



Empowering Coastal Communities through Crab Shell Waste Valorization: A Community-Based Environmental Conservation Program in Cirebon, Indonesia

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Abstract

Blue swimming crab (rajungan) is the main catch in Citemu Village, a coastal village in Mundu Sub-district, Cirebon Regency, Indonesia. Residents boil the crabs and pick the meat, and the shells are left as waste that gives off a strong odor and attracts flies. This community service program aimed to document the local baseline of shell waste and assets, to teach a simple shell-processing sequence, and to include an environmental theology perspective in the training. The program applied an asset-based community development (ABCD) approach in six stages in 2024, namely observation, an environmental education workshop, three seminars, and evaluation. Twenty-six representatives of village institutions, neighborhood units, and fisher business groups took part. Data came from field observation, an interview with the village head, training materials, photographs, and attendance and expense records, and were analyzed descriptively. The results show that observation recorded about five fiberglass containers of shells per production house each week and three existing destinations for shells (dumped, sold wet, or sold dried). Participants were trained in drying and disk-mill grinding of shells, and village youths produced shell powder intended as poultry feed material in a milling trial. The training presented waste as part of creation that should not be wasted. Knowledge change, shell volume, production yield, income, and environmental quality were not measured. In conclusion, the program shows that a low-cost processing sequence can be taught and demonstrated with local assets. Its effect on waste and income remains untested, and the nutritional quality and safety of the powder require laboratory and feeding evaluation.

Keywords: Blue Swimming Crab, Crab Shell Waste, Asset-Based Community Development, Environmental Theology, Coastal Community.

Abstrak

Rajungan merupakan hasil tangkapan utama di Desa Citemu, desa pesisir di Kecamatan Mundu, Kabupaten Cirebon. Warga merebus rajungan lalu mengupas dagingnya, sedangkan cangkangnya ditinggalkan sebagai limbah yang berbau menyengat dan didatangi banyak lalat. Pengabdian ini bertujuan mendokumentasikan kondisi awal limbah cangkang dan aset lokal, mengajarkan urutan pengolahan cangkang yang sederhana, dan memasukkan perspektif teologi lingkungan ke dalam pelatihan. Kegiatan memakai pendekatan Asset-Based Community Development (ABCD) dalam enam tahap pada tahun 2024, yaitu observasi, workshop edukasi lingkungan, tiga seminar, dan evaluasi. Peserta berjumlah 26 perwakilan lembaga desa, rukun warga dan rukun tetangga, serta kelompok usaha bersama nelayan. Data diperoleh dari observasi lapangan, wawancara dengan kepala desa, materi pelatihan, foto, serta catatan kehadiran dan pengeluaran, lalu dianalisis secara deskriptif. Hasil menunjukkan bahwa observasi mencatat sekitar lima wadah fiber berisi cangkang per rumah produksi setiap minggu, dengan tiga tujuan cangkang yang sudah ada, yaitu dibuang, dijual basah, atau dijual kering. Peserta dilatih mengeringkan dan menggiling cangkang dengan disk mill, dan pemuda desa menghasilkan tepung cangkang sebagai bahan pakan unggas dalam uji coba penggilingan. Pelatihan menempatkan limbah sebagai bagian dari ciptaan yang tidak boleh disia-siakan. Perubahan pengetahuan, volume cangkang, rendemen, pendapatan, dan kualitas lingkungan tidak diukur. Kesimpulannya, program ini menunjukkan bahwa urutan pengolahan yang murah dapat diajarkan dan diperagakan dengan aset lokal. Pengaruhnya terhadap limbah dan pendapatan belum diuji, dan mutu gizi serta keamanan tepung perlu dievaluasi melalui analisis laboratorium dan uji pakan.

Kata Kunci: Rajungan, Limbah Cangkang Kepiting, Pengembangan Masyarakat Berbasis Aset, Teologi Lingkungan, Masyarakat Pesisir.

A. INTRODUCTION

Rajungan is boiled and picked by hand in the production houses of Citemu Village, a coastal village in Mundu Sub-district, Cirebon Regency, West Java. The meat goes to local buyers. The shells stay in the village. In several production houses the team found them stored in fiberglass containers, called fiber locally, at about five containers per house each week. At these storage points the shells gave off a strong odor and attracted flies. The village head, who met the team in the village on 28 November 2024 as recorded in the project logbook, reported about 4,246 residents, of whom about 98% work as fishers. Other sources give lower shares. Adriyani et al. (2020) reported 81.98% fishers in a population of 3,819 to 3,926, and a regional news report put the share at nearly 90% (Detikjabar, 2024). The authors treat the village head's figure as an interview statement rather than as a verified statistic, and all three sources describe a village whose livelihood rests on fishing. About 2% of residents are capital owners, locally called *bakul* or *langgan*, who lend money or goods and are repaid in cash or in catch. This arrangement resembles the patron-client ties described for Indonesian fishing communities (Kusnadi, 2000), and it sets the socioeconomic terms for any new activity in the village, since a household that owes a *bakul* works first on what repays that debt. Economic pressure of this kind has been shown to shape how rajungan fishers on the north coast respond to management measures, even when they know what those measures require (Triyanti et al., 2021).

Rajungan, identified in the project documents as *Portunus pelagicus* and not verified taxonomically for this program, is the commodity the program worked with. Cirebon Regency is the principal rajungan landing area of West Java. Production was recorded at 5,645 tons in 2023, the largest in the province, and the regency holds more crab mini-plants than any other regency in West Java, with meat picking carried out largely by women (Pulung et al., 2025). An earlier figure of 12,640.08 tons for 2021, attributed to the regency fisheries office, is more than twice as high (Maulana et al., 2024). This article uses the 2023 figure, because it is the more recent and is reported within a study of the rajungan fishery itself.

At village level the available evidence differs from the account the village head gave. He described Citemu as one of the largest rajungan-producing villages in Mundu Sub-district. The one peer-reviewed study of fisheries in Citemu records the catch of village fishers between July and November 2023 as dominated by squid, followed by scad, mackerel, anchovy, and cuttlefish, and it does not list rajungan among the main groups (Mustaruddin et al., 2024). That study also notes that marine fish production in the Cirebon area is landed mainly at the Kejawan fishing port and at the Bandengan landing site in Citemu. The two accounts can be reconciled, because picking is not the same as landing. The regency holds the largest concentration of crab mini-plants in the province, and the shells the team observed come from crabs boiled and picked in the village, whether or not those crabs were landed at Citemu itself. What matters for this article is the condition the team could observe, namely that shells accumulate in production houses in the village. The superlative claim about village production is reported as an interview statement, since no official village-level statistic supports it.

Shell waste is a recognized disposal problem in seafood processing. Crustacean shells are generated at roughly eight million tons a year worldwide, are commonly discarded at sea or sent to landfill, and can alter soils, waters, and marine ecosystems where they accumulate (Topić Popović et al., 2023). The same shells hold protein, minerals, and chitin that can be recovered instead (Yan & Chen, 2015). Rajungan shell flour has been reported at 19.97% calcium and 1.81% phosphorus, with 32.95% protein cited for crab waste in general (Zahro & Ainiyah, 2022). What the shells do in Citemu is less certain. No air, water, or health measurement exists for the village. The odor and the flies were observed by the team, while the wider risks of pollution and disease are plausible on evidence from elsewhere and remain untested locally. This article treats them accordingly.

Shells already leave the village by three routes, which the training materials listed as dumping, sale while wet, and sale after drying. Each has a limit. Dumping keeps the nuisance in the village. Sale while wet moves a heavy and unprocessed material at whatever price the buyer offers. Sale after drying adds labor without adding a step that raises the price. None of the three was recorded with a price or a named buyer, so households had no basis for comparing them. Picking skills are widespread among residents. Experience in processing the shells is not.

Community programs have worked with rajungan by-products before. (Adriyani et al., 2020) assisted a rajungan cracker group in Citemu itself, using material other than shells. (Mudaningrat et al., 2020) proposed processing lemi into food products in the (Mudaningrat et al., 2020) installed a crusher and a storage place for shells at a fish landing site in Karawang. (Mubaroq & Jailani, 2022) supported rajungan micro-enterprises in (Murdiningsih et al., 2021) trained fishers' wives in Barru, and (Saputri et al., 2023) trained residents in shell-based products in Konawe Utara. (Natalia et al., 2021) showed that chitosan can be produced from rajungan shells at room temperature. Taken together, this work establishes that shells can be collected, reduced in size, and turned into saleable material, and that training is the usual point of entry. It says little about two things. The first is how the assets a community already holds were inventoried before an intervention was designed. The second is how environmental education was connected to the religious vocabulary that these communities use for obligation and restraint. We found no documented program on shell waste in Citemu. The contribution of this program is correspondingly narrow. It documents a processing sequence taught to village-level representatives, with an asset inventory taken beforehand and an environmental theology perspective carried through the sessions.

The program used asset-based community development (ABCD), which starts from what a community already holds instead of from its deficits (Kretzmann & McKnight, 1993) and which has been applied to local enterprise assistance in Indonesia (Fitrianto et al., 2020). In the form widely used in Indonesian community service, ABCD proceeds through discovery, dream, design, define, and destiny phases (Dureau, 2013). Empowerment here means increasing the capacity of groups to act on their own conditions (Zimmerman, 2000). The approach fits a village that already holds a steady supply of shells, the labor that produces them, and an organizational base of fisher groups.

The environmental theology perspective rests on Islamic concepts that are widely discussed in the literature. Humans are described as stewards (khalifah) who hold the earth in trust (amanah), and creation is not made in vain (Q. 3:191; Foltz et al., 2003; Nasr, 1996). The Qur'an also prohibits corruption on earth after it has been set in order (Q. 7:56) and excess in consumption (Q. 7:31), and Muslim writers on the environment have read these provisions as grounds for duties of conservation (Khalid, 2010). In Indonesia such teachings have been used in conservation work, including through fatwas of the Indonesian Ulema Council (Mangunjaya, 2011). Waste management also has a statutory basis in Law No. 18 of 2008 (Undang-Undang Republik Indonesia Nomor 18 Tahun 2008 Tentang Pengelolaan Sampah, 2008). In Citemu the perspective entered the program through the training materials, which treated waste as part of creation and linked the economic use of shells to a wider concern for sustaining life. The program did not measure how participants received this perspective, so it is presented as part of the intervention and not as a tested effect.

The program had three objectives. The first was to document the baseline of shell waste and the local assets that could be used to address it. The second was to teach a simple shell-processing sequence to community representatives and to test it in a trial production. The third was to include an environmental theology perspective in the training and to record what the program did and did not demonstrate.

B. METHODS AND IMPLEMENTATION

This was an asset-based community service program implemented in Citemu Village, Mundu Sub-district, Cirebon Regency, in 2024 by three lecturers of UIN Siber Syekh Nurjati Cirebon. Funding came from the Directorate of Islamic Education, Ministry of Religious Affairs, under its environment-based community service scheme.

The project describes six stages, namely observation, workshop, seminar stages I, II, and III, and evaluation. The stages were aligned with ABCD phases as shown in Table 2. Participants were 26 representatives (Table 1). They were mostly chairs of village bodies and groups, and they were not limited to fishers. Chairs of seven joint business groups (KUB) attended, while the village head reported eight fisher groups. Because participants were representatives, the findings describe the training of community leaders and not of every household that picks crabs.

Table 1. Participants by category.

Category	Positions represented	n
Village institutions	Chairs of BPD, TP PKK, LPM, Karang Taruna, BUMDes, Pokdarwis, and Poklahsar	7
Neighborhood leaders	Chairs of three RW and nine RT	12
Fisher business groups	Chairs of seven KUB	7
Total		26

Table 2. Methodological summary of each program stage.

Stage	Objective	Participants	Activities	Data collection procedure	Evaluation indicator
1. Observation 20 and 22 Nov (ABCD discovery)	Establish the baseline of shell waste and inventory local assets	Project team; village head; households in production houses	Direct observation of shell storage and handling; interview with the village head; inventory of natural, human, physical, social-institutional, and financial assets	Field notes and photographs; unstructured interview	Containers of shells per production house per week; asset categories documented
2. Environmental education workshop 4 Dec (ABCD dream)	Raise shared concern for coastal waste as a basis for joint action	26 representatives (Table 1); resource person from environmental education practice; Cirebon Regency Environmental Agency	Session on coastal pollution sources, the 3R principle, government roles, and the meaning of coastal conservation	Slide deck; attendance and catering records; photographs	Session delivered; number of participants attending
3. Training day one 4 Dec (ABCD dream and define)	Present the economic value of shells and the religious-ethical ground for not wasting them	26 representatives; resource person for shell processing	Product options (fertilizer, feed additive, handicraft); production chain; shell composition; environmental theology material	Slide deck of the resource person; photographs	Topics delivered; product options and production chain presented
4. Training day two	Specify a processing	26 representatives	Low-cost processing	Slide deck; photographs	Processing steps and

5 Dec (ABCD design)	technique that local assets can support	ves; resource person for shell processing	sequence; facilities required (land, drying dome, milling machine)		facility requirements specified
5. Training day three and trial 6–8 Dec (ABCD destiny)	Demonstrate the sequence and test it in a trial production	26 representati ves; village youths as operators; project team as facilitators	Practice of drying and disk-mill grinding; trial production of shell powder; plan for a follow-up group	Photographs and video of the trial; product observation	Shell powder produced
6. Evaluation (ABCD destiny)	Review implementation and formulate follow-up recommendatio ns	Project team	Review of the stages and drafting of recommendati ons	Project report	Follow-up recommenda tions formulated

The environmental theology perspective was operationalized as training content rather than as a measured variable. It was delivered by the resource person for shell processing on the first training day, in the form of statements about waste as part of creation and about the intention behind processing it. For analysis, the authors mapped those statements onto themes in the literature on Islamic environmental thought (Foltz et al., 2003; Khalid, 2010; Mangunjaya, 2005).

C. RESULTS AND DISCUSSION

Stage 1. Observation, baseline conditions, and local assets

Observation took place on 20 and 22 November 2024 in the production houses where rajungan is boiled and picked. Table 4 gives the baseline findings that the records support. Shells were stored in fiberglass containers, and one production house generated about five containers a week. Odor and flies were observed at the storage points. Meat is sold to *bakul*, and the training materials described three destinations for shells, namely dumping, sale while wet, and sale after drying. The team found that picking skills were widespread among residents, whereas experience in processing shells was absent.

Table 3. Baseline findings on shell waste in Citemu Village.

Item	Finding	Basis
Shell generation	About five fiberglass containers per production house per week	Team observation
Existing destinations of shells	Dumped, sold wet, or sold dried	Training materials
Observed nuisances	Strong odor and flies at storage points	Team observation
Skills in the community	Meat-picking skills present; shell-processing skills absent	Team assessment
Training needs identified	Drying and size reduction of shells; the economic value of the product; handling of waste for environmental reasons	Team assessment from observation and interview
Requirements to start processing	Land, a drying dome, and a milling machine	Training materials

The asset inventory (Table 5) follows the ABCD premise that groups act from what they already hold (Mathie & Cunningham, 2003). Two features matter for the design of any processing route.

Shells already reach buyers in wet or dried form, so processing has to offer a better return than these routes, and the program did not make this comparison. Dependence on *bakul* for credit and for the sale of meat (Kusnadi, 2000) may also shape how a new product competes for the same households' time and capital. Shell composition reported in the literature suggests a source of minerals and protein (Younes & Rinaudo, 2015), but the composition of Citemu shells was not analyzed.

Table 4. Assets identified in Citemu Village.

Asset type	Assets identified
Natural	Rajungan shells generated continuously by meat picking
Human	Fishers and household members with meat-picking skills; village youths who operated the mill in the trial
Physical	Fiberglass storage containers; open space for sun drying on tarpaulin; a disk mill used in the trial
Social and institutional	Eight fisher groups reported by the village head; village bodies listed in Table 1; the Cirebon Regency Environmental Agency as an external partner
Financial	Village funds, proposed in the planning stage as a possible source of support for equipment; credit relations with <i>bakul</i>

Stage 2. Environmental education workshop

The workshop was held on 4 December 2024 and delivered by an environmental education practitioner in cooperation with the Cirebon Regency Environmental Agency, and 26 representatives took part. The slide deck, titled *Melestarian Lingkungan Pesisir dari Limbah* (Preserving the Coastal Environment from Waste), covered community involvement in waste management, the role of government through regulation and incentives, the use of environment-friendly technology and monitoring, strategies to reduce waste such as limiting single-use plastic and applying the 3R principle, the definition and importance of coastal conservation, and sources of coastal pollution from agriculture, households, and industry. The content addressed coastal waste in general. Rajungan shells were taken up in the seminars.

Public education of this kind has been discussed as part of environment-based coastal development (Trinanda, 2017). Waste management in Indonesia is also a duty shared by government and residents (Pemerintah Pusat Indonesia, 2008) and the workshop's attention to government roles and community participation reflects that arrangement.

Stage 3. Training day one, economic value and environmental theology

The first training day, on 4 December 2024, presented the economic potential of shells and the options for products. Three options were named, namely organic fertilizer, feed additive, and simple handicrafts. The slides of the shell-processing resource person described the production chain as collection and sorting, drying, milling, packing, and sale, and named four determining factors, namely education, government policy, solid human resources, and facilities. A composition slide gave 19.97% calcium, 1.81% phosphorus, 32.95% protein, and 10.89% crude fiber and attributed them to a Universitas Yudharta Pasuruan publication. In that publication (Zahro & Ainiyah, 2022), calcium and phosphorus refer to rajungan shell flour, whereas protein and crude fiber refer to crab waste in general. None of these values was measured on Citemu shells.

The slides also listed the effects of unmanaged shells, namely pollution, odor, flies and maggots, a source of disease, and dirt, and noted that people were reluctant to process shells because they regarded them as garbage. They then proposed a different view of waste. Waste was described as a creature, all creatures were said to interact with one another, no creation of God was said to be in vain, and a threat to one creature was said to be a threat to others, humans included. The example given was that felling trees removes the birds that carry seeds. The slides added that processing waste should not be motivated by economic gain alone but should aim at a sustainable cycle of life in which surroundings stay clean, pollution is avoided, conflict is prevented, and soil is not contaminated.

The product options match those pursued in other programs, including feed, fertilizer, and chitosan (Natalia et al., 2021). The production chain gave participants the order of steps from

collection and sorting through to sale. The claim that shells are a source of minerals and protein is consistent with the literature (Younes & Rinaudo, 2015).

Stage 4. Training day two, processing technique and facilities

The second training day, on 5 December 2024, introduced a low-cost sequence that needs no advanced technology and named three facilities needed to start, namely land, a drying dome, and a milling machine. The sequence is set out in Table 6. The planning stage proposed that equipment for women processors be supported by village funds and by the fisher groups.

Mechanical size reduction of rajungan shells has been introduced elsewhere. (Widianto et al., 2020) provided a crusher and a storage place at a fish landing site in Karawang, and the Citemu sequence uses the same principle with a disk mill. The infrastructure requirement is not trivial, since covered drying and a milling machine need space and capital that the village would have to supply.

Stage 5. Training day three and the trial production

The third training day, on 6 December 2024, moved to practice, and the product trial followed on 7 and 8 December. Shells were collected and dried on the first trial day and ground on the second. Village youths operated the disk mill, and the milled material was packed in a sack as shell powder intended as animal feed material (Figures 1 to 4). Table 6 sets out the sequence and the parameters that the records do not contain.

Table 5. Shell-processing sequence demonstrated in the trial.

Step	Documented practice
Collection 7 Dec	Shells that had been boiled during meat picking were collected in fiberglass containers. Boiling removes residual meat and reduces odor.
Drying 7 Dec	Shells were spread in a single layer on a tarpaulin under direct sunlight so that they dried evenly and were not stacked.
Milling 8 Dec	Dried shells were ground in a disk mill to a finer and smaller form.
Product 8 Dec	Fine shell powder intended as animal feed material.



Figure 1. Boiled rajungan shells collected in fiberglass containers.



Figure 2. Sun drying of shells on a tarpaulin.



Figure 3. Grinding of dried shells in a disk mill.



Figure 4. Shell powder intended as animal feed material.

The trial shows that the sequence can be carried out with local labor and a small mill. Whether the powder is suitable as feed is a separate question. Shell flour has been tested as an additive in quail feed (Zahro & Ainiyah, 2022) , and broilers have been reported to digest chitin at inclusion levels up to 75 g per kilogram of diet without a significant change in weight gain (Hossain & Blair, 2007). These findings concern specific materials and doses and do not transfer to Citemu powder without analysis. Rajungan shells can also take up heavy metals such as lead, zinc, and copper

(Muslih & Ambalika, 2011), which makes testing of metal content necessary before the powder is fed to animals. Fine powder also raises occupational concerns that a repeat production would have to address.

Stage 6. Evaluation

The evaluation stage reviewed the implementation and produced the recommendations set out below. Table 7 lists the outputs that the project records support.

Table 6. Outputs supported by the project records.

Output	Evidence
Participants reached	26 representatives; attendance and catering records for 30 portions per day
Sessions held	Ten dated logbook entries, slide decks, and photographs of the workshop, the three training days, and the trial
Shell powder produced	Photographs and video of the milling trial and of the packed powder
Baseline of shell waste	About five fiberglass containers per production house per week, from team observation

Programs that reported economic effects, such as that of (Mubaroq & Jailani, 2022), described enterprise formation and employment, which need follow-up well beyond a training phase. The Citemu program stands earlier in that sequence. Joint business groups have served as an organizational base for fisher empowerment in Jepara (Suwandi & Prihatin, 2020), and seven KUB chairs took part in Citemu, which indicates an existing organizational base for follow-up.

Environmental Theology Perspective in the Program. The perspective entered the program as content. The statements in the seminar slides correspond to three themes in Islamic environmental thought. The claim that no creation is in vain matches Q. 3:191 and the view that nature is held in trust (Foltz et al., 2003). The statement that harm to one creature threatens others, humans included, matches the concern with disorder on earth in Q. 7:56 (Khalid, 2010). The insistence that the intention not remain economic matches the argument that duties of conservation arise from religious obligation and not from use alone (Mangunjaya, 2005). In Indonesia the same reasoning has been formalized in fatwas of the Indonesian Ulema Council (Mangunjaya & Praharawati, 2019) and used in education on conservation (Mangunjaya, 2011).

The program therefore offered two reasons for processing shells, an economic one based on the value of by-products and a religious-ethical one based on not wasting creation. The two reasons can diverge. If powder sells below cost, the economic reason weakens, and the ethical reason may then be what sustains the activity. Whether participants adopted either reason is unknown. Interviews or focus group discussions with participants would be needed to find out, and the delivery of the perspective by a single resource person limits what can be said about its reach.

A follow-up program should begin with measurement. A repeat production should record input weight, output weight, drying time, particle size, and storage conditions, and should send samples for proximate and heavy metal analysis before any feeding trial. Participants' knowledge and practices should be measured before and after training, and shell volumes per house should be weighed over several weeks so that any change in dumping can be detected. Safety measures for milling and the handling of wastewater and residue should be written into the procedure. An economic assessment should compare the powder with the existing markets for wet and dried shells and should include the cost of milling and packing. Cooperation with the regency government, universities, and the joint business groups can supply facilities and technical support. Other product routes, such as fertilizer or chitosan, would need separate testing because the program demonstrated only the feed powder route.

CONCLUSION

The available evidence supports three statements. First, the training process is feasible. Twenty-six representatives of village institutions, neighborhood units, and fisher business groups took part in six stages, and village youths carried the sequence through to a product in a trial that

used shells boiled during meat picking, sun drying, and disk-mill grinding. Second, the skills addressed were specific and modest, namely drying shells so that they dry evenly, grinding them in a disk mill, and recognizing shells as a material with economic value rather than as refuse, a recognition the training grounded in the view that waste is part of creation and should not be wasted. Third, the potential for further development rests on assets that the village already holds, namely a continuous supply of shells, meat-picking labor, open space for drying, a small mill, eight fisher groups, and a working relationship with the regency environmental agency.

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