihood that the positive effects of the project will persist as the pellet production will continue after the project and is planned to be upscaled. The interest of potential pellet users is gradually increasing. At the moment of report preparation, the strongest interest is shown by dairy industries and businesses producing aerated foods. Besides the three companies that started using briquettes or pellets still during the project lifetime, by now a few additional dairy businesses have taken steps to use pellets instead of firewood for their boilers. It is likely that further industries will follow this example. Since the availability of biomass raw materials is sufficient at the current plant site, an increased demand for pellets can be answered with an upscaling of the production at Sagarnath in the future up to 300% of the current capacity. BO_2 investment bank is interested to financially support the upscaling process. Social sustainability: The employment of local people will continue as the production of pellets continues. The biomass harvest process will be more mechanized to increase the harvest efficiency and amount of collected raw materials to upscale the production and make it more profitable. That way the created jobs can be sustained and equity sharing with the local communities can be started.

Environmental sustainability: Forest tree biomass is not touched for the pellet production, only the fast-growing invasive and highly inflammable shrub biomass is used which is anyway intended for annual removal by the Sagarnath forest program even without the pellet production. Potential long-term impacts from the shrub removal on the soil characteristics are biannually monitored through permanent sample plots.

Economic and financial sustainability: BAKAS has been actively lobbying for supportive measures with stakeholders and representatives of local/provincial government in order to create a more favourable business environment for pellet production. This includes advocating for policies that promote economic growth, such as tax breaks and regulatory reform. The company has also been working closely with local officials to address any concerns or issues that may arise, and to identify opportunities for collaboration and partnership. By engaging with government and

other key stakeholders, the pellet business hopes to ensure that its interests are represented and that it is able to continue to thrive and contribute to the local economy.

5.6 Coherence

At the policy level, the national regulations were not supporting the export of pellets until recently, applying a custom duty rate of 200%. However, the project has had an influence on this regulation, and the custom duty rate for pellet exports was reduced to 10% in July 2023 after continuous discussion between BAKAS and policy makers during the project lifetime. With respect to forest policy, the project objective is coherent with the Nepalese Forest Regulation 2022 which regulates the payment of a royalty value for the extraction of forest shrubs, thus providing incentives for provincial forest departments to utilize available shrub biomass. Similarly, the national priority program under the *President Chure Conservation and Development Program* has identified the expansion of renewable energy as one of its expected result areas. The project is also in coherence with the forest management planning of the provincial government with the objective to reduce the forest fire risk at the Sagarnath plantation by removing the invasive shrub species.

There are also project initiatives which align well with our project so that collaboration has been established. The GCF-financed project *Building a Resilient Churia Region in Nepal (BCRN)*, is looking forward to collaborating with BAKAS in one of the project activities “support 500 households to access and adopt renewable energy in the project area”. As part of that project, Nawalpur, a neighbouring municipality, will provide household and commercial pellet stoves to the project beneficiaries, using pellets provided by BAKAS.

One of the community forests in Madesh province is collaborating with BAKAS to remove understory shrub and provide that to Bakas. A joint proposal has been submitted to the *Rural Enterprises and Economic Development Project (REED)* which is financed by the World Bank. Similarly, *Forestry For Prosperity*, also a project supported by the World Bank, is active in Madesh province to enhance forest-based enterprises and expand the area under plantation. The pellet production can benefit from this project as the availability of shrub biomass will increase.

6. INNOVATION

One innovation of the project is the establishment of the first biomass pellet factory in Nepal, producing renewable energy that helps to mitigate climate change, while at the same time providing employment and future prospect of equity sharing with the local communities in the production and sale of the pellets. The supported local communities are located in an under-developed region of Nepal, and women and disadvantaged people have been equally considered for the created jobs. As the pellets are produced from forest shrubs which contribute to forest fire spread during

the dry season, their removal from the forest floor also supports forest fire control and prevention, therefore contributing to climate change adaptation.

Another innovation is the use of laser scanning (Lidar) technology to measure the tree and shrub biomass in the project area at high resolution, and the setting up of a web map system with mobile access to share the biomass maps for easier harvest planning and forest fire risk management. The application supports tracking of shrub harvest operations for pellet production and provides data relevant for assessing the forest fire risk such as canopy fuel weight, bulk density and canopy base height.

7. POTENTIAL FOR SCALING UP AND FOLLOW-UP INVESTMENTS

It is planned that the project will be scaled up. In particular, it is planned to triple the pellet production amount at the Sagarnath plantation area by making the shrub harvest more efficient and profitable through semi-mechanization and diversification of the feedstock. The anticipated new feedstock consists of needles of pine from the nearby mountain district, thinning products from Sagarnath forestry project and short term rotation crop from the private plantation in Sarlahi and Mahottari districts.

Further grant financing and investment will be needed for the planned upscaling. Funding options are currently being investigated. Willingness for investment has been indicated already by Business Oxygen investment bank and equity investors. Additional options for investment or loans by international funds are being explored at the moment. A meeting with Finnfund was held who showed interest in a possible investment on upscaling this project. More details on the envisaged financing scheme are currently being prepared by Bakas to be shared with Finnfund and other investors.

8. RISKS

The project was the first of its kind in Nepal. The risks associated with the entire project are summarized below:

1. Risk associated with the collection of the biomass feedstock

This risk relates to the collection practice. The manual collection process of the shrubs using traditional harvesting methods has been slow and costly. The mitigation is the combined use of machines and human power, i.e. a mechanization of the biomass collection in the future. Through iterative actions, a status of equilibrium between cost effort and cost benefit has been identified during the project. The first adaptation made was the use of a harvesting machine for the shrubs instead of cutting the shrubs with simple equipment (sickle). Second, the collection and transport of the shrubs from collection to the factory site was initially done without processing which turned out to be an expensive solution since the total weight carried was small compared to the cost of feedstock collection. Therefore, a different approach was then used: The shrubs were dried for a few days on the ground and chipped on the site, which enhanced the cost effectiveness of the feedstock transportation. A revised agreement with the Sagarnath Forestry Development Project was made for this.

2. Risk associated with the production of the pellets

There is limited skilled manpower available in Nepal for operating the pellet plant. Therefore manpower for jobs that demand a higher skill level had initially to be brought in from India. Two skilled Indian workers were temporarily hired which had the task to supervise and train the local workers. At the time of report preparation, the Indian workers have already been replaced by local staff.

3. Risk associated with the marketing

Biomass pellets are a new product in Nepal and the marketing had to start from scratch. A complicating factor for the marketing is that a change of burner is required on customer side when changing from fossil fuels to biomass pellets. The marketing therefore puts an emphasis on the long-term financial benefit of investing into pellet stoves.

4. Risk associated with construction of the factory

The lock-down caused by the Covid pandemic has lead to a delay in several of the project activities related to the factory construction and purchase of machinery and equipment. The lock-down also caused a delay in the payments from Business Oxygen (BOs). Therefore, an additional bridging loan was acquired from NMB Bank Limited to overcome the financial difficulties. The factory establishment was also affected by the price hike on steel and other construction materials which increased the cost of the project. This has been tackled through additional loan financing from local banks. In addition, due to the war in Ukraine the fuel price and cost of raw materials and operations have increased. This had to be compensated by increasing the price of the pellets.

9. MONITORING AND EVALUATION

The project output level monitoring has been conducted by the grantee. The outcome and impact level monitoring has been made by several government agencies and academia. Representatives from the Climate Change Management Division, Ministry of Forest and Environment (MOFE) have made multiple visits to the project site. Similarly, the State Secretary from Madesh and Bagmati Province, State Forestry Director, Madesh Province, Divisional Forest Officer, Salrahi and Mahottari districts, and all provincial forestry officials responsible for sustainable management of all types of forests within the provincial jurisdiction have visited the site. They have provided suggestions and feedback on biomass collection, pellet production and marketing across various clients. Similarly, the mayor and the ward chair from the local municipality have visited the project on several occasions and have been part of few functions including tree planting at the project site.

Representatives from different international and national institutions have also visited the site and provided their feedback. Key among them are representatives from ICIMOD, Deputy Resident representative FAO Nepal, Country Director HELVETAS Nepal and Business Development Service providers from Bara, Parsa, Sarlahi and Mahottari districts, all from Madesh Province.

One of the feedbacks received from the provincial secretary was use of equipment for the collection of feedstock from the forest, particularly during the harvest. Based on the feedback and ground reality, the project has made appropriate changes in the procedural document signed by the project with Sagarnath Forestry Development Project.

The Sagarnath Forestry Development Project has suggested using the thinning products that are generated in large quantities annually from the SFDP. Part of the thinning materials are taken by the local people to use as trellis for their vegetable farming but large quantities remain in the forest floor service as source for forest fire. Accordingly, SFDP is in the process of developing the price rate for such stock. Once this process is completed, the project will collect thinning products also in future.

Furthermore, project details are provided on a monthly basis to the investor Business Oxygen investment bank as required by IFC norms. Also the project manager and other officials from Sagarnath Forestry Development Project will continuously monitor the project activities in the long-term to ensure that the forest resources are managed in a sustainable way. The project also initiated a soil monitoring on permanent sample plots to monitor the soil carbon content to identify possible effect of the shrub extraction. This monitoring is continuing beyond the project lifetime. During the project, no changes were found.

10. LESSONS LEARNT

Technical lessons learnt

a) An unexpected technical problem with the purchased dryer machine caused a significant delay in the supply of dried shrub biomass for the pellet machine. Already harvested material had to be piled up and stored as it was not possible to process it soon. As a consequence, the shrub harvest had to be slowed down. These kind of possible technical challenges had not been considered when planning the project schedule and estimating the target production quantities. Towards the end of the project we have recognized that the production of 20 000 tonnes of pellets during the project lifetime had been a too ambitious target.

b) The labour-intensive manual harvesting method that was applied to collect the shrubs from the forest has shown to be very inefficient and cost-intensive. The BAKAS team and the SFDP representatives have recognized that this way of harvest is not financially sustainable and does not contribute efficiently to reduce the forest fire risk. Shrubs must be cleared

from a much larger area than what had been achieved during the project lifetime. In the future, a mix of manual and machine-operated harvest will be applied in order to increase the harvest quantity.

c) During the marketing survey at project start the local team became aware that companies need to make a modification to the combustion chamber of their stove if they want to substitute fossil fuels with pellets. The alternative option is to acquire a completely different stove in form of a pellet burner. This is not an obstacle but requires additional support and consultations for pellet customers which need to be considered during the marketing.

Social lessons learnt

a) It is difficult to find skilled labour in the area as the skill level is generally low in the surrounding communities. Attracting temporal foreign workers has helped to train the local factory staff and to increase the local skill level.

b) A well-planned timing of the shrub harvest is crucial for ensuring that enough workers are available. The optimal timing has shown to be during the winter months before the start of the hot dry-season. Harvesting is still possible also during the early monsoon season, but it overlaps with the rice planting period in the nearby communities. During this time it has been challenging to find enough local people that are available for the shrub harvest as many are busy cultivating their fields.

Other lessons learnt

It has been overly optimistic to assume at project start that the pellet production would run at a profitable level right from production start. As the planned equity sharing agreement with the local community can only be made once the production is creating some profit, we know now that it was a too ambitious target to achieve such an agreement already during the project lifetime.

Lessons learnt from development of the IT application for sustainable harvest planning and forest fire management

As for the development of the mobile apps, Arbonaut has made the experience that it was challenging to collect user requirements during the first phase of the project because the local users did not have a clear idea on the use cases. Therefore, it would have been better to develop an alpha version of the technical solution very early on in the project even without a clear picture of user requirements. We made the experience that concrete requirements and user needs were only received after the first version was presented to users and stakeholders. While most of these requirements were considered in the final version, some of the feedback was not possible anymore to implement due to time constraints towards the end of the project.

11. OUTREACH

A brochure about the project and pellet production has been produced and distributed to more than 1000 people, largely users of the pellets. A promotional video has been created. The video can be accessed through this link.

More than 300 people from federal, provincial and local government as well as academic institutions have visited the factory site to understand the process. The company management has given several presentations about the use options for pellets and about the advantage for countries like Nepal of reducing the import of fossil fuel. The project team has given a presentation to the provincial government, to gain their support and inform them about the importance of the biomass pellets. Similarly, the project has provided the decision support tools for the extraction of the shrubs with the help of the information generated through the LiDAR-based forest survey.

The visiting journalists from local newspapers and other institutions have written about the importance of the pellet in their articles. Few of them can be found from the web link below:

- Not letting waste go to waste
- Financing Climate Adaptation
- PFAN Annual Report
- NMB Bank Collaborates with Bo2 and BAKAS Renewable
- The Industrialisation of Forest-Based Bioenergy Production in Nepal and Its Impacts on Women and Other Forest-Dependent Peoples

Arbonaut has posted about the progress of the project, the field visit to Sagarnath site and the project results on social media (Facebook, LinkedIn, Twitter). All results data (map data, field+lidar inventory data, technical report) have been disseminated to the Sagarnath Forest Development Project and the Sagarnath Forest Products Development Board. In addition, all relevant users from BAKAS and the forest authority have received logins to the web and mobile application for easy data access. Furthermore, access to the inventory field and lidar data has been shared with the Division Forest Office in Rupandehi for research purpose, and with Kathmandu Tribhuvan University, Institute of Forestry, to support an ongoing PhD research work.

Several events have been organized by the project under the environmental and sustainability theme to raise awareness on these topics in the region. For example, the World Environment Day was celebrated with representatives from the local government and community.

12. FINANCIAL SUMMARY

Expenditures, EUR	NCF	Arbonaut	BAKAS	Total
Arbonaut	249 045	64 237		313 282
BAKAS	250 948		1 508 966	1 759 914
Total	**499 993**	**64 237**	**1 508 966**	**2 073 197**

13. CONCLUSIONS AND RECOMMENDATIONS

The project has introduced manufacturing of densified biomass pellets from shrubs in Nepal. A pellet factory was established and the biomass supply chain was set up, providing more than 200 jobs for local people. The production of biomass pellets and briquettes was started during 2022, and by the end of the project 768 tonnes of pellets have been sold. Three industries in the region have started substituting fossil fuels either partly (2 companies) or fully (1 company) by pellets or briquettes. To plan and monitor the shrub harvest operations and to better control the forest fire risk in the plantation area, a mobile app was developed that provides the forest workers and the Sagarnath Forest Development project with digital maps of the forest biomass. The map data were collected using high-resolution airborne laser scanning of the entire plantation area. Despite the challenges that the factory construction involved, the project was completed in time and stayed in line with the available budget.

As a side effect, the project has created interest in the neighbouring communities and districts to collect biomass from forest management side-products and from agricultural residues. The continued interest of relevant stakeholders and industries in this project and the demand for pellets in Nepal show that there is a good potential for upscaling and replicating this approach in other parts of the country.

The project has shown that it is important to have a local partner that is well connected with local, provincial and national stakeholders and that is able to attract local financing. The active networking of Bakas with various stakeholders at different levels including the BO_2 investment bank has been essential for the progress of this project. As international coordinator, Arbonaut can confirm that a good connection with the local partner based on mutual openness, trust and very regular communication has been key for overcoming the various challenges, especially during the Covid pandemic. Also, it has been a strong benefit for this project that the team on Arbonaut's side included two Nepalese colleagues which are familiar with the local culture and habits which made the communication with the local partner much smoother. For successful project implementation, we recommend to have local staff on board in the project coordination team.

Annex 1 Project completion fact sheet

Project Name:	**Biomass Pellet industry: a clean energy solu͡on for Nepal**		
Project no.	NCF-C8-289		
Country:	Nepal	**Financing:**	
		EUR	**%**
Nordic Partner:	Arbonaut Ltd.	64 237	3.1
Local Partner:	Bakas Renewable Energy Ltd.	1 508 966	72.8
Other Partner:			
	NCF grant disbursed	499 993	24.1
	Total	**2 073 197**	**100.00**
Classification:	Combination		
Project cycle:	Project start date: 15.06.2020 Original closing date: 15.12.2022 Actual closing date: 15.12.2022		
Short project description:			

Project performance:	**Expected Outcomes and Outputs**	**Achieved**	**End-of-project status**
	Outcome 1: Production and sales of 20 000 tons of pellets	Partly	• Production ongoing and 1800 tonnes of pellets/ briquettes were produced (initial target: 20 000 tonnes) • Sales have started with 3 customers (initial target: 3) • 576.5 tonnes of coal have been replaced (initial target: 15 000 tonnes fossil fuel) • Emission reductions during the project lifetime 797 tonnes CO2e (initial target: 28 519 CO2e) • Total estimated emission reductions including the 9 years following project completion: 110 218 tonnes CO2e • 230 new jobs were created (initial target: 190) • 24 680 EUR income for local communities (initial target: annually 10 000 EUR)
	Output 1.1: Pellet factory established and running	Partly	• Factory was established and production is ongoing • Produced amounts during project: 1 000 tonnes of pellets and 800 tonnes of briquettes (initial target: 20 000 tonnes in total)
	Output 1.2: Raw material supply chain established	Partly	• Supply chain was established. Raw materials have been collected and used for pellet/briquette production. Following amounts were achieved during project: • 1 140 tonnes of shrub biomass (initial target: 15 000 tonnes) • 1 585 tonnes of ply waste and bagasse peel waste (initial target: 6000 tonnes)

			• 1 530 tonnes of sawmill by-products such as saw dust (initial target: 6000 tonnes)
	Output 1.3: Pellets are marketed and sold	Partly	• 769 tonnes of pellets and briquettes have been sold (initial target: 20 000 tonnes). • One company has replaced 100% of their fossil fuels by briquettes, one company has replaced 100% of their diesel fuel need by biomass pellets, and one company has replaced 10% of coal fuel with pellets. (Initial target: 3 private companies replace at least 10% of their energy need by biomass pellets.) • One online outlet and two physical outlets have been established (initial target: 3 outlets are distributing pellets).
	Output 1.4: Local people are engaged in raw material collection, production and marketing of pellets	Yes	• In total, 230 new jobs (for 80 women and 150 men) have been created (initial target: 190 jobs): • 181 jobs for biomass collection and handling (79 women, 102 men). Initial target: 140. • 12 jobs for biomass transport (12 men). Initial target: 10. • 30 jobs in the pellet factory (30 men). Initial target: 20. • 5 jobs for office work (1 woman, 4 men). Initial target: 10. • 2 jobs for marketing (2 men). Initial target: 10
	Output 1.5: Income generation for the community and SFDP	Partly	• 3,500 EUR have been paid to SFDP as royalty payment for extraction of shrub biomass (initial target: 15 000 EUR). • 230 new jobs have been created resulting in 24 680 EUR of salary income for the local communities during the project life-time. • Agreement on equity sharing will be made with local communities when the pellet production becomes profitable (initial target: equity sharing agreement signed during project lifetime).
	Outcome 2: Forest fire risk reduced at least by 50% measured in terms of frequency and extent at SFDP by removal of understory biomass	Partly	• Fire risk is reduced on 200 hectares from which shrubs have been harvested (initial target: roughly 6500 hectares reflecting 50% of the project area). • Fire frequency has been lower in 2022.

	Output 2.1: Up-to-date inventory data of Sagarnath forest biomass available	Yes	• Lidar and field inventory of tree and shrub biomass carried out. Detailed inventory tables and maps shared with SFDP. • Data is accessible on a web+mobile application to all registered users.
	Output 2.2: Mobile map application is introduced to plan sustainable biomass harvest and track understory extraction	Partly	• Web platform and mobile app implemented and ready for use. More than 20 persons (out of which 1 woman) have been trained to use the application (initial target: 20 persons). • 10 user accounts created on request, out of which 3 have been used during the project (initial target: 5 weekly users). • A licensing agreement between BAKAS and Arbonaut for the app has not been signed, but a memorandum of understanding was made (initial target: signed service agreement).
	Output 2.3: Removal of easily inflammable understory biomass	Partly	• More than 30 locals are trained and skilled for harvesting understory (initial target: 30 persons). • 1140 tonnes of understory shrubs harvested from 200 hectares (initial target: 15 000 tonnes from 6500 hectares).
	Output 2.4: Mobile Fire Risk Management application is introduced to plan forest fire management activities	Partly	• Web platform and mobile app implemented and ready for use. More than 20 persons (out of which 1 woman) have been trained to use the application (initial target: 20 persons). • 10 user accounts created on request, out of which 3 have been used during the project (initial target: 5 weekly users). • A licensing agreement between BAKAS and Arbonaut for the app has not been signed, but a memorandum of understanding was made (initial target: signed service agreement).
Climate change outcomes and impacts:	3281 tonnes of CO2-equivalent have been avoided by replacement of fossil fuels through biomass pellets. 1,000 tonnes of biomass pellets and 800 tonnes of biomass briquettes have been produced. 60 tonnes of biomass pellet and 708 tonnes of biomass briquettes have been sold. 3 agencies/outlets are engaged in the sale and distribution of the pellets. 3 companies/industries (Janakpur Refinery, Kathmandu Dairy and Bhaktapur Itta Udhyog) have replaced more than 10% of their annual energy need by biomass pellets. 1140 tonnes of the highly inflamable forest understory (shrubs) have been harvested, thus reducing the forest fire risk especially during the dry season. The project has actively promoted green climate-friendly energy. As a result, the awareness of pellets as an alternative source of energy for industrial and domestic use instead of fossil fuels has increased.		

<table>
<tr><td>Development outcomes and impacts:</td><td>The pellet factory has been established with a yearly production capacity of 20,000 tonnes of pellets. Income has been generated for the local communities by creating 230 jobs out of which 80 have been given to women. The local government has been (and will be) financially supported through yearly royalty payments for the use of the forest shrubs for pellet production. The Sagarnath Forestry Development Program is supported by through leasing payments by Bakas and through cost savings on fire control, fire prevention and fire fighting.
More than 30 local people have been trained in the sustainable harvest of the shrubs. Detailed digital maps on forest biomass as well as forest fire risk, canopy fuel amount, canopy bulk density, canopy base height and existing fire breaks have been created. The maps are accessible for the Sagarnath forestry officials to better plan the shrub harvest, fire prevention and fire fighting activities. All maps and field survey data are available through a web-map platform and a mobile map application. 20 persons have been trained in using the apps for harvest and fire management.</td></tr>
<tr><td>NCF core indicators</td><td>
<table>
<tr><th>NCF core indicator</th><th colspan="3">Results (quantitative)</th><th>Clarifications/Means of verification</th></tr>
<tr><td rowspan="3">Number of beneficiaries reached</td><td colspan="2">women</td><td>460</td><td rowspan="3">Derived from the number of people with increased resilience to climate change</td></tr>
<tr><td colspan="2">men</td><td>460</td></tr>
<tr><td colspan="2">total</td><td>920</td></tr>
<tr><td rowspan="3">Number of people with increased resilience to climate change</td><td colspan="2">women</td><td>460</td><td rowspan="3">Includes number of people with improved livelihoods and their household members. Average household size is 4 persons.</td></tr>
<tr><td colspan="2">men</td><td>460</td></tr>
<tr><td colspan="2">total</td><td>920</td></tr>
<tr><td rowspan="3">Number of people with improved livelihoods</td><td colspan="2">women</td><td>80</td><td rowspan="3">Based on the number of people that got decent jobs through this project.</td></tr>
<tr><td colspan="2">men</td><td>150</td></tr>
<tr><td colspan="2">total</td><td>230</td></tr>
<tr><td rowspan="12">New decent jobs created</td><td rowspan="3">full-time</td><td>women</td><td>1</td><td rowspan="12">- Harvesting (seasonal full-time): 49 (F), 82 (M)
- Raw material collection and handling (part-time): 30 (F), 20 (M)
- Machine operation and maintenance: 8 (M) full-time, 22 (M) part-time
- Transport of biomass (part-time): 12 (M)
- Marketing (full-time): 2 (M)
- Office work (full-time): 1 (F), 4 (M)</td></tr>
<tr><td>men</td><td>14</td></tr>
<tr><td>total</td><td>15</td></tr>
<tr><td rowspan="3">part-time</td><td>women</td><td>30</td></tr>
<tr><td>men</td><td>54</td></tr>
<tr><td>total</td><td>84</td></tr>
<tr><td rowspan="3">seaso-nal</td><td>women</td><td>49</td></tr>
<tr><td>men</td><td>112</td></tr>
<tr><td>total</td><td>131</td></tr>
</table>
</td></tr>
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Annex 2 Results Framework

See section 2.1 - Achievement of outcomes and outputs.

Annex 3 Pictures

Selected project photos are documented in an online photo album:
https://photos.app.goo.gl/PiKNNA4NMTsK2buE8

Annex 4 Tree and shrub biomass inventory - Technical report

The technical report is available from here:

https://drive.google.com/file/d/1d9yXQMNgDdJT-pAVN-6-tWTWrPcOUDr4/view?usp=sharing

Annex 5 Greenhouse gas emissions calculation

Enclosed separately to Completion Reporting

Annex 6 Other supplementary deliverables/documentation/links

A video about this project has been created.

Annex 7 Impact story

Situation before the project

Every year during the dry season, the government-owned plantation forest at Sagarnath, Nepal, covering 13,000 ha, suffers from forest fires. The forest understory, consisting mainly of invasive Eupatorium species, boosts these fires. These understory bushes rapidly grow each year during the rainy seasons and then get dry during the winter seasons, turning into a big fuel source for the forest fires. The Sagarnath Forestry Development Project (SFDP) is spending a significant budget each year to remove the shrubs in order to suppress fires.

Situation after the project

BAKAS Renewable Energy Ltd. (BREL), a company from Kathmandu specializing in climate-friendly energy sources, has established a briquette and pellet factory in the neighborhood of the Sagarnath plantation. BREL is leasing the plantation forest for extracting the fire-prone invasive understory shrubs. Local people, the majority of them women, have been trained in shrub harvest and collection of other raw materials. Additional local people were hired to operate the factory, where the chipped and dried shrub biomass is turned into densified biomass pellets and briquettes. These are used by local industries as energy source instead of fossil fuels such as coal or diesel. Arbonaut Ltd., a forestry IT and technology company from Finland, has coordinated an airborne laser scanning campaign to measure the Sagarnath forest resource. Detailed maps of the shrub density and tree biomass have been created. A mobile web map platform was established to share the collected data and to provide functionalities for supporting the shrub harvest operations and fire prevention management. To establish the factory and production chain, the project has successfully raised a significant funding of over 1.5 million Euros, besides the 500 000 EUR NCF grant.

Impact of the project

This pellet plant with industrial production capacity is the first of this kind in Nepal. Since project start, many businesses in the area have switched from fossil fuels to pellets, reducing cost and green-house gas emissions. As a side effect, the removal of the shrubs from the forest prevents an easy spread of forest fires which results in additional emission reductions. The project has created 215 seasonal and 15 permanent jobs. For the jobs related to harvest and material collection, priority has been given to women from a socially disadvantaged group of the local communities. Women are also employed in the factory. One of them, Ms. Jina Khatun from Ishworpur, a community a few kilometers away from the factory, is happy with her new position. “Before the pellet project arrived in our remote village, I struggled with unemployment. Now, working in the factory does not only provide financial stability but also brings a sense of fulfillment. It has positively impacted my life both economically and emotionally.” Mr. Sharwan Kumar Mahato, who has been hired as factory operator, shares his initial surprise about the pellet production: “We never thought that waste biomass could replace coal and LPG gas in industries. I feel very lucky to be contributing to the production of the ‘green coal’.” Once a barren land, the factory area has developed into a center of economic and environmental knowledge which has already attracted more than 300 visitors from different governmental, research and donor institutions.

Jina Khatun got a permanent job at the factory. She is handling the chipping of raw materials and feeding the chips to the pellet machine.

People from nearby communities which are employed during the seasonal shrub harvest.