

COMMUNITY ECONOMIC EMPOWERMENT THROUGH HONEY SUCTION TECHNOLOGY AND COLONY SPLITTING EQUIPMENT FOR STINGLESS BEEKEEPERS IN TANJUNG PASIR VILLAGE

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Abstract

Stingless bee (*Trigona* sp.) cultivation in Tanjung Pasir Village, Pangkalan Susu, Langkat Regency, North Sumatra has become an important economic activity managed by the Hutan Maju Bersama Trigona Farmer Group since 2024, through a sustained international community service program in collaboration with Universiti Teknologi MARA (UiTM) Terengganu, Malaysia. In its third year, the partner group faced a shift in problems from colony quantity toward harvesting efficiency and production capacity: the honey suction device used lacked suction control and an integrated filtering system, causing slow, unhygienic harvesting and occasional bee loss, while limited beehive boxes (lots) restricted colony-splitting expansion. This activity aimed to design and implement a honey suction machine with an integrated filter and to provide additional beehive lots for colony splitting. The method included needs assessment, machine design and fabrication at the Faculty of Mathematics and Natural Sciences Laboratory, Universitas Sumatera Utara, field trials, user training, and distribution of new beehive lots. Field testing on 15 August 2026 showed the machine successfully performed suction and filtration simultaneously, reducing manual filtering steps and improving honey cleanliness. The number of beehive lots owned by the group increased from around 20 to 40, with several new lots showing successful colony development. This program strengthens sustainable livelihood and supports SDGs 2, 8, and 17.

Keywords: Stingless Bee, Appropriate Technology, Honey Suction Machine, Colony Splitting, Community Economic Empowerment

INTRODUCTION

Tanjung Pasir Village, located in Pangkalan Susu Subdistrict of Langkat Regency, North Sumatra, spans an area of 1,065 hectares with a population of 4,293 residents, located roughly 92.1 km from Medan City. The village holds various economic opportunities, such as agriculture, palm sugar production, soft-shell crab farming, duck farming, the use of palm midribs, fishing, and stingless bee (*Trigona* sp.) cultivation. Over the past three years, the local government has focused on enhancing stingless bee farming, as these bees are nonaggressive, making them suitable for cultivation within residential areas, and the resulting honey commands a higher market value than honey produced by stinging bee species.

The Hutan Maju Bersama Trigona Farmer Group, which consists of 13 houses and is situated in Tanjung Pasir Village in Pangkalan Susu, is involved in stingless bee farming. This group has participated in an international community service program run by Universitas Sumatera Utara (USU) in partnership with Universiti Teknologi MARA (UiTM) Terengganu, Malaysia, an institution for its well-established stingless bee cultivation and its "UiTM

Honey" product, which is marketed globally and has undergone laboratory testing for its antioxidant and vitamin content.



Stingless Bee Colony Belonging to the Hutan Maju Bersama Trigona Farmer Group

When the collaboration began in 2024, they had to buy bee nests from forest loggers in Aceh at prices ranging from Rp 1,500,000 to Rp 3,000,000 per nest due to their insufficient understanding of colony multiplication. The partner was able to grow colonies on their own thanks to training in colony-splitting methods given by UiTM Terengganu experts. In 2025, attention shifted to product quality, as the harvested honey had a high moisture content that shortened its shelf life; a moisture-reduction machine was subsequently developed at the USU Vocational Faculty Laboratory, alongside training on propolis-based soap production.

Two new issues emerged by 2026 as a result of the service team and partner's ongoing coordination. First, the harvesting equipment remained basic: partners relied on a basic suction machine purchased from online marketplace, which lacked an integrated filtering system and an adjustable suction strength. This resulted in prolonged harvest time, occasional bee loss during suction, and residue contamination necessitating manual filtering with tea or coffee strainers, this methods considered unhygienic and inefficient. Second, despite growing proficiency in colony splitting since 2024, the lack of beehive boxes (lots) to accommodate newly split colonies prevented further production increase, even though several parent colonies were biologically ready for splitting.

Old Suction Machine

These two interrelated problems; harvesting inefficiency and limited propagation infrastructure, directly affect the quantity and quality of honey produced, and consequently the household income of farmer group members.



In addition to supporting the university's key performance indicators (IKU 2, IKU 3, and IKU 8) through off-campus student and lecturer engagement and international program development, addressing them is in line with Sustainable Development Goals (SDGs) No. 2 (Zero Hunger), No. 8 (Decent Work and Economic Growth), and No. 17 (Partnerships for the Goals). In addition to providing additional beehive lots to support colony-splitting efforts for the Hutan Maju Bersama Trigona Farmer Group, this study details the design, implementation, and field testing of an integrated suction-filtration honey harvesting system.

LITERATURE REVIEW

Economic Potential of Stingless Bee Cultivation

Stingless bee (*Trigona* sp.) cultivation has increasingly been recognized as a viable source of supplementary income for rural communities in Indonesia, largely because the species does not sting and can be reared safely near residential areas. Studies from farmer groups in West Kalimantan and Riau report selling prices for kelulut honey ranging from Rp 350,000 to Rp 400,000 per liter, and note that each colony or hive can generate an economic benefit of Rp 500,000 to Rp 1,000,000 depending on colony productivity. These figures indicate that kelulut honey commands a substantially higher market value than conventional honey from *Apis* species, largely due to its

perceived nutritional and medicinal properties, reinforcing its potential as a strategic commodity for village level economic empowerment.

Honey Quality and Moisture Content

A recurring technical constraint in stingless bee honey production is its naturally high moisture content, which is generally higher than that of *Apis* honey and can range from approximately 20 percent to more than 40 percent depending on species, season, and environmental humidity. High moisture content accelerates fermentation and shortens shelf life, making it a key determinant of honey quality and commercial value. Several dehydration methods, including vacuum drying, freeze drying, food dehydrators, and microwave heating, have been shown to reduce moisture content to below the 17 to 22 percent threshold considered acceptable under regional quality standards, while also improving phenolic content and pigmentation associated with honey quality. These findings support the rationale for introducing a moisture reduction mechanism in earlier phases of the partner program, as unresolved moisture issues directly affect the marketability and storage stability of the honey produced.

Honey Harvesting Technology

Traditional harvesting methods for stingless bee honey, including manual suction using simple pumps, are widely reported to be inefficient and prone to contamination, since residual comb fragments and debris are easily drawn into the honey during extraction. Engineering studies addressing this issue have proposed suction devices with adjustable extraction strength and automated or sensor assisted control to reduce the risk of over extraction, which can inadvertently draw bees into the collection system along with the honey. The integration of filtration mechanisms directly within the extraction unit, rather than relying on post-harvest manual straining, has similarly been identified as a practical improvement for reducing harvest time and maintaining hygienic standards in small scale honey production.

Colony Splitting Techniques

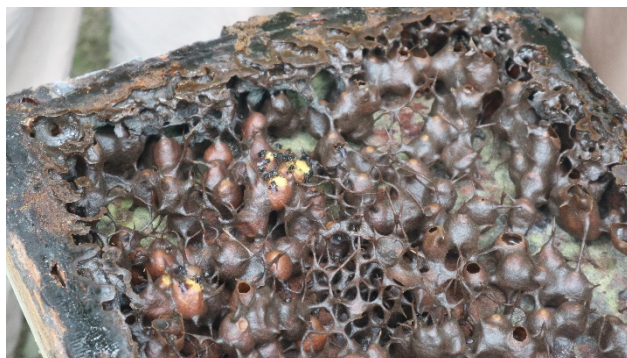
Colony splitting is a widely applied method for expanding stingless bee populations without incurring the cost of purchasing new colonies from external sources. The technique generally involves transferring brood combs containing eggs or a developing queen cell into an empty hive to stimulate the establishment of an independent colony. Comparative studies on splitting, bridging, and combined splitting bridging techniques indicate that the splitting method tends to produce more consistent brood development outcomes than bridging alone. Field trials applying nest grafting techniques on *Trigona* bee hives have also reported favorable colony retention rates, further supporting the reliability of splitting based propagation when adequate rearing infrastructure, such as empty hive boxes, is made available.

Propolis Utilization

Beyond honey, propolis generated within stingless bee hives represents an underutilized by product with considerable economic potential. Studies on value added product development from stingless bee derivatives have demonstrated that propolis can be incorporated into cosmetic and hygiene products such as soap, sanitizer, and throat spray, with reported income increases ranging from approximately 25 to 81 percent based on production cost, depending on the product category. This body of evidence supports the diversification strategy adopted in the second year of the partner program, in which propolis was introduced as a raw material for soap production.

Propolis from The Stingless Bee

Participatory Approaches in Community Empowerment



Methodologically, community service programs aimed at rural economic empowerment are commonly guided by Participatory Action Research (PAR), which emphasizes active community involvement across all stages, from problem identification to implementation and evaluation. This approach is considered effective in producing context specific and locally sustainable interventions, as it ensures that technical solutions, such as the honey suction machine and colony splitting facilities introduced in this program, are grounded in the actual needs and operational conditions reported directly by the partner group.

METHOD

The target community, Kelompok Tani Hutan Maju Bersama Trigona, participated actively in all phases of problem-finding, planning, implementation, and assessment of the participatory action research methodology of the Community Service Programme, rather than being passive recipients of the technology. This strategy is consistent with previous relevant technology interventions in rural livelihoods, which underline that when local stakeholders are actively involved in identifying needs and testing prototypes, solutions are more likely to be adopted and maintained.

The first phase consisted of a field survey and a mapping exercise, which was carried out in cooperation with the head village of Tanjung Pasir and members of the beekeeping community. The aim of this survey was to determine the current state of honey harvesting practices, the technical limitations of existing suction machine, equipment for beekeepers and the availability of bee hive lots for the splitting of colonies. Discussion took place both through direct field visits and through online coordination with the international partner team from Universiti Teknologi MARA (UiTM) Terengganu, which had previously assisted the group with training on the separation of colonies in 2024 and moisture mitigation technologies in 2025.

On the basis of the identified needs, the team held an initial socialization meeting to present the proposed solutions to the partner group. Two interventions have been agreed upon: the development of a honey suction machine equipped with an integrated filtration system and the provision of additional hives and materials needed to split the colonies. The design of the suction machine followed an iterative human-centered approach, comparable to the design-thinking methods used in other apiculture equipment development studies, in which user requirements (adjustable suction strength, filtration and storage capacity) were translated into technical specifications prior to the production of the machine.

The Team with the New Suction Machine

The honey suction machine was manufactured at the FMIPA Laboratory, Universitas Sumatera Utara by



team members with technical knowledge of machine tools. The design specifically addressed the deficiencies identified in the partner's existing equipment, namely uncontrolled suction power which could draw bees into the honey stream, tubing clogged with residuals and the lack of an integrated filter requiring manual filtering by tea or coffee sieves. The machine was constructed with a wet cell battery power supply to increase the suction strength and durability, following the model specified by UiTM Terengganu for the processing of honey. This development sequence from laboratory to field mirrors the methodology used in other beekeeping technology studies where prototypes are first assembled and tested for functionality before being subjected to field trials under realistic apiculture conditions.



(a) Developed Honey Suction Machine (b) New Bee Hive from Colony Splitting

RESULTS AND DISCUSSION

On August 15, 2026, a team consisting of Dr. Wahyu Ario Pratomo, S.E., M.Ec., Dr. Ir. Zikri Noer, S.Si., M.Si., Yola Anggia, S.E., M.Ec., and four undergraduate students of the Universitas Sumatera Utara, travelled to Tanjung Pasir Village to introduce the newly developed honey suction machine to the Kelompok Tani Hutan Maju Bersama Trigona beekeeper group, to explain its main components (suction system, integrated filtration mechanism, and collection reservoir), and to conduct a live trial directly on the partner's existing stingless bee hives. During the test, the team observed suction performance, flow continuity through the tubing, filtration efficiency, and the visual purity of the honey collected, while also monitoring whether bees were inadvertently drawn into the system and how effectively debris and hive residue were retained by the filter before the honey reached the container. The trial confirmed that the machine could perform suction and filtration in a single integrated process, reducing the need for subsequent manual straining with tea or coffee filters and shortening the overall harvesting cycle, after which the device was formally handed over to the group for independent use in future harvests, accompanied by instructions on preparation, operation, filter inspection, and post-harvest cleaning and storage.

Honey from The New Suction Machine

At the same time, the team addressed the shortage of hive lots reported by the partner by creating and distributing new wooden lot boxes as physical media for the propagation of colonies identified as ready for splitting (i.e., containing eggs or viable queens). These additional lots were provided to ensure that biologically ready colonies could be divided without delay, thereby converting the colony-splitting skills acquired during the 2024 training into tangible increases in production capacity rather than leaving them constrained by a lack of housing for new colonies.



Progress was qualitatively assessed during a three-month post-distribution monitoring period, using the apiculture baseline of approximately 20 lots in 2024 versus around 40 lots in 2026, harvesting cycles of two to three weeks, and an average honey yield of 500 ml to 1.5 liters per productive lot per batch as the programme's impact indicators, with each 100 ml bottle of kelulut honey marketed at approximately Rp75,000. Within this period, several of the newly provided lots were already in use for active colony splitting, and nearly all of the split colonies showed favorable development, while the remaining empty lots were being held in reserve pending the biological readiness of other parent colonies, reflecting a normal and expected pattern in stingless bee husbandry where splitting depends on the reproductive cycle of the source colony. This evaluation structure, which uses before-and-after comparisons based on locally reported production metrics (number of lots, harvest frequency, yield per lot, and unit price), follows the evaluation procedures adopted in comparable participatory community empowerment programmes and aligns with the programme's theory of change in which improved harvesting technology and expanded colony capacity jointly contribute to higher effective output, better product hygiene, and ultimately greater household income for the

beekeeper group. The results indicate that the intervention successfully addressed the two constraints identified at the outset of the third-year programme: inefficient and unhygienic honey harvesting, and insufficient infrastructure to translate colony-splitting knowledge into additional productive hives. The integrated suction-filtration machine directly remedied the limitations of the partners' previous self-assembled device, which lacked suction regulation, was prone to clogging, and required separate manual filtration, by providing a more controlled suction process, a built-in filter that captures debris and residue during extraction, and a larger, more durable collection system powered by a wet-cell battery as recommended by the UiTM Terengganu collaborators. Concurrently, the provision of new lot boxes removed the physical bottleneck that had begun to emerge as the group's colony-splitting capability matured, ensuring that increases in biological capacity (more egg-bearing colonies) could be matched by increases in physical capacity (more available hives). Qualitatively, partners reported that the new machine made harvesting more practical, cleaner, and faster, while the successful establishment of split colonies in the new lots reinforced their confidence in managing kelulut bee cultivation independently, with the university team increasingly assuming a facilitative rather than directive role. These outcomes are consistent with the programme's broader trajectory from basic technology introduction in 2024, through quality and value-added processing in 2025, to efficiency and capacity consolidation in 2026, and suggest that the combination of appropriate technology transfer, hands-on training, and targeted infrastructure support can sustainably enhance both the technical and economic dimensions of community-based stingless bee enterprises in rural North Sumatra .

CONCLUSION

Three years of international cooperation between Universitas Sumatera Utara and Universiti Teknologi MARA (UiTM) Terengganu allowed Hutan Maju Bersama Trigona Farmer Group in Tanjung Pasir to move from knowledge based to self-supported beekeeping, with a move to a combined humidity filter (2024) and a hive separator (2025). This stepwise, needs-based approach is in line with the literature on appropriate technologies which show that empowerment is most effective when interventions are developed in parallel with community capacity, and field results confirm this: hive numbers have increased from 20 to 40 units in field trials, and the newly transplanted colonies have developed well, mirroring the improvements reported in similar Indonesian stingless beekeeping programmes.

These results support the general argument that technology and participation are complementary, not substitutable, requirements for sustainable rural development, and the clean and high-yield harvesting achieved here is consistent with evidence that the modernised facilities can significantly increase yields and protect colonies in comparison with traditional methods. Some plots remain empty until the colonies are ready, indicating that the need for continued monitoring rather than further installation should be the priority of future efforts, as well as market and branding support, a gap noted in similar studies. Overall, the programme demonstrates that, in accordance with SDGs 2, 8 and 17, progressively developed, participative appropriate technologies can enhance the economic self-sufficiency of rural beekeeping communities.

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