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Advances in the Registration of Farmers' Varieties: Four Cases from the Global South

Bram De Jonge [1,2], Isabel López Noriega [3,*], Gloria Otieno [3], Ximena Cadima [4], Franz Terrazas [4], Siviengkhek Hpommalath [5], Frederik van Oudenhoven [2], Santosh Shrestha [6], Niranjan Pudasaini [6], Deepa Singh Shrestha [7], Devendra Gauchan [3], Patrick Kasasa [8], Tsungai Bwerazuva [9], Claid Mujaju [10] and Sipiwe Manjengwa [8]

1 Law Group, Department of Social Sciences, Wageningen University, 6708 PB Wageningen, The Netherlands; bram.de.jonge@oxfamnovib.nl
2 Oxfam Novib, 6708 PB The Hague, The Netherlands; frederik.vanoudenhoven@oxfamnovib.nl
3 Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), 00153 Rome, Italy; g.otieno@cgiar.org (G.O.); d.gauchan@cgiar.org (D.G.)
4 Fundación PROINPA, Cochabamba 4285, Bolivia; x.cadima@proinpa.org (X.C.); f.terrazas@proinpa.org (F.T.)
5 National Agriculture, Forestry and Rural Development Research Institute (NAFRI), Laos Ministry of Agriculture and Forestry, Vientiane, Laos; siviengkhek@yahoo.com
6 Local Initiatives for Biodiversity, Research and Development, Pokhara P.O. Box 324, Nepal; santosh.shrestha@libird.org (S.S.); niranjan.pudasaini@libird.org (N.P.)
7 Nepal Agricultural Research Council, Kathmandu P.O. Box 5459, Nepal; deesshrestha@gmail.com
8 Community Technology Development Trust (CTDT), Harare, Zimbabwe; patrick@ctdt.co.zw (P.K.); spiwe@ctdt.co.zw (S.M.)
9 Champion Farmer Seeds Cooperative Company, Harare, Zimbabwe; tsubwe@gmail.com
10 Seed Services Institute, Harare P.O. Box CY594, Zimbabwe; claidmujaju@yahoo.com
* Correspondence: i.noriega@cgiar.org

Abstract: Over the last few decades, there has been a growing appreciation of crop varieties developed by local farmers, commonly referred to as farmers' varieties. These varieties often have attractive characteristics for both producers and consumers, such as adaptability to harsh environmental conditions and high nutritional values. Yet they are usually not sold in formal markets, and tend to be limited to farmers' seed systems. This is partially due to national seed laws that, in an effort to guarantee good quality seed of uniform and stable varieties, create obstacles for farmers' varieties to reach the market. This article describes the experiences of four countries—Bolivia, Laos, Nepal and Zimbabwe—that are developing alternative variety registration systems for farmers' varieties. Most of these cases have never been documented before. The cases present the main drivers behind and approaches to the registration of farmers' varieties in different legal contexts and at different stages of development. We conclude that farmers' variety registration systems can generate benefits including faster and cheaper variety releases, improved farmer incomes, and a larger diversity of well-adapted varieties in the market—but some important issues are still to be resolved.

Keywords: plant variety registration; farmers' seed systems; farmer varieties; seed laws; seed quality control

Citation: De Jonge, B.; López Noriega, I.; Otieno, G.; Cadima, X.; Terrazas, F.; Hpommalath, S.; van Oudenhoven, F.; Shrestha, S.; Pudasaini, N.; Singh Shrestha, D.; et al. Advances in the Registration of Farmers' Varieties: Four Cases from the Global South. *Agronomy* **2021**, *11*, 2282. https://doi.org/10.3390/agronomy11112282

Academic Editor: Niels P. Louwaars

Received: 15 September 2021
Accepted: 2 November 2021
Published: 11 November 2021

1. Introduction

Seed systems go back to the origin of agriculture. Over millennia, for each crop every farmer had a strategy to select, multiply and use seed for the next season. Remaining seed was sold or exchanged for other seed from neighboring farms. Farmers were breeders, seed multipliers, quality controllers and seed suppliers. As agricultural research and development has become more specialized and production more industrialized, tasks that used to be carried out by farmers have been taken over by specialized actors in many parts of the world. This has profoundly impacted seed systems and the diversity of crops and varieties that they supply to farmers.

Several types of seed system co-exist. At one extreme, formal seed systems deliver seed of crop varieties that have been bred, registered and released by specialized organizations based on criteria and procedures created through national policies and laws. At the other extreme, farmers' seed systems (also called informal seed systems) are managed mostly by farmers and their communities. In these systems, farmers select and multiply seed of landraces and improved varieties that are adapted to local conditions. Seed distribution is largely based on local indigenous knowledge passed down over millennia and regulated by informally established norms. Across many developing countries, farmers' seed systems supply 65–80 percent of seeds [1].

In recent decades, mixed or integrated seed systems have emerged in a number of countries [2]. They imply coordinated action between the formal and informal seed sectors: for example, farmers and farmers' organizations working outside the formal channels cultivate, multiply and distribute both improved varieties developed by the formal sector and their own landraces; and governmental and non-governmental organizations (NGOs) support the certification and distribution of farmer-managed varieties and farmer-produced seed, in line with national rules and regulations.

Landraces and varieties developed by farmers are used differently in these systems. In formal systems, breeders use them as sources of genetic variation, useful agronomic traits (e.g., pest and disease resistance; drought, heat and cold tolerance) and organoleptic characteristics valued by consumers. Participatory plant breeding programs include landraces and farmers' varieties in the pool of genetic resources subjected to participatory testing, selection and crossing, to integrate farmers' preferred characteristics in the resulting improved lines. In family farming systems, farmers cultivate landraces for their adaptability to harsh environments and reliability in the absence of external inputs. Farmers' crop management and constant seed selection, combined with environmental pressures, contribute to the continuous evolution of landraces, leading to the emergence of new ecotypes and populations with distinct characteristics.

In the second half of the 20th century, conservation efforts focused on landraces and farmers' varieties as repositories of the bulk of genetic diversity in domesticated species. In the 21st century, interest in farmers' varieties is also linked to increasing demands for more diverse and localized food production systems and a wider recognition of farmers' actual and potential roles in these systems, particularly in developing countries.

This increased interest has prompted some countries to consider the registration of farmers' varieties and landraces in the official catalogues and registers of commercial varieties, as a way to allow their inclusion in formal seed systems, and thus their commercialization in national and international seed markets. There are several examples of local varieties that have been released into the market after national and international research organizations have tested, evaluated and sometimes improved them, such as the local climbing beans that were released by the Pan-Africa Bean Research Alliance in Rwanda [3], and the landraces of various crops (including sorghum, pearl millet and pigeon pea) that were released in various countries following testing and evaluation by the genebank of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), where they were, and are still maintained [4]. In this article, we focus explicitly on cases that have involved smallholder farmers in the selection, development and registration of their varieties. We present recent experiences from four countries, Bolivia, Laos, Nepal and Zimbabwe, and reflect on the opportunities and challenges that arise from the registration of farmers' varieties.

We have adopted a broad definition of farmers' varieties, which includes local landraces, ecotypes and varieties bred by farmers through mass selection or deliberate hybridization [5,6], as well as improved varieties that have been jointly developed by farmers and formal breeders through participatory plant breeding. Based on previous works [2,7], we have identified three main characteristics of farmers' varieties: managed by farmers on-farm; good adaptation to local agroecological conditions; and dissemination mainly through farmers' social networks such as neighbors, local markets or local institutions. We

acknowledge that farmers' varieties are often considered synonymous with traditional varieties or landraces, but also note that there is legal and taxonomic uncertainty about the term [8]. Our preference for a broader understanding is informed by the recognition that in all the instances mentioned above, farmers' knowledge, local germplasm and farmers' fields are central to the development of these varieties. While we will refer to farmers' varieties as an overarching category in the remainder of this article, we may still refer to more specific terms where relevant. e.g., the case study of Laos deals with improved PPB varieties, the Bolivia study only with landraces.

2. Materials and Methods

This paper is based on a case study approach. The four countries—Bolivia, Laos, Nepal and Zimbabwe—were selected for their uniqueness and ability to demonstrate different drivers and approaches to registering farmers' varieties in developing country contexts. To our knowledge, this is the first time experiences on registering farmers' varieties in Bolivia, Laos and Zimbabwe have been reported in writing. The cases deal with different socioeconomic and policy contexts, different stages in exploring alternative procedures for registering farmers' varieties, and different crops. This provides a range of insights into challenges and opportunities. The paper aims to describe the four cases in enough detail for development workers, researchers and policy makers to compare or replicate similar initiatives somewhere else.

The work described in Bolivia and Nepal was carried out in a series of research and development projects coordinated by Bioversity International between 2010 and 2020, the last of which focused on improving the conservation and use of crop biodiversity and farmers' seed systems in remote areas of these and other countries. The work described in Laos and Zimbabwe was supported by Oxfam's program Sowing Diversity = Harvesting Security (SD = HS). This program aims to enhance farmers' capacity to access, use and improve plant genetic resources, mainly through farmer field schools where farmers work together to select, adapt and develop new plant varieties that better fit their needs and preferences (https://sdhsprogram.org/ (accessed on 1 October 2021)). Throughout the process, the projects collaborated with their respective national variety registration services to discuss issues such as minimum requirements for farmers' varieties to qualify for registration, such as distinctness, uniformity and stability (DUS); minimum requirements for value for cultivation and use; processes to follow when applying for registration; who can register a variety and who maintains a variety; and the legal and policy space for registering farmers' varieties.

The data presented here were obtained from years of participatory varietal selection and enhancement with farmers in the four countries [9]. In all the cases, farmers' varieties were evaluated by farmers and selected for their best-performing traits with superior qualities using their traditional knowledge. In the case of Laos, farmers' varieties with desirable traits were crossed with breeders' varieties through a process of participatory plant breeding. National policy workshops were also held in each country to discuss key policy elements required for the registration of farmers' varieties. In December 2018, an international workshop was held in Entebbe, Uganda, with the participation of several other countries [10].

The key questions in this research paper include: What are the drivers behind registration of farmers' varieties? What different approaches can be taken? What is the legal context for the registration of farmers' varieties? Additionally, what efforts are being made in these countries to commercialize and maintain these varieties beyond registration?

3. Results

3.1. Registering Native Potato Varieties in Bolivia

Small farmers and their families in remote parts of Bolivia maintain an enormous range of crops and crop varieties as a strategy for ensuring a diverse, secure and continuous food supply over time. This diversity does not only represent a cornerstone of Bolivia's

food security and sovereignty, but also an important component of its natural and cultural landscapes. Among more than 50 native species cultivated in Bolivia, three stand out: potatoes, with more than a thousand native varieties [11]; maize, with seven racial complexes, 45 races and hundreds of native varieties [12]; and groundnuts, with 62 races and hundreds of native varieties [13].

The National Plant Variety Registry (Registro Nacional de Variedades) officially collects technical information on new varieties of crops. Its main purpose is to formalize the entry of new varieties into the seed market, giving them access to the officially sanctioned processes for seed quality accreditation. National seed laws establish that registering a variety in the National Registry is a requirement to obtain quality seed certification by the National Institute for Agriculture and Forestry Innovation [14,15].

In Bolivia, there is no officially recognized alternative system for registering landraces and farmers' varieties, and no specialized seed quality control system adapted to the seeds and varieties produced by farmers. Formal seed production of any variety, whether from breeders or farmers, must follow the standard rules. As a result, most of the seed which are farmers' varieties are produced and disseminated informally [16].

In the last few decades, initiatives to promote traditional crops have led to more and more attention from the urban population, opening new markets for crops and varieties that were previously consumed only by farmers and their families. Growing demand for good quality seed to increase production of these crops and varieties has created the need to include them in the National Registry.

The PROINPA Foundation has facilitated the registration of at least seven varieties of native potatoes, as part of its participatory work with farmers and collaborating organizations to evaluate, select and add value to native potatoes with the potential to improve farmers' food and nutrition security and livelihoods. The first variety was Pintaboca, which was rediscovered at least 20 years ago in the municipality of Colomi (Cochabamba Department) and is moderately tolerant to late blight (*Phytophthora infestans*) and highly appreciated locally for its taste and floury, quick-cooking characteristics. Farmers did not believe that Pintaboca could have value for urban consumers, seeing it as a variety "for the poor". They cultivated it using very poor-quality seed, infested with pests and viruses and yielding only around 5–6 tonnes per hectare.

As a first step, PROINPA improved the sanitary quality of the seed through thermotherapy and tissue culture techniques. It returned to farmers potatoes with quality characteristics equivalent to those required for "pre-basic" seed, i.e., 100% disease free. This high-quality seed turned out to be very productive, yielding up to 20 tonnes per hectare even without improvements in agronomic practices. It also showed great adaptation capacities, allowing production at different altitudes (from 2800 to 3800 m) and different planting times. As production of Pintaboca expanded, so did demand for seed in various villages. As traditional local producers struggled to meet demand, PROINPA worked with farmers' associations to consider the possibility of producing seed of officially certifiable quality. This required first registering the variety, which set the path for the registration of other native potato varieties in the last six years.

Article 25 of the Rules for the National Registry of Varieties establishes that old varieties, for which a breeder cannot be identified, can be registered without cost in the name of INIAF [14,15]. It also says that varieties of which seed has been already sold in the market ("varieties in use", as opposed to "new varieties") must be regularized through registration, again in the name of INIAF. The fact that INIAF has become the applicant and maintainer of these varieties may represent a violation of indigenous peoples' collective rights over the varieties that their ancestors bred and maintained over centuries. However, it avoids the problems that could arise when trying to identify a single applicant for traditional varieties whose origins cannot be traced, and which are grown by many farmers and farmer associations in different parts of the country.

The application form asks for information about the variety's performance and about the breeder. In the case of native potato varieties, INIAF allowed PROINPA and its farmer

partners to use catalogues and technical reports to demonstrate that cultivation over the years and in multiple locations had sufficiently showed the distinctness, uniformity and stability of the variety, so it could be exempted from DUS testing. INIAF also agreed that PROINPA did not need to submit information about the breeder.

The form also requires the applicant to use the UPOV descriptor list (Figure 1). Up to 2008, native potato varieties registered could be typified using these standard UPOV descriptors. However, the varieties submitted for registration from 2008 onwards had distinctive features that were not included in the UPOV list. This complicated their acceptance for registration. PROINPA negotiated with INIAF the possibility of using morphological descriptors from the International Potato Center (Figure 2), which are more appropriate to describe the diverse tuber shapes and colors that characterize native varieties. INIAF has still not formally adopted the CIP descriptors, but it considers them acceptable to describe characteristics that are not in the UPOV list.

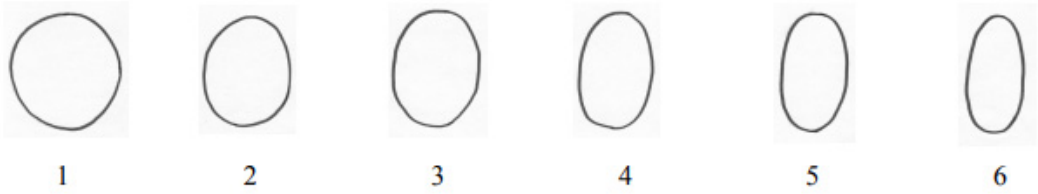

Figure 1. UPOV morphological descriptors for potato tuber shape. 1: Round; 2: Short oval; 3: Oval; 4: Long oval; 5: Long; 6: Very long. [17].

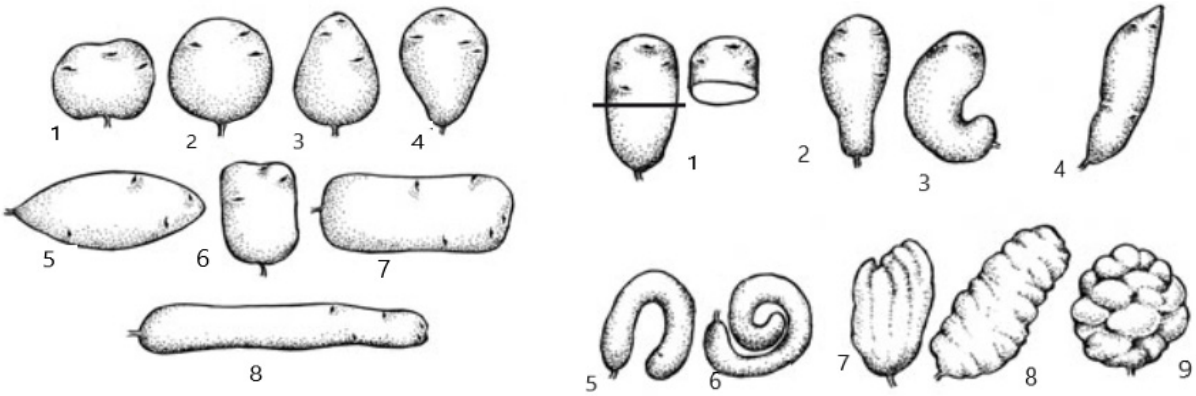

Figure 2. International Potato Center (CIP) descriptors for potato tuber shape. On the **left**, descriptors for general tuber shape: 1: Compressed; 2: Round; 3: Oval; 4: Obovate; 5: Elliptical; 6: Oblong; 7: Long oblong; 8: Elongate. On the **right**, descriptors for unusual tuber shape: 1: Flattened; 2: Clavate; 3 Reniform; 4: Fusiform; 5: Falcate; 6: Spiral; 7: Digitate; 8: Concertina; 9: Tuberosed [18].

Currently, ten landraces of maize, 14 of peanuts and 17 of native potatoes are included in the National Registry, changing their status from "illegal/informal" to "legal/formal" [19]. Small farmers can request a higher price for seed of these varieties with certified quality, which gives them an incentive to produce quality seeds. It also gives greater opportunities to access markets beyond the local ones and participate in public calls for tenders issued by municipal or departmental governments to provide seeds in case of emergencies. In general terms, including native varieties in the National Registry helps to diversify crops in the seed market and recognize Farmers' Rights over the genetic resources they have developed and conserved for centuries.

However, much work remains to be carried out. All the varieties so far have been registered in the name of INIAF, which—on paper—limits Farmers' Rights and responsibilities for their maintenance and marketing. In all cases, development organizations—rather than farmers themselves—have promoted and led the registration of landraces and farmers' varieties, due to the length of the process, the technical requirements of the application forms

and the need to investigate and submit existing documentation. It may be appropriate to put in place a supplementary, "lightweight" registry that allows the registration of all farmers' varieties together with associated knowledge. Finally, the process for registration of native potato varieties has evidenced legal, procedural and technical gaps that need to be addressed; the ad hoc flexibilities allowed by INIAF technicians at local and regional levels should be formalized by national authorities as part of the legal framework.

3.2. Piloting the Registration of Farmers' Varieties in Zimbabwe

Zimbabwe's agricultural production has been premised on the use of formal varieties of a limited number of crops, mainly (hybrid) maize, wheat, tobacco, cotton and soyabean. As weather patterns are becoming increasingly unpredictable, with longer and more frequent drought spells, civil society organizations, among other stakeholders, started to encourage farmers to diversify their crops, growing traditional farmers' varieties in drought-prone areas [20]. The government has set up a number of conservation agriculture programs through the Pfumvudza Scheme, providing seed packs to farming communities to grow traditional small grains and legume crops [21].

However, farmer consultations organized by the Community Technology Development Trust (CTDT) indicate a widespread misconception among farmers that "seed from shops is good and will do well under any environmental condition". This has caused farmers to under-value or even neglect their local varieties [22]. As part of a strategy to promote recognition and support for small grains and legumes traditionally grown by farmers, CTDT started a pilot project with the SD = HS program and national stakeholders to register two sorghum varieties and one of pearl millet.

No policies or legislative frameworks exist to facilitate the registration, production and marketing of farmers' varieties in Zimbabwe. The Seed Act of 1965 [23] requires all varieties of crops multiplied and sold as seed to be registered on the Second Schedule of the Seed (Certification Scheme) Notice 2000. The seed certifying authority assesses candidate varieties for both DUS and value for cultivation and use (VCU) based on at least two growing seasons over at least five sites in Zimbabwe in appropriate agricultural environments. To qualify for registration, the candidate variety must be new and outperform existing registered check varieties for one or more relevant traits.

The pilot project on registering farmers' varieties in Zimbabwe was initiated at a workshop in 2019 [24]. Participants repeatedly mentioned the DUS standards as the main factor precluding the registration of farmers' varieties and pointed out that the important benefit of farmers' varieties is their value for cultivation and use. Processes to register farmers' varieties should consider traits deemed important by farmers but not normally considered in registration, such as taste, cooking time and quality, and storability.

As this would be the first effort to register farmers' varieties in Zimbabwe, it was suggested to create an expanded variety release committee including stakeholders who do not normally sit on the existing committee. Its remit would include looking at not only the commercial value of the varieties but also criteria that best serve the farmers' interests, taking into account the socio-cultural values they attach to varieties. The panelists could be drawn from traditional leaders in the communities and organizations that work directly with farmers, as well as experts from the national genebank. Workshop participants also agreed that another key issue was the lack of a formal document of descriptors for many crops traditionally grown by farmers, and the pilot should develop such a list together with farming communities.

Seed Services, the Zimbabwean seed certifying authority, was requested to assist in developing guidelines and initiating legislation for farmers' varieties. In the draft guidelines being developed, it is proposed that the farmers' varieties are maintained by the Genetic Resources and Biotechnology Institute so that quality of parent stock can be maintained. The issue of ownership raised questions at the workshop, as farmers' varieties belong to various communities and the concept of ownership in customary African society differs from that reflected in formal intellectual property rights [24]. After

further consultation with farmers, the draft guidelines propose that the Genetic Resources and Biotechnology Institute play the role of moderator if disputes over ownership arise: as custodians of the original material, they can assess whether, for example, varieties carrying a different name are actually the same.

CTDT and Seed Services have drafted a new "Local/Traditional Seeds (Certification Scheme) Notice". This proposed statutory instrument defines a farmers' variety as "the local/traditional variety or landrace either developed, or improved or discovered by an individual farmer or community". It proposes "verification of the distinctness, consistency and stability (DCS) of a variety proposed for recognition if developed for traditional and local seed systems", instead of the standard DUS criteria for varieties developed for formal seed systems. The aim is to assess whether the proposed farmers' variety has distinct characteristics compared to other varieties, consistent in expressing these characteristics, and stable in maintaining these expressions after several multiplications. Replacing the 'uniformity' standard with 'consistency in expression' would allow more heterogeneous materials—which many farmers' varieties are—to be registered.

To assess and inform farmers about the merits of a variety, it is proposed that a variety "shall be subjected to tests to determine performance and adaptability for two years in the agro-ecological zone for which it is developed at a minimum of five different sites". These VCU tests can be conducted by the applicant or by an independent and competent agricultural organization that may be private or public.

The draft guidelines proposed that registered farmers' varieties should be produced only in those areas where they have been successfully tested. The draft Notice takes a less stringent approach, stating that "A farmers' variety that is approved and released by the certifying authority may not be permitted into other parts of Zimbabwe where the certifying authority is of the opinion that the variety is

1. Not suitable for cultivation in [other parts of] Zimbabwe; or
2. Not accepted by farmers as a result of specific, well-known variety characteristics; or
3. A health risk to other varieties, humans or the environment."

Regarding seed certification, the draft Notice simply states that "Once the farmers' variety has been recognized, seed certification will follow guidelines prescribed by the Certification Authority from time to time". The draft guidelines propose that seed produced by farmers from registered farmers' varieties shall be classified as "Quality Declared Seed", a quality assurance system already implemented in other countries such as Tanzania and Uganda [25], to lessen the burden and costs of producing and inspecting the seed lots to be certified.

At the time of writing, two sorghum varieties (Cimezile and Tsvimbo yeMupositori) and a pearl millet variety (Nyati) were being studied with a view to registration. These varieties were selected or (in Nyati's case) improved in farmer field schools through participatory varietal selection and enhancement [9]. During the 2019–2020 farming season, CTDT established 12 farmer field schools in Mudzi, UMP, Tsholotsho and Rushinga districts to document the performance of these varieties in collaboration with Seed Services. They were found to be adaptable to climate conditions in their communities and withstand bird damage. For the 2020–2021 growing season, Chiredzi district was added and the number of farmer field schools was increased to 24.

The pilot is overseen by CTDT, while Seed Services conducts field inspections during vegetative, flowering and pre/post-harvest stages to authenticate the varieties' characteristics and monitor the VCU performance tests carried out by the farmer field schools. Once the varieties are registered, seed companies will be approached to establish MoUs with their owners for production and marketing. The pilot outcomes will be evaluated in early 2022 and inform further development of the draft guidelines and statutory document.

3.3. Developing an Alternative Variety Release System in Laos

In Laos, an alternative variety release system is in the making that is tailored to participatory plant breeding (PPB). The National Agriculture, Forestry and Rural Development

Research Institute (NAFRI), which is responsible for plant breeding, variety release and seed certification in Laos, has been a partner in PPB projects since 2000 and instrumental in developing the alternative release system as part of the SD = HS program. There is virtually no private seed sector in Laos. The development and release of new varieties falls entirely on the public sector, which lacks the resources to serve diverse farmers across the country. In this context, PPB has proven to be a cost-effective mechanism to support the development, testing and dissemination of new crop varieties that are adapted to the contexts and needs of farmers in different provinces.

The alternative variety release system exists in parallel with the standard system, which releases new plant varieties after multi-location testing on DUS standards for at least two years. The new Seed Decree ("Decree on Plant Varieties"), approved in 2020, allows for the registration of "new plant varieties" as well as so-called "promotion varieties". These promotion varieties are "tested for quality and natural characteristics" on the basis of their "distinguishing characteristics including cultivation, stability, high yield, pest resistance, good quality and popularity". The varieties are tested "in a large production area and certified by the Provincial Plant Variety Management Organization" [26] (Article 22).

In practice, as explained further below, this means that candidate varieties can be tested against existing "check varieties" in farmer field schools in any region. In this parallel system, the standard UPOV-based DUS criteria are not applied, and release is at provincial instead of national level (Whereas provincial release only allows for the commercialisation of the released variety in that particular province, popular varieties that spread around the country can be registered and released as a promotion variety on the national level. For that purpose, performance data from one province in each of the three agricultural zones in the lowlands (i.e., north, middle and south) need to be provided). Another difference is that only varieties registered as "new plant varieties" can be protected by plant breeders' rights. The provincial research centers of the government extension service, PAFO, maintain the source seed, while NAFRI maintains small seed quantities in the national genebank.

The legal changes follow the release in 2018–2019 of two rice varieties, a result of crosses between valued local landraces and improved breeding lines. The Rice Research Centre, part of NAFRI, carried out the pre-breeding and early generation selection based on breeding objectives set by farmers in the farmer field schools. The resulting segregating populations (F3 and F4) were given to farmer field schools in different provinces, where farmers applied pedigree selection starting at F4, generally for two generations. From these materials, PAFO distributed promising lines (F6) to other farmer field schools in the SD = HS program. At F6, there is still some segregation, and new diversity still emerges, but this is selected out through farmer (bulk) selection in subsequent generations. So, while these lines would not meet the stability criterion of formal breeding, by this stage they were sufficiently stable for farmers to evaluate them against other stable lines and varieties and perform preliminary yield trials. The final selection and propagation work was conducted by individual farmers in their own fields. For these farmers, DUS is not essential: they are eager to continue selection activities in late-generation materials as it can easily be combined with agricultural production, and there is no cost in terms of yield lost.

The adoption and spread of the most promising lines in these other locations prompted their release, with no further testing needed at Rice Research Centre sites. Two released varieties are named after the village (Thinkeo 17-TK17) and province (Salavan 1-SLV1) in which they were selected and tested. A third variety, named after the district Meuong Phiang (MP1), is in the process of registration. Since SLV1 has quickly spread across Salavan and nearby provinces, it has now also been registered as a promotion variety at the national level.

The alternative, provincial release system has several advantages. Uptake of PPB varieties is virtually guaranteed, at least at a local level, since only proven utility in farmers' fields and kitchens will lead to the release of a variety. In contrast, the national release of varieties does not involve farmers in the breeding process; they see the varieties only when they are showcased in demonstration plots, by which time a lot of effort has gone

into achieving completely stable lines through a very elaborate process. If farmers do not such as the varieties, the breeding work has been mostly in vain—and less than half of these varieties are estimated to be taken up. Much time and money can be saved when farmers select the traits they value at an early stage. In the future, interested farmers can be involved in the pre-breeding and early generation selection, as has been the case in other countries [27].

The same reasoning applies to local adaptation and disease resistance. To be released nationally, a variety needs to be screened for disease resistance in-station (in a greenhouse) and go through multi-location testing to ensure wide adaptability in the country's different lowland areas (No improved varieties have been developed for the northern mountainous regions). Neither are necessary for release at the provincial level, which arguably makes the process less rigorous but for farmers that is not necessarily a problem —they are concerned primarily with adaptation to the local growing conditions of their farms, rather than wide adaptation. Local agro-ecosystems range from floodplains to mountainous areas, and conditions on farms are often quite different from the more controlled growing conditions in multi-location testing stations, particularly in terms of soil fertility or fertilizer application. MP1 is a good example: selected in farmers' fields with relatively infertile soils, it is highly responsive to the application of only small amounts of fertilizer. It does not respond well to the higher doses of fertilizer commonly applied in testing stations. This also makes the variety highly suitable for broadcast seeding, which is less time-consuming than transplanting, as plants grow quickly and so outcompete emerging weeds.

Similarly, in the provincial release process, new lines are continuously exposed to pests and diseases present in farmers' fields; while disease screening is not officially part of the process, susceptible lines are unlikely to be selected for further development. Breeding lines do undergo screening for pest and disease resistance in the process leading up to a national release, but improved rice varieties that are on the market in Laos still often prove to be quite susceptible to e.g., blast or stem borer. (Improved varieties have different levels of susceptibility because of the different disease strains present in different growing environments. Diseases mutate over the years. For example, the RRC variety TDK8 was found to be resistant to blast when screened in a certain location in year one. Yet three or four seasons later it became susceptible to a mutant strain of blast that had developed in the same location. Farmers' varieties that are selected in the local growing environment are generally found to have a more robust disease resistance, presumably because they are exposed to a larger number of disease strains than when screened in controlled (greenhouse) conditions).

Until now, the government has driven the formal sector development of varieties, pursuing national agricultural objectives. It does all the work, from breeding to propagating, testing, seed multiplication and release, and carries all the costs—which significantly limits the number of lines it is able to release. (Costs of multi-location testing, for example, are between USD 1500 and 2000 per season, with a minimum of two seasons required. These costs are prohibitive to farmer breeders and community-based seed producers, though not quite to NAFRI. While NAFRI is willing to shoulder these costs, the fact that testing in the provincial release process is conducted entirely by farmer field schools is a major advantage.) There is too little money for research, or capacity for seed production, to meet the demands of farmers wanting to buy seed of new varieties they are interested in. In the parallel, provincial system, farmers take on many of those tasks and responsibilities. Rather than being merely the final consumers of seed, they pursue the needs of their communities, assisted by formal sector breeders and the extension service where needed. It is a very efficient use of funds and time, leading to considerable savings in the breeding and release process. This is illustrated in Figure 3, which shows the national variety development process (left) next to the PPB development process at the provincial level (right).

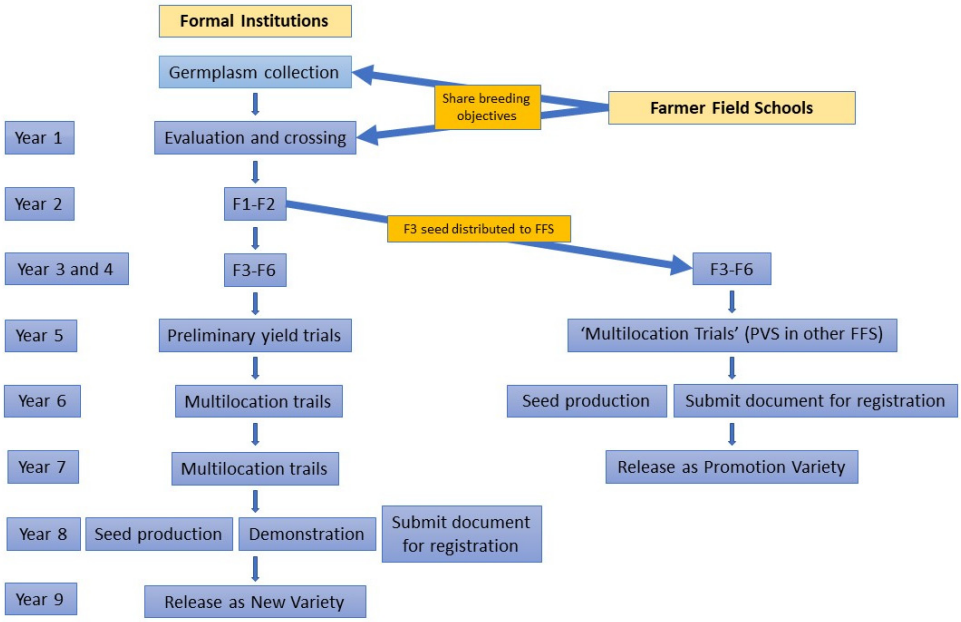

Figure 3. Comparison between the formal breeding and variety release process (left) and the new provincial release process based on participatory plant breeding and variety selection (right). Source: the authors.

The official release of the two farmers' varieties took place during agricultural festivals in 2018 and 2019, where the farmers who made the final selections received awards for their contributions (these are Mr Khamxay (TK17), Mr Bounlerth Phommasith (SLV1) and Mr Chankith (MP1, not yet officially released)). This recognition for farmers' breeding efforts is one benefit of the new release system. Another is having more varieties at their disposal that are specifically adapted to their needs and growing conditions, including varieties that would not pass the standard DUS tests in most countries. For example, PAFO is currently supporting the registration of a new waxy maize variety as a promotion variety at the national level. Crossed from a local white waxy maize open pollinated variety and a purple hybrid waxy maize from China (the variety has been developed by Mr Kham, head of the farmer field school in Attpaue province), the variety is quickly gaining popularity due to its good eating qualities and better performance than other open pollinated varieties in medium-fertile soils. The yields are 5 to 10% lower than existing hybrid varieties, but the seed price is three times lower. The variety is not uniform, however, with varying ear shapes and grain colors, which would make release under most DUS-based systems impossible.

The main benefit of the provincial release for farmers is expected to be in the marketing of seeds. Registration and subsequent seed certification are expected to increase the likelihood of farmers being able to sell the variety to millers as seed, rather than grain, and eventually lead to a higher market price. As farmers in Laos lack formal organization through farmer cooperatives, they depend on millers, middlemen or PAFO to market substantial amounts of rice, whether as seed or as grain. Farmers in Thinkeo, for example, are well known for their ability to produce high quality seed of TK17, which they mostly use for their own fields or exchange with other farmers. They occasionally sell seed to PAFO, and the grain is sold to millers.

PAFO, which accounts for approximately 15% of the total seed market in Laos, has committed to provide farmers with certified seeds of MP1, TK17 and SLV1 and assist them with producing certified seeds, which PAFO will buy from them. Table 1 shows the amounts of the farmers' varieties supplied by PAFO in 2020.

Table 1. Amounts of farmers' varieties supplied by PAFO in three provinces.

Province	Total Production by PAFO Seed Production Centre (kg)	Total Seed Production of Farmers' Varieties (kg)	% of Farmers' Variety against Total Seed Supplied by PAFO
Luangprabang	20,314	16,736 (TK17)	82%
Xayabouly	185,518	84,340 (TK17)	45%
Salavanh	83,000	13,200 (SLV1)	16%

There are still issues to be resolved for the provincial release process to fulfil its potential in generating the benefits discussed above. PAFO needs increased capacity to fully take up its central role. Another key question relates to the sharing of benefits. Since there is almost no private seed sector, competition is very limited with individual farmers, communities, research centers and government agencies working in tandem in variety development and dissemination. It is yet to be seen whether these networks of collaboration will continue to exist, and how benefits will be shared, if seed sales increase and more independent producers enter the scene.

3.4. Experiences with Registering Farmers' Varieties in Nepal

Nepalese farming systems rely heavily on traditional crops and farmers' varieties or landraces for food and nutrition security. A majority of farmers rely on their own saved or exchanged seeds, with the formal seed system contributing less than 20% to national seed demand [28]. A recent study showed that about 95% of farm households living in the Nepal Himalayas meet their seed requirement from informal sources using their own locally adapted seeds of farmers' varieties [29]. Nepal ranks 31st globally in biodiversity richness of flowering plants, and 10th in Asia, [30] but it is facing a rapid loss of crop diversity due to socioeconomic transformation, modernization in the farming system and climate-induced stresses [31]. Local crops and landraces are often neglected and underutilized despite having unique use values and varietal traits [32].

The government has invested hugely in crop development and improvement, with the release and registration of 740 varieties of 75 crops—but only about 20% of them have a local origin [33]. This indicates heavy reliance on exotic genotypes mostly developed by CGIAR research institutes and neighboring countries, especially hybrids—which constitute 52% of total varieties—developed abroad and introduced by the private seed industry [33]. The potential of locally adapted farmers' varieties has received limited attention, and they are being replaced by exotic ones [34,35].

In Nepal, a germplasm or line is officially recognized as a variety only through a notification in the Nepal Gazette. Varieties that are not notified in the Gazette cannot be multiplied for commercial purposes, nor traded legally. Varieties can be notified through two different systems: release and registration (see Figure 4). Various schedules defined the applicable formats and procedures for each system. The release process is subject to Schedule A. This process applies only to varieties bred or developed in Nepal. In order to be released, varieties have to pass stability testing through multi-location trials conducted under scientific protocols and the supervision of researchers for at least three years. The registration process is defined in Schedules B and C. Schedule B applies to varieties developed in Nepal, and Schedule C to imported varieties and varieties developed abroad. Registration requires two years of extensive multi-location trials to demonstrate value for cultivation. A new Schedule D for registration of farmers' varieties with commercial potential was included in the Seed Regulation 2013 [33,36].

The history of including farmers' varieties through PPB in Nepal goes back to the mid-1980s [37,38]. Since then, governmental and non-governmental research institutions have coordinated crop improvement projects in which farmers have played a leading role in setting the breeding goals and objectives, identifying traits, selecting local germplasm, testing crosses, and reselecting the most promising lines. Macchapuchre -3 variety of rice, was the first PPB variety released, in 1996. Other new varieties developed through these

efforts include Maize-Gulmi -2 and Resunga Composite, resulting from the crosses of foreign and local germplasm. Farmers' adoption of these new varieties has been widely documented [39].

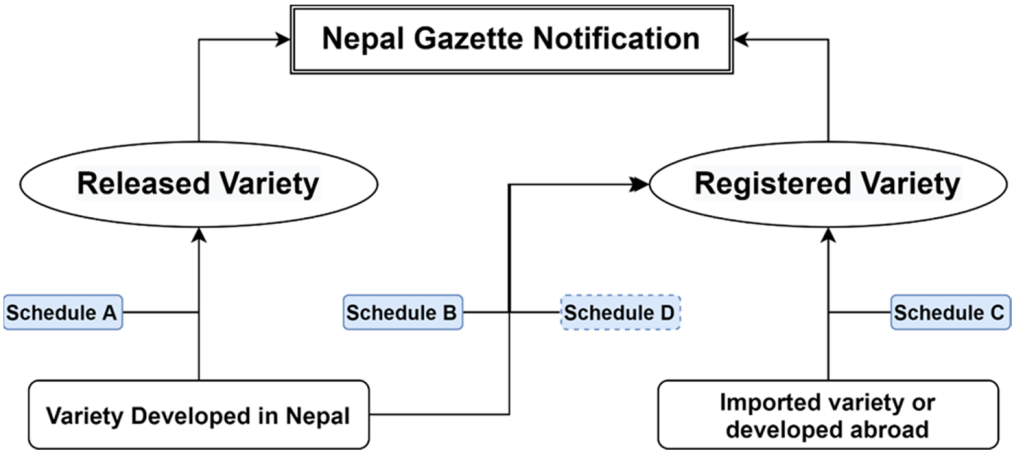

Figure 4. Notification process of new varieties in Nepal gazette (Source: adapted from [33]).

In some cases, these efforts enhanced the quality and genetic purity of landraces. A few were released in the formal seed market by governmental institutions as early as 1990, such as Kabre Kodo -1 (finger millet), Kathmandu Local (cauliflower), Marpha Rayo (broad leaf mustard) and Pyuthane Rato (radish) [28]. The case of Pokhareli Jethobudho, a rice landrace released in 2006, received much attention as for the first time farmers were recognized by the registration system as co-owner of the variety, and certain relaxations in uniformity were made for registration [40].

This case prompted development actors, scientists and farmers to seek the registration of farmers' varieties when: (1) the variety has agronomic traits that make it suitable for production in distinct local environments, and appropriate for farmers' practices and capacities; (2) there is high market demand for the variety; (3) individual farmers and farmers' associations have the capacity to multiply seed of the variety for commercialization and/or exchange at the local level; and (4) registration would allow farmers and associations to commercialize the variety as truthfully labelled, or certified, seed. However, applications to register other local and PPB varieties in the years following the Pokhareli Jethobudho were held up by a cumbersome process. Particularly problematic requirements included:

1. Applicants had to have a minimum of university-level education and professional training, to show they would be able to maintain the breeder and foundation seed.
2. Applicants had to present multi-season data with statistical analyses conducted following conventional breeding procedures.
3. The variety had to meet rigid standards for distinctness, uniformity and stability.

From the early 2000s until today, alternative procedures and flexibilities have been introduced to address these difficulties. The Nepal Agricultural Research Council (NARC) was the only mandated institution for crop improvement and varietal development until the Seed Policy 1999 began a shift towards recognizing other agencies in varietal development, and the Seed Act 2008 amendment introduced flexibility for including private sector registration. In 2013, Nepal launched its National Seed Vision 2013–2025, which recognized the value of landraces in food and nutrition security and the ability of local and farmers' seed systems to meet demand for seed in remote areas where the formal sector is inadequate. Additionally in 2013, the Seed Regulation was amended to enable listing and registration of farmers varieties, creating a separate category (Schedule D) with relaxed provisions. These changes provided space in the formal seed system to accommodate the registration of farmers' varieties.

A few landraces such as Gujmuje Rayo (broad-leaf mustard) were registered by the NARC under Schedule D. However, the Seed Regulation 2013 did not kick off momentum

for farmers' variety registration as expected, neither in the inclusion of farmers in the varietal development process nor the registration of the local crops. The provision aimed to facilitate farming communities to register their potential local varieties in the national crop variety list, but major bottlenecks remained, including:

1. Unclear and inadequate instructions in the registration template for farmers.
2. Lack of awareness among the members of varietal release and registration committee and key stakeholders about the relaxed provision for registration of landraces.
3. Inadequate orientation of the farming communities and community-based organizations about provisions and mechanisms of registration.

The non-governmental organization Local Initiatives for Biodiversity, Research and Development (LI-BIRD) collaborated with the Nepal national genebank (from NARC) to overcome these challenges, through collaborative projects led by Bioversity International which included policy advocacy and technical support to the NSB through the Seed Quality Control Center. A participatory approach was used to draft a relaxed, farmer-friendly format for varietal registration application under Schedule D, based on multiple consultations with stakeholders including policymakers, farmers and civil society. The application template was tested and submitted to NSB for approval, which it received in 2020. The template addressed issues that had hindered the effective utilization of Schedule D by providing clear instructions for farmers and their institutions to prepare a registration proposal. The uniformity criteria were also relaxed for local plant varieties and landraces.

In parallel, from 2015 to 2018 LI-BIRD, and NARC worked closely with community seed banks in Nepal to identify potential landraces for improvement, using grassroots plant breeding in diversity field schools [41]. As shown in Table 2, a total of 11 promising landraces of proso millet, foxtail millet, amaranth, finger millet, common beans and rice were jointly identified, and farmers collected the necessary yield and agronomic data with technical support from the two institutions. Although it was not mandatory, cover letters from local agencies were submitted with the proposals expressing their commitments to support the farmer organizations in source seed maintenance and promoting the varieties. The process for landrace registration of the identified germplasm is depicted in Figure 5. In the most recent cases, farmers themselves have presented and defended their registration proposals in front of the Variety Release and Registration Committee of the Seed Quality Control Center [42].

Table 2. Farmers' varieties proposed for varietal registration under Schedule D.

Name of the Organization, Village and District	Type of Organization	Crop	Name of Varieties Proposed for Registration under Schedule D	Remarks
Jawik Srot Samraxyan Abhiyan, Pokhara, Kaski	Community-based organization	Rice	Ekle, Bayerni, Kalo Jhinuwa, Pahnele.	Approved by NSB as varieties
Himchuli Multi-purpose cooperative, Dolakha	Community seed bank	Common bean	Rato Anadi Dolakha Pahenlo Simi, Dolakha Khairo, Ghiu Simi.	Approved by NSB as a variety
Dhauligadh Community Seed Bank, Hanku, Jumla	Community seed bank	Finger millet	Rato Kodo	Approved by NSB as a variety
		Amaranth	Rato Latte	Approved by NSB as a variety
Kharpunaath Agriculture Coperative, Chhipra, Humla	Community seed bank	Proso millet	Dudhe Chino	Approved by NSB as a variety

Six of the 11 landraces proposed under Schedule D have been approved as a variety and recommended for notification in the Nepal Gazette [42]. Institutional responsibilities for source seed maintenance is a remaining challenge, including financial sustainability. Lack of clarity around ownership rights can also affect farmers' and farmers organizations'

interests in registering and commercializing their varieties. The Seed Regulation amendments in 2013 and the Seed Act amendments in 2008 were intended to establish rights of farmers over traditional and local varieties, but did not specify the nature and scope of such rights. When farmers register local varieties, there is no clarity about whether they become "exclusive" owners, as in an intellectual property system, or what would be the conditions and requirements if any other farmer, breeder or company wanted to commercialize the registered traditional varieties or use them for breeding purposes [43,44]. Nevertheless, there are no instances—even in conventionally bred varieties—of a breeder applying for ownership rights, partly because of inadequate provisions in Seed Acts for the protection of plant varieties [43].

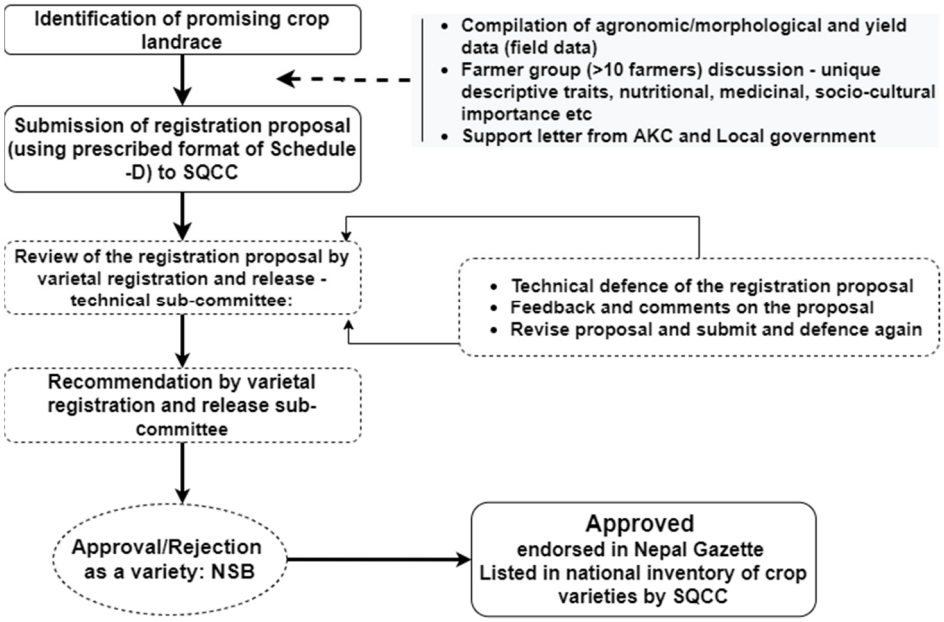

Figure 5. Process for registration of farmers' varieties in Nepal (Source: the authors).

4. Discussion

The four cases described in this article show diverse national-level approaches to make space for farmers' varieties in registration and release processes. Zimbabwe, Laos and Bolivia are still at the early stages compared to Nepal, but all countries are covering new ground in their attempts to develop alternative registration systems. Based on these cases and other experiences documented in specialized literature [8,45], we can distinguish three general approaches that countries have adopted to the registration of farmers' varieties:

(1) Ad hoc registrations: public organizations support and sponsor the ad hoc registration of traditional varieties. This does not imply changing existing laws, regulations and norms, but it may include adopting different procedures in an ad hoc way, without a normative basis or officialization—though this may follow. Registration of native potatoes in Bolivia falls under this approach.

(2) Adjustments in legal framework and standardization of flexibilities for farmers' varieties: in this approach, the legal framework is revised to relax standards and simplify procedures for registering traditional and farmers' varieties. Commercialization of such varieties is often subject to geographical and other limitations. Nepal, Laos and Zimbabwe fall into this category, as does Benin and the European Union, with its regulations on conservation and amateur varieties. Within this category, there are gradations: in Nepal, for example, implementing measures have been adopted and authorities have started to operate comfortably under the new framework. In Benin, the seed law includes provisions for the registration of farmers' varieties on a specialized register but implementing measures have not yet been adopted [46]. In the European Union, more than a decade of experience with the registration of landraces and amateur varieties has allowed several

countries to establish well-functioning registration systems and resulted in the introduction of numerous conservation varieties in the European common catalogue of commercial varieties [47]. However, many practitioners consider that national seed laws regarding conservation and amateur varieties are still restrictive and require further revisions [48].

In various countries, adjustments in variety registration procedures have been part of a wider package of legal measures to reinforce the national seed sector by giving a more prominent role and support to community-based organizations as variety developers and seed producers. Countries including Ethiopia, Tanzania, Uganda and Zambia have introduced new seed quality certification procedures, mostly inspired by the concept of Quality Declared Seed (QDS) developed by the FAO [49]. QDS is a class of commercial seed that has been subjected to quality control procedures that are less demanding than those required for certified seed but still guarantee comparable quality [50]. The QDS system was initially conceived to increase the production and supply of new improved varieties; however, seed quality control agencies in countries such as Ethiopia and Uganda are currently considering extending it to farmers' varieties [51]. The QDS system decentralizes and reduces seed production inspections, which facilitates local seed producers' access to seed quality control services and decreases the costs of these services [50–52]. The QDS system has a lot of potential to meet the demands of local level organizations which are interested in multiplying and selling farmers' varieties' seed as certified quality seed.

(3) No registration is required: in this approach, seed can still be subject to quality certification processes, but it may not be required for traditional varieties. In Switzerland, for example, the regulation on niche varieties provides for a simplified admission of old and local varieties to the seed market that does not require the official registration of the varieties or the certification of their seeds or planting material. Only limited amounts of reproductive material for each niche variety can be produced or used, depending on the culture [53]. In the United States of America, there is no mandatory registration for any variety as a prerequisite for commercialization [54].

Which approach to adopt is largely based on the seed market's level of liberalization, which in turn may depend on how advanced and diversified the seed sector is.

A striking commonality among all four countries analyzed in this study is that "formal" variety registration implies a lengthy process of multi-location testing and protocols to provide scientific data showing adherence to international standards on DUS and VCU. In addition, in all four countries, variety registration is a pre-condition for commercial seed production and marketing. Other literature has shown that these characteristics are common in many other countries [55,56]. This means that farmers' varieties are effectively excluded from commercial use, severely limiting the potential of farmer seed systems to contribute to food and nutrition security. Since many farmers' varieties do not meet formal DUS standards, and the registration process is too cumbersome and costly for farmers, farmers' varieties are not eligible for production of certified seed and commercialization. This situation has triggered initiatives to explore and test alternative registration systems for farmers' varieties.

All four countries are amending, to various extents, the variety registration requirements that exist in their current seed laws. In Bolivia, the International Potato Center list of descriptors is being used to complement the narrow UPOV descriptor list. In the four countries, the strict DUS requirements have been relaxed or amended. Laos and Nepal do not require DUS testing under particular variety registration schemes, while Nepal requires a variety to have some unique characteristics to qualify as a registered variety even if it does not meet DUS requirements. All countries prioritize VCU testing, which is carried out by or in close collaboration with farmers. In Zimbabwe, there is a proposal to replace the "uniformity" requirement with "consistency in expression"—DCS, instead of DUS—for the registration of farmers' varieties. This would also allow space for more heterogeneous materials to be eligible for registration.

Strong partnerships with development organizations, and the direct involvement and support of governmental agencies, are essential to make such initiatives successful. In

the end, it is the government that needs to change the relevant policies and procedures and ensure their implementation. In Laos, much progress has been made in a relatively short time span, because some key governmental bodies see strong added value of involving farmers in the breeding process and aim to facilitate farmer testing, evaluation and dissemination of breeding materials. The case in Nepal, however, shows that policy and legal changes alone are not enough: it is equally important to have awareness raising and capacity building among those that need to implement the new rules (the seed certification office) and those that may make use of them (farmers).

Strong farmer involvement is key to any initiative for registration of farmers' varieties. In Zimbabwe, farmer consultations have taken place as part of the policy development process and it has been proposed to include farmer representatives in the release committee. In Zimbabwe, Laos, Nepal and Bolivia, farmers are directly involved in the definition and evaluation of descriptors of the candidate varieties. VCU testing in these countries is overseen by government institutions in close collaboration with farmers who grow and evaluate the candidate varieties in their fields.

While all country cases show achievements and progress in establishing systems for the registration of farmers' varieties, they also show some pending questions and challenges. One issue relates to questions of ownership and benefit-sharing. The cases refer to Farmers' Rights—in particular to use, exchange and sell their farm-saved seeds—and stress that farming communities have different conceptions of ownership than the private and exclusive narrative that forms the basis of intellectual property rights systems such as patents or plant breeders' rights. Farming communities often conceive of shared or community-based ownership, linked to the idea of "taking care of" instead of mere property. This idea needs to be accommodated in the variety registration process, for example by allowing varieties to be registered in the name of (multiple) communities instead of an individual or legal entity. Furthermore, variety registration should not prescribe formal property rights. In the case of Laos, for example, the registration of a "new plant variety" provides the registrant automatically with a plant breeder's right title, but this is not the case for registration of "promotion varieties" as described above.

While farming communities involved in maintaining and developing farmers' varieties may not be interested in acquiring private property rights over these varieties, they still want them to be protected from misuse and appropriation by others. In the case of Laos and Nepal, it is hoped that the act of registering will provide such protection since the varieties and their originators will be publicly documented. In other countries, initiatives such as Open Source Seed [57] are aiming to achieve the same effects while establishing a protected commons.

All country cases conclude that more discussion and reflection is needed on this topic, which has many dimensions. One such dimension relates to the question of who is to be recognized, and in what manner, for having contributed to a PPB-derived variety. The farmers and researchers involved may have diverging needs and interests. In most country cases, such varieties are registered by the national research organization. The farmers may receive an award (in the case of Laos) and—as part of the PPB process—they usually get access to clean planting materials, with which they have the freedom to do what they want. The question is whether this is enough of a recognition of farmers' contributions, and whether and how the interests of and relations between farmers, researchers and others should be formally recognized at the start of PPB projects. Nepal was the only case country where farmers themselves apply and defend the registration of farmers' varieties, which are then registered under the name of a given community that becomes responsible for their maintenance. The communities can commercialize these varieties or collaborate with private seed companies and negotiate royalty payments.

Issues of ownership and benefit-sharing become especially pressing when farmers' varieties are successfully commercialized; who is to benefit—and in what way? The process from varietal development to commercial seed production is long, and all kinds of investments are made by various parties. How are these contributions to be weighted

when dividing up profits? Even before this question comes up, the key issue seems to be more about burden-sharing than benefit-sharing, as registration often comes with certain responsibilities. The question of who is to maintain the variety is one example. Maintaining breeder seed costs time and other resources, and it is often uncertain whether these costs will be recuperated at a later stage. In all case countries but Nepal, the national agricultural research station takes up this responsibility. In Nepal, an innovative proposal for a maintainer fund is being developed to cover the costs and incentivize variety maintenance at the community level. Even when this issue is solved, many other investments need to be made if a variety is to be commercialized successfully, including in seed production, certification, packaging, transport and marketing. Those who invest in these practices will be keen to recuperate their costs and share in any profit.

While much thought is being given to these considerations, we must not forget that registration of farmers' varieties is just one step in the seed value chain. Whether or not that chain eventually generates benefits for farmers who embark on the adventure of breeding and releasing their varieties will depend on the varieties' market potential and the investments made in seed multiplication, quality certification, variety promotion, development of market channels, and so on. Registration of farmers' varieties needs to be considered in connection with complementary measures to incentivize demand for, and supply of, these varieties if income is to flow to seed producer communities. The country case studies illustrate some of these measures, and similar initiatives are proliferating in many other countries. The use of mechanisms, such as quality marks and geographic indications, can play an interesting role in giving farmers' varieties an advantage in the seed and food markets. In Mexico, for example, the national collective trademark *Milpaiz 100% Nativo* was approved for use by small native maize farmers who cultivate and sell criollo maize varieties, including those resulting from PPB [58].

As experiences with the registration of farmers' varieties increase, it is important to closely analyze the economic, social and ecological effects derived from their entry into formal seed markets. In addition to assessing the extent to which seed markets contribute to improving livelihoods of small seed producers, including farmers, it is important to observe possible unintended consequences on the conservation and use of crop genetic resources and their availability to smallholder farmers [59]. For millennia, farmer-led seed systems have been very effective in generating and disseminating crop genetic diversity without the incentives of variety release and formal commercialization [60]. There is a risk that regularizing and commoditizing farmers' varieties could alter farmer seed systems and the critical services they provide, particularly the conservation and management of constantly evolving genetic resources.

Author Contributions: Conceptualization, B.D.J., I.L.N., G.O. and F.v.O.; investigation, B.D.J., I.L.N., G.O., X.C., F.T., S.H., F.v.O., S.S., N.P., D.S.S., D.G., P.K., T.B., C.M. and S.M.; methodology, B.D.J., I.L.N. and G.O.; writing—original draft, B.D.J., I.L.N., X.C., F.T., S.H., S.S., N.P., D.S.S. and D.G.; writing—review and editing, B.D.J., I.L.N., G.O., F.v.O., S.S., P.K., T.B., C.M. and S.M. All authors have read and agreed to the published version of the manuscript.

Funding: The work described was funded by the Swiss Development and Cooperation Agency (SDC), the Global Environmental Facility (GEF), the CGIAR Research Program on Policies, Institutions and Markets (PIM) and the Swedish International Development Cooperation. The authors are grateful for their support.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors thank Andrew Wright and Leander van der Linden for the editorial revisions and Ronnie Vernooy for his useful comments on the final draft.

Conflicts of Interest: The authors declare no conflict of interest.

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