


## Article

# Indigenous Knowledge Systems in Ecological Pest Control and Post-Harvest Rice Conservation Techniques: Sustainability Lessons from Baduy Communities

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**Abstract:** With the impending threat of global climate change, the past decades have witnessed an increasing recognition of the potential contribution of indigenous knowledge to tackling global challenges of environmental sustainability. In this study, we used a qualitative analysis of data collected in September 2018 from key informant interviews and focus group discussion sessions in the Baduy communities in western Java to examine how their swidden cultivation, pest control and rice preservation techniques contribute to strengthening the sustainability of their livelihoods. The study also examines the potential for knowledge sharing between Baduy indigenous knowledge holders and outside scientific communities for mutual enhancement. Our analysis of collected data indicates that while the Baduy are open to sharing their ecological knowledge with outsiders for the sake of a greater environment protection, they remain wary of adopting external knowledge sources, as these external influences constitute a threat of disruption to their own epistemic system and way of life.

**Keywords:** indigenous knowledge systems; post-harvest conservation techniques; ecological pest control; sustainable livelihoods; Baduy community



**Citation:** Habiyaemye, A.; Korina, L. Indigenous Knowledge Systems in Ecological Pest Control and Post-Harvest Rice Conservation Techniques: Sustainability Lessons from Baduy Communities.

*Sustainability* **2021**, *13*, 9148. <https://doi.org/10.3390/su13169148>

Academic Editor: Leslie A. Duram

Received: 31 May 2021

Accepted: 12 July 2021

Published: 16 August 2021

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## 1. Introduction

With the mounting pressure to build a more sustainable world in response to the looming threats of global climate change, the need for ecologically efficient solutions to the problems of modern food production techniques is widely recognized. On the one hand, the lion's share of efforts to deal with the afferent challenges has been invested in scientific research with the view to generate modern technological knowledge that addresses ecological concerns. (In a study covering USD 1.3 trillion research grants for climate change issues from 1950 to 2021, Overland and Sovacool [1] found that natural and technical sciences received USD 40 billion in research funding for climate change between 1990 and 2018, which represents 770% more funding than what was granted to social sciences. Over the same period, social science and humanities research on climate change mitigation received only USD 4.6 billion.) On the other hand, indigenous societies, such as the Baduy (Urang Kanekes of Lebak in the Banten province of Indonesia), have been using centuries-old methods that proved highly effective for soil fertilization, pest control and nature preservation by relying primarily on their traditional knowledge systems [2,3]. The natural wisdom and skills maintained by these keepers of indigenous knowledge are based on a dynamic and sophisticated understanding of their local surroundings [4–6]. Thanks to its anchoring in a holistic view of culture and nature, indigenous knowledge possesses cognitive and institutional potentials for balancing the use and conservation of natural resources. It also lends practical insights for devising adaptation and mitigation measures to cope with climate change [7–10]. Various case studies from regions as

diverse as Central Africa, South America, Zimbabwe and Vietnam have documented evidence showing how indigenous knowledge systems applied culturally anchored methods (including the use of taboos, totems and consecration of water streams and forests) to successfully preserve environmental resources from degradation or restore them once they were damaged [11–16].

Indigenous knowledge (sometimes referred to as traditional knowledge) is therefore understood as a process of social construction developed through the experiences of communities interacting with their surrounding ecosystems on the basis of shared symbolic representations, epistemology, norms, values and practices [12,17–23]. One of the main characteristics of indigenous knowledge is its localisation and its grounding in a particular culture of distinct communities whose members share the worldview that carries this knowledge [21,24]. Indigenous people (who are the depository of indigenous knowledge) can be defined as communities of people living in geographically identifiable areas within modern nation-states whose settlement is often anterior to the formation of the corresponding nation-state and who have maintained their distinct linguistic, cultural, social and organizational characteristics to a large extent [21,22]. There is, however, no official definition that sets the boundaries of who is an indigenous person and who is not: the United Nations Organization recognizes self-identification of indigenous community members as the main requirement [23,25].

Because its foundational values are based on observation and practice, indigenous knowledge is very dynamic and highly adaptive as it co-evolves with the changing elements of the environment [22,24,26,27]. Members of each new generation adapt the knowledge handed down by their preceding generations by incorporating their own observations and interpretations before transmitting it to the next generation. This transmission is usually structured through oral tradition, shared observations, practices and cultural rituals. The conservation and propagation of indigenous knowledge throughout the community is often entrusted to individuals and families who are recognized for this role by community members because of their distinctive skills and competence [22,24].

As already pointed out by van der Ploeg and Long [28] and Posey [29], among others, these sources of indigenous knowledge represent a considerable potential for strengthening sustainable development processes using bottom-up approaches. Because of the inherent ecological orientation that characterizes indigenous knowledge systems, there has been a growing realization among climate scientists and policymakers since the 1990s that much can be learned from their environmental protection methods [17,30–32]. Contact with outside population groups has constituted a constant threat of erosion for indigenous knowledge, as exemplified by the effects of centuries of colonization, attempts to assimilate indigenous people into dominant population groups and the ongoing quest for resource extraction in the rich ecosystems inhabited by indigenous population groups [13,33–35]. What distinguishes the Baduy knowledge system from other indigenous systems is the extent to which the community has been able to preserve it for more than four centuries despite the effects of more than 150 years of Dutch colonization, while being completely surrounded by the dominant Islamic culture on the rest of the Java Island [36]. Thanks to their distinctive knowledge protection mechanism, whereby a section of the indigenous community (the outer Baduy) was allowed to maintain limited contacts with outsiders, they formed a buffer zone that shields the core of knowledge custodians (the inner Baduy) from direct exposure to external influences.

The main objective of this study was to explore how the Baduy protect their ancestral knowledge and practices in rice cultivation, ecological pest control and post-harvest conservation and use them for the preservation of their livelihoods. A good understanding of the intricate connections between those practices and the sustainability of their environmental resources can indeed provide ecological lessons that modern agricultural methods and grain storage techniques could advantageously draw inspiration from in order to optimize costs and reduce environmental impact. While mindful of the threat of knowledge erosion, we were also interested in how the potential absorption of modern

scientific knowledge into the Baduy's indigenous knowledge systems could contribute to rendering the existing techniques more efficient without altering their fundamental meaning. We also wanted to examine whether the potential adoption of external sources of knowledge could strengthen the connection between their own practices and the overall objective of livelihood sustainability and nature preservation.

More specifically, the study aimed to understand the mechanism of knowledge protection from external erosion through buffering and the potential for knowledge co-creation by shining light on three mechanisms underlying its structure:

1. The functioning of organizational structures through which the Baduy communities institutionalize new knowledge creation, the protection of knowledge sources, intracommunity knowledge transmission and knowledge preservation mechanisms.
2. Sociocultural systems used by the Baduy communities to transform existing and new knowledge in order to apply it to sustaining their livelihoods and preserving their autonomy vis-à-vis the outside world.
3. Institutionalized attitudes towards external sources of ecological practices and towards knowledge sharing with outside communities.

Deeply rooted in the accumulation of empirical observations and in the interaction with the living environment, indigenous knowledge has been essential to the subsistence and survival of the entirety of humanity. Accordingly, it is acknowledged as having a considerable potential for strengthening sustainable development processes and disaster management [22,23,28,29]. Official recognition of the important role of indigenous knowledge in environmental protection gained traction thanks to the Convention on Biological Diversity (CBD) and the subsequent UN declaration of the rights of indigenous people [21,23]. Consequently, a growing number of scientists and policymakers have been calling for the integration of indigenous knowledge systems with modern scientific knowledge, especially in the realm of designing adaptation solutions to global climate change and biodiversity conservation [4,37–39]. The Convention on Biological Diversity (CBD) also recognized the value of traditional knowledge in protecting species, ecosystems and landscapes and incorporated language regulating access to it and its use in article 8 (j) in 1992.

The reach of indigenous knowledge systems goes far beyond environmental conservation, however. They also include types of knowledge about traditional technologies of agriculture, climate, subsistence, midwifery, ethnobotany, traditional ecological knowledge, traditional medicine, celestial navigation, ethno-astronomy and others [17]. Their integration into global knowledge systems, therefore, stands to enrich humanity in several domains. The International Council for Science Study Group on Science and Traditional Knowledge characterizes indigenous knowledge as:

*“A cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview”* [40] (p. 9).

Indigenous knowledge systems are complex arrays of knowledge, know-how, practices and representations that guide members of human communities in their multiple interactions with their natural environment [12,18,19,21,22,27]. In the indigenous knowledge systems, empirical knowledge is intricately connected with the metaphysical domain. Unlike modern scientific knowledge methods, indigenous knowledge systems do not impose a separation between what is empirical and objective on the one hand, and the sacred and intuitive on the other: the boundaries between them are permeable.

It is through these multiple experiments of interplay between society and environment that indigenous knowledge systems have developed diverse structures, complexity, versatility and pragmatism [41]. They encompass knowledge and practices related to agriculture and animal husbandry, hunting, fishing and gathering; struggles against disease,

injury and accidents; naming and explaining natural phenomena; and strategies for coping with sizeable changes in their environments [21,22,24,34,42]. They also include types of knowledge about traditional technologies of agriculture, climate, subsistence, midwifery, ethnobotany, traditional ecological knowledge, traditional medicine, celestial navigation, ethno-astronomy and natural disaster risk mitigation [21,24,27].

The complementarity between indigenous knowledge systems and modern science represents an important potential for knowledge co-production aimed at enhancing environmental sustainability [43]. As pointed out by Pohl et al. [43], knowledge co-production between scientists and other key stakeholders is crucial for finding more sustainable ways of managing environmental resources. Indigenous knowledge sources can help the global scientific community to tap into a rich repository of knowledge gathered over centuries of careful observation of long-term cycles. For this reason, this study maintains that these two processes of knowing can and should greatly enhance each other. (The debates on conceptualizing co-production of knowledge have still not settled on a common way to integrate the indigenous knowledge system with the mainstream scientific knowledge. On the one side, there are proponents of using boundary organizations as independent interfaces to bridge the differences [44,45], and on the other, those who see knowledge co-production as being defined by the context, involving multiple actors with a heterogeneity of cognitive and social skills (e.g., [46].) If combined, they complement each other and lead to results that neither system could achieve alone in ensuring the sustainability of life on Earth [4,33,47,48].

This study uses the examples of swidden cultivation practiced by the Baduy for rice production on dry hillsides (*huma*), their ecological pest control techniques and their harvest preservation practices as sources of demonstrable ecologically efficient practices that can contribute to enriching the global knowledge stocks needed to address the environmental sustainability challenges of our time. We contribute to the debates on the validity of indigenous knowledge by highlighting the congruence between the knowledge applied in indigenous practices and the corresponding knowledge derived according to experimental Western scientific methods.

We also highlight how the uptake of the metaphysical values associated with those practices enhances social cohesion. The remainder of the paper is structured as follows: Section 2 presents the methodology used for this study, including the data collection process. Section 3 sheds light on *huma* rice cultivation, ecological pest control and post-harvest preservation techniques used by Baduy communities to ensure their food security. It anchors these methods in the indigenous cosmic view, which is centered on living in harmony with nature. It also presents empirical findings of the experiences and attitudes of Baduy community members towards knowledge creation, protection preservation and dissemination. Section 4 discusses the aspects of knowledge creation, dissemination and preservation as well as the potential for knowledge sharing and lessons that can be drawn for the adoption of these cost-effective and eco-friendly indigenous practices. The final section concludes and suggests avenues for further research.

## 2. Materials and Methods

Understanding the working of the Baduy pest control and post-harvest rice conservation techniques requires broad insights into the cultural context in which these techniques were developed and evolved [17,43]. Similar to what is observed in numerous other indigenous communities, the relationship of Baduy communities to nature constitutes the foundation of the social construction within which their knowledge system is anchored [17]. It is generally agreed that indigenous knowledge systems comprise the local sources of knowledge that are unique to a culture or society. The aptitude and skills for the preservation of ecosystems and biodiversity among the indigenous communities are so pervasive because they are inextricably linked to the preservation of their own cultural systems, which have coevolved with these ecosystems [49,50].

The practices used by the Baduy communities for the production and preservation of the *huma* rice (*Huma* rice is cultivated on dry hillside fields, in contrast to wetland *sawah* rice; the term *huma* refers to the dry hillside fields in which this rice is planted), their main staple food, are an integral part of a comprehensive set of values, beliefs, worldview and way of life that define the community in its collective image and its projection into the future. Our research therefore sought to gain insights into the nature of the epistemic relations between the Baduy and outsiders and how they are used to preserve their own epistemic system. Our focus was on exploring the organizational structure that Baduy communities may have put in place to filter and adopt new knowledge developed outside of their communities (such as scientific ecological practices) and on probing their willingness to afford outsiders access to their indigenous knowledge systems, ecological techniques, agricultural practices and life wisdom.

In order to gain the necessary insights into the worldview and epistemological systems that inform the observed practices, we designed a qualitative data collection process that enabled us to access essential information by directly engaging with resource persons among both the inner Baduy (Baduy *dalam*) and the outer Baduy (Baduy *luar*) community members. We engaged them on their habitat, community life, belief system, agricultural techniques, interactions with fellow Baduy communities and relations with outsiders. This data collection involved in situ observations, individual interviews and focus group discussions in five Baduy villages (3 Baduy *luar* village settlements and 2 Baduy *dalam* village settlements) in the district of Lewidemar in the Banten Province of Indonesia. The last component enabled us to triangulate the information obtained from the first two sources.

In situ observations consisted of spending three weeks in a number of Baduy villages in order to get a sense of their community members' daily life, their activities and their social interactions. Observation of their agricultural practices enabled us to gain a deeper understanding of the link between their worldview, their production methods and the overall objective of nature preservation. Since no mechanized means of transportations are allowed on the Baduy territory, all displacements related to these observations had to be done on foot. Extensive discussions with various individual members of both Baduy *luar* and Baduy *dalam* communities enabled our research team members to garner and digest valuable information about the meaning of the symbolism, practices as well as objects used in various rituals that we witnessed.

With permissions obtained from the Baduy community village secretary, we conducted interviews in the local dialect by native Sundanese speakers from our research team (including one of the authors) during the month of September 2018. (Despite living in a quasi-seclusion, the Baduy use *Sunda kasar* as their daily language, which is considered a vernacular of Sundanese similar to the dialects used by surrounding communities. Other Sundanese speaking residents can thus easily communicate with them without the need for any interpreter.) The aim of the interviews was to get first-hand information from the Baduy community members themselves about the application of their traditional knowledge in cultivation, pest control and rice conservation. We also aimed to probe their perceptions about the transmission of this knowledge within their own communities and their views of the compatibility and complementarity of their knowledge system with external scientific knowledge. Interview questions also covered the various aspects of the cultural practices, the origins of the secluded life, the adaptation to a changing environment and the use of traditional approaches to mitigate the risk and impact of external influence on their way of life. The focus group discussion sessions were an opportunity for participants to share their views regarding knowledge generation, transmission, preservation and diffusion in an interactive setting.

### 3. Results

This result section is divided into two subsections: the first subsection deals with Baduy ecological practices in food production and post-harvest conservation while the



second covers the analysis of interviews and focus group discussion data collected on their knowledge production system, its transmission and preservation mechanisms, and their attitudes towards sharing of their knowledge and practices with outsiders.

### 3.1. The Baduy and Their Ecological Practices in Rice Production and Post-Harvest Conservation

From the analysis of our observations, the content of the interviews and the views of focus group discussion participants, the following insights were garnered about the epistemic traditions, sociocultural customs, livelihoods and daily life practices of the Baduy communities in their natural habitat.

#### 3.1.1. The Baduy and Their Habitat

The Baduy are members of an indigenous community of a Sundanese tribal group who call themselves Urang Kanekes. Their population of about 16,000 people is located in the Kendeng Mountains in the Indonesian Banten province, where they occupy an area of approximately 52 km<sup>2</sup> in the hill forest, only 120 km from Jakarta (this population size is an estimation given by one of the traditional leaders (*Jaro kapamarentahan*) during the interview). The Baduy are divided into two sub-categories: the Baduy *dalam* (also called Baduy Tangtu, i.e. inner Baduy) and the Baduy *luar* or *Panamping*, i.e. outer Baduy (a third layer of the Baduy community, the Baduy Dangka, lives outside the traditional Baduy territory and has largely intermingled with the surrounding Muslim population). The Baduy *dalam* are those who maintain strict adherence to the religious prescriptions and inhabit the inner areas of Desa Kanekes. They form the core of the cultural, religious and epistemic system of the community and are in charge of preserving the rituals and protecting all sacred sites of the Baduy territory. They can be distinguished from other Baduy by their traditional clothing featuring white and black colors. Currently, there are only about 40 families of Baduy *dalam*. They live in three *kampung* (village settlements) in the forbidden territory (*tanah larangan*) of Cibeo, Cikartawana and Cikeusik, where no foreigner is allowed to spend the night. They guard the knowledge of spirituality and rituals within their community, permitting no outsider to access the sacred places or view traditional rites within their territory. The traditional chief (*Jaro Tangtu*) and the spiritual leader (*Pu'un*) of the Baduy come from one of these families. The role of *Jaro Tangtu* as the custodian of Baduy traditions and customs is hereditary and transmitted to male descendants. In addition to the *Jaro Tangtu*, who comes from the Baduy *dalam*, there are two other *Jaro* elected from Baduy *luar*: *Jaro kapamarentahan* (elected by the village assembly to oversee the relations with the government) and *Jaro Tujuh*, in charge of traditions and customary laws. Decisions regarding relations with the government, of which *Jaro kapamarentahan* is in charge, are first discussed between him and the two other *Jaro* as well as with the *Pu'un* before being adopted and submitted to the regent (our interview with *Jaro kapamarentahan*, 13 September 2018).

The Baduy *luar*, in contrast, are allowed to have limited contacts with outsiders and form the buffer between the external world and the Baduy *dalam*. They are distinguished by their traditional black clothing and are also permitted to wear clothes produced outside the Kanekes territory. By serving as intermediary between the outside world and the Baduy *dalam*, they help filter external influences and constitute the shield that protects the epistemic centre from external erosion.

Thanks to their worldview based on respect for all forms of life, the Baduy have developed ecologically efficient systems of forest conservation, plant-based pest control and post-harvest rice preservation techniques that can serve as an advantageous inspiration for dealing with challenges of building sustainable livelihoods elsewhere ([51–53], etc.). The techniques used by the Baduy are of particular interest as they are considered to have been developed with the deliberate purpose of ensuring long-term autonomy of community members and protect them from subjugation by foreign invasions [54]. The Baduy are indeed believed to be the descendants of the aristocratic families of the Sunda Kingdom of Padjadjaran, who refused to surrender to Islamic conquerors and fled to

the Kendeng Mountains when the capital city of Padjadjaran was overrun by invading Fatahillah Muslims in 1579 [54,55] (other sources, such as Danasasmita and Djatisunda [56], contest this and affirm that Baduy are indigenous to this area). The worldview and techniques that they developed and transmitted through generations were thus meant to ensure a permanent autonomy and sovereignty in an area surrounded by the domination of a religion and a culture that were foreign to them. With their tenacious determination to retain autonomy and their buffering mechanism, they have also succeeded in keeping their knowledge system intact despite the constant pressure of surrounding local and foreign influences [36]. To be able to preserve their autonomy for so long, the Urang Kanekes have also cultivated among their community an ancestral repository of wisdom related to the interconnectedness of all living things with the earth and the cosmos, as well as a thorough knowledge about the conservation and sustainability of ecosystems. This knowledge system based on pre-Islamic Sundanese ways of life and religious beliefs (*Agama Sunda Wiwitan*) is pivotal to preserving their livelihoods against external overrun. It includes precepts on moral conduct (*pikukuh*) and a prohibition to kill any form of life, to use any form of transportation, touch silver or gold, drink alcohol, commit adultery or cut their hair. As one of the interview respondents explained, the strict prohibition of the use of machines, vehicles and roads has been very useful in ensuring that destructive equipment for logging and transport of wood will not easily enter the territory to threaten their forests.

### 3.1.2. Ecological Huma Rice Planting Process and Pest Control

The Baduy culture and their belief system impose the obligation on every Baduy family to farm rice on dry fields (*ngahuma*). The whole cultivation process until harvest and post-harvest preservation has to strictly avoid any use of chemicals, either as a fertilizer or pesticide, lest the quality required for long-term preservation will not be attained. The Baduy calendar and timing of rice planting uses the observation of astronomical events, such as the position of the belt of Orion and the Pleiades, but also the flowering periods of forest trees and shrubs in *reuma* (i.e., fields in fallow) (the changing of the seasons based on the flowering periods of the plants: the ripe of Kanyere fruits (*Bridelia Monoica*) for example, is used as the indicator of the coming of dry season) as well as customary calculations (see also [51]). By looking at the position of particular stars or constellations (Orion and Pleiades), they can read the season conditions along with the changing ecliptic and the expected weather so that harvest losses due to weather changes can be avoided or kept to a minimum [2].

The planting season is inaugurated by sowing (*ngaseuk*) rice seeds on *huma serang*. (Traditionally, the work of *huma* rice planting is preceded by the propitiation ceremonies in honour of Dewi Sri, the rice goddess, whom the assembled community members invoked to protect the land.) Different types of *huma* are then cultivated with delayed time intervals to mitigate the risks of harvest loss as a result of extreme weather conditions or unforeseen natural hazards. To control pests in their rice plantations, the Baduy consistently give preference to repelling rather than killing. That is why they use natural biopesticides made from *rawun pare* (*Momordica charantia*), *walang* (*Amomum walang*) or *kanderi* (*Bridelia monoica*) to repel insects and other pests from their rice instead of chemical pesticides considered toxic and damaging to the environment. The Baduy also stick the stems or the branches and leaves of *Pelah besar* (*Goniothalamus scortechinii*) in their fields at the beginning of each planting period because of their distinctive smell that serves as a repellent for rodents and insects. The use of these natural, plant-based pesticides has proved to be very effective at keeping pests at bay (*Momordica charantia*, *Amomum walang* and *Bridelia monoica* were all scientifically proven to be midget-repellent plants [57–60]).

### 3.1.3. Sustainable Soil Regeneration and Pest Control Methods

The Baduy's cosmic view, which gives precedence to spiritual life over materialism, also translates into their life leitmotiv that emphasizes taking only from nature what is important to satisfy primary needs [2,3]. For the Baduy, there is no need for excessive

surplus production that would justify the need for unnatural fertilizers. They find it sufficient for their crops to use their own home-made fertilizers which are produced with organic ingredients (Organic fertilizers are generally made from dried leaves (*koleang*) and forest humus (*surubuk*)). Soil fertility is also achieved through the practice of cutting and burning bushes to make the minerals contained in the ashes and charcoal available for rice growth (see Figure 1). This burning process plays an important ecological role, since a substantial proportion of the mineral energy that feeds the crops comes from burned forest ashes (see also [5]). The crucial ecological importance of this forest burning process is comparable to the swidden cultivation practiced by the Karen tribespeople in northern Thailand, as documented by Nakashima and Roué [5], or the customary mosaic burning practices of various aboriginal population groups of the Northern Territory in Australia, as documented by Ens et al. [48]. Such controlled forest burning is also widely known for its use in helping manage the forest biodiversity and in mitigating the risks of wild forest fire.



**Figure 1.** Huma fields prepared for sowing rice (Photo: HSRC).

When the harvesting process is completed, all land plots that were used as *huma* for that season are fallowed and can be cultivated again after three or more years. The imposition of fallow periods and the burning of forest vegetation biomass in each farming period is intended to break the cycle of pest life or to destroy rice pests. It therefore allows the soil to regenerate without the need for external fertilizers or additional pest control inputs [61]. This farming method is also closely related to the concept of low external input sustainable agriculture (LEISA) (see [62]).

#### 3.1.4. Rice Conservation in Leuit as Baduy's Symbol of Food Autonomy

*Huma* rice preservation plays a pivotal role in the lives of Baduy communities as it not only guarantees their autonomy and their food security but also represents their insurance against shortages due to adverse weather conditions, health hazards and natural disasters. Before storing the rice harvest, the Baduy allow it to dry by tying it in bunches (ears with



stalks) and hanging them on a long bamboo pole. Dried bunches are then kept in small bamboo-walled barns called *leuit*, made only from wooden materials. The Baduy build these barns on stilts with a mechanism to protect the stored harvest from rats and other rodents. The rat protection mechanism is made of wooden discs called *geuleubeug*, which are placed on top of the *leuit* stilts to make it physically impossible for rodents to reach the inside of the barns. These wooden discs are large enough that the rats have no possible way of climbing past the *leuit* leg. They may attempt to crawl horizontally on the downside, but that side is made very slippery so that no rat can crawl upside-down and reach the edge (see Figure 2). That way, rats are kept at bay without incurring any risk of being killed. The so-preserved rice can remain unattended for a long time, which can reach 50 to over 90 years (Rice barn harvest can even be inherited from one generation to the next [63]).



**Figure 2.** *Leuit lenggang* with a *geuleubeug* in a Baduy *dalam* village (Photo: HSRC).

Even though the *leuit* are built outside the houses and are left unguarded, the rice can remain safely protected for several decades because the Baduy community relies on all its members to abide by the moral conduct prescribed in *pikukuh*. The trust in their moral conduct is enough to ward off against theft. The social interdependence values are so inculcated in the Baduy community members that it would not occur to any of them to steal the rice from the unguarded *leuit*.

### 3.2. Findings on Knowledge Protection, Knowledge Transmission and Attitudes towards Its Sharing to Enhance Ecological Outcomes

Local sources of knowledge still govern the decision making and farming practices throughout the history of the Baduy communities and have ensured the sustenance of their livelihoods down to the present. For the Baduy, their indigenous knowledge processes are thus as crucial as scientific knowledge systems elsewhere in addressing production, health and environmental challenges facing the world. We have therefore sought to understand how the Baduy communities stand towards knowledge production, preservation and sharing, as well as the use of complementary sources of knowledge that can feed into their own practices.

#### 3.2.1. Traditional Knowledge Production, Transmission and Preservation Mechanisms

The bulk of the knowledge stocks that are circulated among the Baduy comes from ancestral practices and community members are encouraged to keep them without adding to their reach or shortening it. The guiding principle underlying most of their responses towards new knowledge creation or adoption of external sources is expressed by their ancestral aphorism, which was repeatedly cited during the focus group discussions: “*lojor teu meunang dipotong, pondok teu meunang disambung*”. This literally translates to: “if something is long, the Baduy should not seek to cut it, if something is short, the Baduy should also not strive to extend it”.

To enforce this principle, traditional leaders (*tokoh adat*) come to all Baduy *luar* villages every one to three months to control and clean up any prohibited objects that may have been introduced from outside for modern comfort. (Baduy *dalam* are by definition those who have always abided by the prescription and have therefore not used unauthorized objects.) The Baduy traditional leader, *Jaro adat*, is the depositor of the traditional knowledge, which is orally transmitted from father to son throughout generations and is spread among all families. Being a patriarchal society, the Baduy community relies primarily on male community members to uphold its knowledge system and traditions. Women are informed through their male relatives and learn mainly from warnings about what is not allowed, which forms the opportunity to explain to them what is prescribed by traditions and customary law. In principle, most Baduy adults are acquainted with the essential knowledge, traditions and practices. Children under the age of 10 are taught by their parents, while those above 10 can also refer their questions to the traditional leaders (*tokoh adat*) of their respective villages during any of the meetings that they regularly hold with community members.

There are no formal mechanisms for knowledge generation and preservation other than spreading it among community members so that everyone knows the essential elements of the epistemic system and thus participates in its preservation. Formal education is viewed with suspicion by the Baduy, because it brings the potential for those of them who would acquire external knowledge and become smarter to use their intellectual advantage to further their own benefits at the expense of fellow community members. The knowledge base prescribed by the *pikukuh* code of conduct is regarded as containing essential knowledge and guidance needed to preserve their environmental resources. It also serves to maintain production and consumption methods that keep community members in harmony with nature.

#### 3.2.2. Attitudes towards Knowledge Exchange with Outside Communities

Understanding the attitude of Baduy towards knowledge co-production and knowledge exchange requires the realization that, for them, the primary role of knowledge should be to preserve and sustain the resources that their ancestors have entrusted the current and future generations. Recurrent throughout most key informant interviews and group discussions that we held with both Baduy *dalam* and Baduy *luar*, their responses reflect the view among community members that nature protection and preservation is their primary responsibility. The Baduy hold onto a very conservative approach to new knowledge

development. Their doctrine is based on the conviction that, save for human greed bent on ever-increasing production, existing knowledge is capable of sustaining a healthy human existence in harmony with nature. Baduy are convinced that without keeping out modernity and technological gadgets that threaten to disrupt traditional way of life, the ancestral territory cannot be protected. They consider that permitting the entry of modern gadgets and external practices aimed at increasing efficiency could alter their mode of production and could eventually unduly burden their relationship to the environment that so far has provided all resources they need for leading a healthy life. Moreover, their cosmic view considers the Baduy territory as the heart of the entire earth, so that preserving its forests and mountains is, for them, a transcendent obligation for the protection of the world in its totality.

As pointed out by one resident of Cipondok, the Baduy are open to sharing knowledge as long as this does not bring disruption to their existing culture:

*I believe nothing is impossible if we want to learn. But we are not allowed to go to school for formal education because people, once they become clever from schooling, they use acquired knowledge to deceive others and have power on them.*

Any exchange of knowledge with the government, including proposals for infrastructure or medical clinics, must be subjected to the approval by the *Jaro pemerintahan* to ensure that nothing of what is brought from outside violates their existing customary laws. External knowledge is only accepted in rare circumstances and only when it is not in conflict with traditional laws.

A resident of Cibeo (one of the three Baduy *dalam* kampung) explains the attitude:

*There are frequent proposals from the government to give information sessions about health. We usually decline the offers. There were even proposals to build a permanent clinic. But in Baduy dalam and in Baduy luar, we oppose the construction of permanent buildings and we are still relying primarily on traditional herbal medicine for all our health care needs. Only when every available traditional medication has been tried and there is still a need for other means, then Baduy may seek the medical help provided by the government, like consulting a doctor or a midwife. Until today, however, Baduy dalam have been able to handle everything with traditional medicine solutions. Only in Baduy luar, a part of them is still exclusively using traditional medicine while the other part sometimes seeks the help from midwives.*

This filtering of outside knowledge is led by the *Jaro Kapamarentahan*. The healthy lifestyle of the Baduy relying on continuous physical activities, with prohibition to use of mechanical implements, plays an important role in keeping them away from the need for doctors and pharmaceuticals. This life hygiene holds precious lessons for outside communities as part of sustainability practices. Their combination of labour-intensive and environment-friendly production methods with a healthy lifestyle to achieve environment protection suggests that when learning from their epistemic system, it is not enough to take isolated elements from their practices. The applicability and benefits of adopting any indigenous set of practices come into full effect when the corresponding practices are seen in the perspective of their complementary practices.

Despite their traditional resistance to change, the Baduy we interacted with during interviews and focus group discussions showed a general willingness to share their knowledge for the benefit of the outside world, provided that this knowledge sharing can be structured in a way that does not violate their customary laws, but rather contributes to environmental protection in the world outside. As stressed by Pohl et al. [43], the enhancement of mutual learning for knowledge co-productions requires a deep understanding of the power relations, the availability of integrative skills and the capacity to build trust that transcends established hierarchies and cultural boundaries between epistemic communities. Nonetheless, for such an integrative learning to take place, it is important that awareness of indigenous knowledge systems and their paradigms be broadened within the mainstream scientific communities, with the view to prepare the interface for such a

collaborative learning process between indigenous knowledge depositors and modern scientific knowledge producers.

#### 4. Discussion

Baduy community members consider as part of their duty to share their experience and indigenous knowledge to enhance nature conservation anywhere on the planet but are wary of the intrusion of modern knowledge that may upset their traditional way of life and threaten the long-term sustainability of their own livelihoods. Their buffering system, which permits limited contacts between the outer Baduy with the outside world while keeping the Baduy *dalam* secluded from such contacts enables them to observe the effects of external influences on the behaviour of community members and keep out what is harmful to their culture and knowledge system. This filtering system also enables them to more accurately appraise the potential advantages that can be derived from mutual learning between the scientific knowledge and indigenous practices. It therefore makes it possible to develop better knowledge toolkits combining the best of both worlds to face the looming challenge of climate change. A holistic knowledge framework for humanity is critical if the environmental crisis confronting us as a people is to be averted swiftly and appropriately, as pointed out by various indigenous knowledge scholars. As Nakashima and Roué [5] have pointed out, the integration of traditional knowledge into modern science is often conceived as implying the application of a validation process based on scientific criteria that purportedly separates the useful from the useless, the objective from the subjective, the indigenous useful ‘science’ from indigenous superstitious ‘beliefs’. Such a process of cherry picking, extracting only the knowledge corresponding with the paradigm of Western science and rejecting the rest, may threaten indigenous knowledge systems with dismemberment and dispossession.

The resistance of indigenous knowledge holders to embracing modern scientific methods is generally born out of negative experiences of disruption that the modern way of life brings to indigenous livelihoods [64–66]. The fear of material greed creeping in to disrupt the social harmony and the problem of intellectual property rights have also repeatedly been raised when unscrupulous Western corporations use patenting of technologies based on indigenous knowledge to deprive its originators of their traditional rights to use the epistemic asset that they have always held and exploited [65,67]. Although the surveyed Baduy community members reflected the consistent willingness of their community to exchange knowledge with outside communities for the greater benefit of environmental conservation, the implementation of such exchange requires a process of mutual trust building, supported by integrative skills and an organic approach to transboundary communication. The integration of external knowledge in indigenous epistemic systems is by itself a potential threat because it carries the risk of altering these systems if the integrative process is not tightly controlled [22,64,66]. That is why the process of social co-learning and co-production should explore and deepen the understanding of the following issues that may contribute to fostering better dialogue and mutual complementarity:

1. It is still often argued that some aspects of indigenous knowledge are incompatible with modern science. Those arguments are usually rooted in an ethnocentric paradigm, whose validation norms are defined by a cultural context, yet purports to separate knowledge from culture. It would be interesting to explore new epistemological and ontological theories of knowledge validation based on a new thinking about diversity of cognition.
2. Further inquiry is needed in order to explore the optimal ways to foster the dialogue between modern scientific knowledge practitioners and indigenous knowledge holders in various domains where they can complement one another. Complementarity of knowledge systems is namely a major source of potential for mutual learning.
3. Further debate in the intellectual property right regimes should thus also be opened to explore how the owners of traditional knowledge sources can benefit more (be-



yond the existing sui generis protection) from their contribution to the global knowledge stocks.

## 5. Conclusions

In this article, we have explored the indigenous practices used by the Baduy communities in sustainable rice cultivation, ecological pest control and harvest conservation as well as the mechanisms used to protect and preserve the knowledge system in which those practices are embedded. By their cost efficiency and the ease with which they can be applied, the agricultural and environment conservation methods practiced by the Baduy communities are potent sources of practical knowledge that can be applied to devise solutions to the sustainability challenges of our time. The rice production and conservation techniques used by the Baduy, are underpinned by their harmony with nature and offer various advantages for enhancing the sustainability of livelihoods at minimum costs. By avoiding the use of chemicals and relying exclusively on natural methods, Baduy practices provide an ecological and cost-effective way of managing land and agricultural resources.

Their combination of ecologically sound production methods with a healthy lifestyle to achieve environment protection suggests that when learning from their epistemic system, it is not enough to selectively adopt only preferred elements from their practices. The integration of traditional knowledge system with mainstream science and curricular education system also implies the need for a process of co-learning and knowledge co-production between mainstream scientific communities and the holders of traditional sources of knowledge.

Where modern scientific research intersects with indigenous knowledge for mutual enrichment, it is important to remain alert to the vulnerability of indigenous knowledge systems as well as to the vulnerability of the livelihoods of their depository communities to external threats. The rich contribution to global knowledge stocks can only continue to benefit humanity if the distinctive ecosystems and livelihoods of their holders are adequately protected from appropriation attempts by outsiders as well as from the altering influences of knowledge hybridization. The readiness of the Baduy communities to share their knowledge with outside scientists for bettering environmental conservation outcomes is a welcome opportunity that ought to be seized with the view of broadening and enriching the range of instruments that the global community can deploy to confront the looming threats of climate change. However, for the global community to continue benefiting from these knowledge sources, any form of knowledge exchange with indigenous knowledge systems ought to be organized in a way that puts their protection and preservation at the heart of any engagement.

**Author Contributions:** Conceptualisation, A.H. and L.K.; methodology, A.H.; formal analysis, A.H.; investigation, L.K. and A.H.; resources, A.H.; data curation, L.K.; writing—original draft preparation, A.H. and L.K.; writing—review and editing, A.H.; visualization, L.K.; project administration, A.H.; funding acquisition, A.H. All authors have read and agreed to the published version of the manuscript.

**Funding:** No external funding was received for this study.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Informed consent was obtained from all participants involved in the interviews and focus group discussion sessions. No personal data of key informants or focus group discussion participants were collected during this study. No reward or incentive was used to obtain participation.

**Data Availability Statement:** Interview transcripts (in Sundanese) can be obtained from authors on request.

**Acknowledgments:** This paper is part of the research on indigenous post-harvest techniques in Western Java and Southern Africa, which was carried out with financial support from the Human Sciences Research Council. It draws on an earlier version of what was circulated as a working paper

to garner comments. The field research assistance by Monita H. Adilla is gratefully acknowledged. The authors also wish to thank the Baduy village secretary for his gracious support during the field research visit, as well as all key informants and participants in the focus group discussion sessions.

**Conflicts of Interest:** The authors declare no conflict of interest for this study.

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