

Review

# Opportunities for Underutilised Crops in Southern Africa's Post-2015 Development Agenda

Tafadzwanashe Mabhaudhi <sup>1,\*</sup>, Patrick O'Reilly <sup>2</sup>, Sue Walker <sup>2</sup> and Simon Mwale <sup>3</sup>

<sup>1</sup> Crop Science, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa

<sup>2</sup> Crops For the Future (CFF), Jalan Broga, 43500 Semenyih, Selangor, Malaysia; patrick.oreilly@cffresearch.org (P.O'R.); sue.walker@agro-impact.com (S.W.)

<sup>3</sup> Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA), Gaborone 00357, Botswana; smwale@ccardesa.org

\* Correspondence: tmabhaudhi@gmail.com; Tel.: +27-33-260-5442; Fax: +27-33-260-6094

Academic Editor: Kevin Murphy

Received: 15 February 2016; Accepted: 21 March 2016; Published: 25 March 2016

**Abstract:** Underutilised crops represent an important component of Southern Africa's agro-biodiversity that has potential to contribute to the region's post-2015 development discourse. We reviewed the potential of underutilised crops with respect to how they can contribute to topical challenges, such as food and nutrition security, human health and well-being, climate change adaptation, the environment, and employment creation in poor rural communities. The fact that underutilised crops are the product of generations of landrace agriculture supports the idea that they are resilient and adapted to the needs of farmers in marginal agricultural environments. In addition, underutilised crops are also seen as offering economic advantages due to their uniqueness, suitability to environments in which they are grown and low input requirements. In certain cases, underutilised crops are associated with specific gender roles with women being seen as particularly significant in their production. Evidence also suggests that the inclusion of underutilised crops in cropping systems contributes to dietary diversity and improved nutrition. In the context of the post-2015 agenda, the potential of underutilised crops to generate income, address food security and their status as a "subset of biodiversity" links with a number of Sustainable Development Goals (SDGs) addressing social, economic and environmental issues.

**Keywords:** agro-biodiversity; food and nutrition security; resilience; sustainability; underutilised crops

## 1. Introduction

The seventeen recently agreed Sustainable Development Goals (SDGs) represent a broad international consensus for the post-2015 development agenda. They incorporate a range of targeted social, economic and environmental objectives which are likely to have a profound impact on agricultural development strategies in Southern Africa. Historically, agricultural policy across the Southern African Development Community (SADC) has incorporated elements of a broadly defined "green revolution" paradigm. Innovation is primarily seen to arise from formal scientific and breeding infrastructure and is then transmitted to farming communities via extension services. Ultimately, this approach targets yield increases of a small range of "improved" food and commercial crops, which are then distributed through mechanisms which link producers to "formal" markets. Unsurprisingly, this approach remains remarkably durable. It has contributed to dramatic increases in global food supply, the major crops involved have been comprehensively researched, improved high yielding varieties are widely available and their agronomic requirements are well-understood by producers and extension

services. Nevertheless, the future of this approach has been the subject of considerable debate for many years [1,2].

In practice, the results of conventional approaches to agricultural development are mixed [3]. Their capacity to facilitate market participation by smallholders and support adaptation to climate change has been questioned [4,5], as has the lack of linkage between such policies and local adaptation strategies [5]. This contributes to concerns that the solutions which were effective in delivering increased food supply over the past half century may no longer be capable of maintaining the rate of yield increase previously achieved. While forms of incrementalism which propose further research and refinements of the current agricultural model play perhaps the dominant role in addressing this challenge, calls for a more fundamental reappraisal of agricultural development practices have also been made [1,6–8]. In this context, the potential role of “underutilised crops” in agricultural development has gained more traction.

The term underutilised is applied to a wide range of very different crops which are perceived as being used to a relatively small degree of their potential. Within the small world of underutilised crop research, a principle concern has been the need for the genetic conservation of these crops as an important component of agro-biodiversity. However, based, in part, on the observation that underutilised crops are grown in, and suited to, the conditions under which some of the world’s most vulnerable people currently live, a range of additional features have come to be associated with underutilised crops. The fact that these crops are the product of many generations of landrace agriculture supports the idea that they are more resilient and better adapted to the needs of farmers located in marginal agricultural environments [9,10]. In addition, such crops are also seen as offering economic advantages due to their uniqueness, suitability to the environments in which they are grown and low input requirements [11,12]. In certain cases, underutilised crops have come to be associated with specific gender roles with women being seen as particularly significant in their production [13]. Evidence also suggests that the inclusion of underutilised crops in cropping systems contributes to dietary diversity and improved nutrition [14]. In addition to field and plantation crops, several researchers have drawn attention to the important role that a wide range of underutilised crops and non-domesticated species play in ecologically sensitive systems such as the Miombo woodlands. Here, a number of researchers have drawn attention to the role that indigenous fruit trees could play in more sustainable local livelihoods [15,16].

In the context of the post-2015 agenda, such research highlights the perceived potential of underutilised crops to generate income and address food and nutrition security issues. As in the case of the Miombo woodlands, the status of underutilised species as a “subset of biodiversity,” links with a number of the SDGs addressing social, economic and environmental issues. However, while advocates of underutilised crops make important claims about their potential role in sustainable agricultural development there remains limited rigorous research concerning almost all aspects of their production and use. Furthermore, in contrast to major crops where the articulation of scientific knowledge into policy and extension is well understood and elaborated, for many underutilised crops there is neither the body of work, nor comprehensive research concerning how such a body of knowledge could or should be funded, assembled and put to work in raising the status of underutilised crops. This raises questions as to the likely role of these crops in measures aimed at addressing fundamental challenges such as those posed by climate change and food and income insecurity in Southern Africa, and the scale and nature of the investment required to realise this. Drawing on a recent review of existing public sources available in the region, this paper firstly considers the current state of public knowledge concerning underutilised crops in Southern African, before considering what this knowledge suggests concerning the potential role of underutilised crops in attaining the SDGs. Finally, the paper briefly considers what steps are required to realise the true potential of underutilised crops to support the SDGs. It is important to stress that this paper is not intended to serve as a comprehensive review of underutilised crops within the region. There are a number of such reviews, albeit that they have tended to focus on specific aspects of underutilised crop science (see, for example, Jain and Dutta

Gupta [17], which focus on biotechnology and Ochatt and Jain [18], which examines breeding). It is, of course, also the case that much excellent research has been undertaken by an array of researchers on specific underutilised crops. Rather, the intention of this paper is to start a conversation about the potential such crops have to deliver on their perceived promise drawing on the current state of public knowledge as a starting point.

## 2. Underutilised Crops and the Post-2015 Development Agenda

While not definitive, Padulosi and Hoeschle-Zeledon's [19] description of underutilised crops as "those non-commodity crops, which are part of a larger biodiversity portfolio, once more popular and today neglected by users' groups for a variety of agronomic, genetic, economic, social and cultural factors" embodies many of the features associated with underutilised crops. Such crops are not believed to be part of formal commodity markets, to be currently used to only a limited extent compared with potential or historical levels and to have thus become "neglected". Most critically, underutilised crops are described as a subset of biodiversity that has been primarily maintained by resource poor farmers in low input, mixed systems, and which is declining in significance due to a range of factors.

Much of the discussion on underutilised crops focusses on their suitability to marginal production areas [20], with a particular emphasis on such crops in the developing world. In this regard, if promoted in these areas, it is suggested that they could positively impact on food production. This would in turn improve household incomes and food and nutritional security [14,20]. On this basis, it is evident that underutilised crops may have the capacity to support a number of SDGs including:

- SDG 1: End poverty in all forms everywhere;
- SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- SDG 3: Ensure healthy lives and promote well-being for all ages;
- SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; and
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Seen through the lens of the post-2015 development agenda, therefore, underutilised crops appear to have the potential to deliver on a trifecta of social, economic and conservation development goals [21] in addressing challenges which are unlikely to be met using conventional agricultural development approaches. Indeed, if underutilised crops did not exist, it would perhaps be desirable to invent them.

However, significant knowledge gaps remain concerning underutilised crops. These include issues relating to their current use, seed systems, agronomy, water use, nutritional value, post-harvest handling and storage, and marketing. In addition, the socio-economic consequences of altering the status of these crops has received limited research attention as has the question of protecting the genetic resources that these crops represent to the benefit of their traditional users. In the absence of such information, the relationship between the significance placed on protecting these crops as a specific subset of biodiversity and their wider contribution to development remains poorly elaborated. This raises some concerns regarding the current state of knowledge concerning these crops, and what this suggests concerning their capacity to contribute to the post-2015 developmental agenda within Southern Africa.

## 3. Underutilised Crops in Southern Africa

Agro-ecological conditions in the SADC region permit the intensive production of major crops. However, in many cases this is highly dependent on substantial external inputs. This may have contributed to agricultural sectors in the region being divided between a relatively small and capital intensive commercial sector and a large smallholder sector in which a variety of mixed systems predominate. The majority of the SADC's income and food vulnerable people exist within this

smallholder sector. Significant agro-ecological and socio-economic changes in the region means that the challenges and opportunities smallholders face are changing. At the same time, a large body of research indicates that increases in gross domestic product (GDP) derived from smallholder agricultural production disproportionately benefit such people in economic and nutritional terms [3,22,23]. The fact that underutilised crops are widely believed to play an important role in the region's farming systems, allied with the wider challenges the region's agriculture faces suggest that Southern Africa presents a very real context in which underutilised crops could play a role in delivering the post-2015 development agenda; supporting sustainable and climate resilient agriculture.

For this reason in the latter part of 2013, Crops for the Future (CFF) and Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA) undertook a rapid appraisal of the current state of knowledge related to underutilised crops in Southern African farming systems focusing on three key questions:

- (1) the current state of knowledge and more specifically the quality of available national and regional data concerning underutilised crop use across the region, their distribution, economic value and significance within different farming systems;
- (2) the possible extent and nature of any role for underutilised crops in the region's development; and
- (3) to help identify critical gaps in current knowledge and ways of developing local capacity to address them.

Fourteen (14) national reviewers were commissioned, one for each of the SADC member states with the exception of Angola. These national reviewers gathered publicly accessible national data available through government agencies, libraries, educational and research bodies along with on-line sources concerning underutilised crops and related contextual data. This review thus focused on gathering information from existing public sources. The information collected during this review was subsequently collated in a regional report reviewing the status of underutilised crops in the region's public agricultural knowledge systems [24].

#### 4. The Current State of Knowledge on Underutilised Crops

The CFF-CCARDESA review largely confirmed that information on underutilised crops within the region was sparse. One aspect of this problem was the lack of clarity concerning what is meant by the term underutilised and its status in relation to national record keeping in different countries. In most cases, rather than having access to data which provides information about species which fit within existing definitions of underutilised crops, local reviewers had to rely on their own judgement in attempting to identify underutilised crops. There is a degree of arbitrariness in the classification of crops as underutilised as the term underutilised rarely features in official data. What information is available about crops regarded as underutilised is not disaggregated in ways which provide specific data concerning underutilised crops as this is commonly understood in the underutilised crops literature. Information that is accessible tends to be poorly organised, as a consequence it remains difficult to develop a comprehensive overview of underutilised crops in Southern African farming systems.

This was in marked contrast with the situation regarding major and commercially important crops for which data is regularly gathered and records are much more easily accessible. This disconnect is unsurprising given the limited resources available; national agricultural data focusses on current as opposed to potential crop use with a heavy bias towards crops which are produced on a larger scale. A critical issue is that ideas about underutilised crops, which are widely understood in the academic and advocacy literature, have little significance in national data collections. This, in turn, raises important questions for those involved in the promotion of underutilised crops and the need to link ideas about underutilised crops to the needs of regional agricultural decision makers.

In total the review was able to identify publicly accessible data for 27 underutilised crops (Table 1) alongside data for 26 major commercial crops (Table 2). This represents only a small fraction of the underutilised crops known to be grown in the region. For example, Padulosi [25] suggested that

there were at least 900 species of African leafy vegetables in the region. As the tables demonstrate, major and underutilised crops are employed as main and secondary crops, respectively, in different farming systems. However, in the majority of cases, underutilised crops are considered to be secondary crops. One striking feature of the lists of both underutilised and major crops is the limited presence of indigenous crops, only one of the identified major crops, palm oil, is native to Africa. However, commercial development of this species has largely taken place outside of Africa, while rice varieties used in the region tend to originate from Asia and cannot be considered indigenous. The list of underutilised crops includes some indigenous African crops which are known for their suitability to local agronomic conditions (e.g., bambara groundnut, yam, spider plant) and others which, while having centres of origin outside of Africa, have been used in local farming systems over very long periods of time and could arguably be described as having been indigenised [21]. Sorghum arguably represents the only example of an indigenous African grain which is commercially significant.

**Table 1.** List of identified underutilised crops for which information was available concerning Southern African farming systems. Source: Mabhaudhi *et al.* [24].

Scientific Name	Common Name	Status in Cropping System
<i>Dioscorea</i> spp.	Yam	Main/Minor
<i>Colocasia esculenta</i>	Taro	Main/Minor
<i>Agave sisalana</i>	Sisal	Main/Minor
<i>Triticum secale</i>	Triticale	Minor
<i>Fagopyrum esculentum</i>	Buckwheat	Minor
<i>Phaseolus vulgaris</i>	Dry bean	Main
<i>Cleome gynandra</i>	Spider plant	Minor
<i>Amaranthus</i> spp.	Amaranthus	Minor
<i>Jatropha curcas</i>	Jatropha	Minor
<i>Vigna subterranea</i>	Bambara groundnut	Minor
<i>Capsicum annum</i>	Paprika	Minor
<i>Ipomoea batatas</i>	Sweet potato	Minor
<i>Pennisetum glaucum</i>	Pearl millet	Minor/main
<i>Eleusine coracana</i>	Finger millet	Minor
<i>Cucurbita maxima</i>	Pumpkin	Main
<i>Vigna unguiculata</i>	Cowpea	Minor/main
<i>Bidens pilosa</i>	Black jack	Minor
<i>Abelmoschus esculentus</i>	Okra	Minor
<i>Amaranthus hybridus</i>	Amaranth	Minor
<i>Sorghum bicolor</i>	Sorghum	Main
<i>Panicum miliaceum</i>	Proso millet	Minor
<i>Lablab purpureus</i>	Lablab	Minor
<i>Sorghum bicolor</i>	Sweet reed	Main
<i>Cucurbita moschata</i>	Butternut	Main
<i>Solanum nigrum</i>	Black nightshade	Minor
<i>Brassica juncea</i>	Wild Mustard	Minor
<i>Corchorus olitorus</i>	Jute mallow	Minor
<i>Citrullus lanatus</i>	Wild water melon	Minor

**Table 2.** List of identified major crops for which information was available concerning Southern African farming systems. Source: Mabhaudhi *et al.* [24].

Scientific Name	Common Name	Status in Cropping System
<i>Zea mays</i>	Maize	Main
<i>Musa paradisiaca</i>	Banana	Main
<i>Coffea arabica</i>	Coffee	Minor
<i>Cammelia sinensis</i>	Tea	Main/Minor
<i>Arachis hypogea</i>	Groundnut	Main
<i>Oryza sativa</i>	Rice	Main

Table 2. Cont.

Scientific Name	Common Name	Status in Cropping System
<i>Triticum aestivum</i>	Wheat	Minor
<i>Elaeis guineensis</i>	Palm oil	Main
<i>Brassica oleracea</i>	Cabbage	Main
<i>Lactuca sativa</i>	Lettuce	Minor
<i>Spinacea oleracea</i>	Spinach	Minor
<i>Daucus carota</i>	Carrots	Main
<i>Glycine max</i>	Soybean	Main
<i>Nicotiana rustica</i>	Tobacco	Main
<i>Brassica oleracea</i> var. <i>botrytis</i>	Broccoli	Minor
<i>Allium sativum</i>	Garlic	Minor
<i>Allium cepa</i>	Onion	Main
<i>Brassica napus</i>	Rape	Minor
<i>Zea mays</i>	Maize	Main
<i>Nicotiana rustica</i>	Tobacco	Main
<i>Solanum tuberosum</i>	Irish potato*	Minor
<i>Pisum sativum</i>	Pea	Minor
<i>Cucumis sativa</i>	Cucumber	Minor
<i>Helianthus annuus</i>	Sunflower	Main
<i>Gossypium hirsutum</i>	Cotton	Minor
<i>Saccharum officinarum</i>	Sugarcane	Main

\* The term “Irish potato” is a usage which occurs in Southern Africa, distinguishing the potato (*Solanum tuberosum*) from sweet potato (*Ipomoea batatas*). While the term has no scientific value, in the context of this study it highlights the wider issue of definitions which dogs discussions concerning underutilised crops.

The information in Tables 1 and 2 confirms the deep and effective penetration of green revolution technologies and the non-indigenous crops they promote which dominate cultivation in most of the region’s cropping systems. For better or worse, the input intensive cultivation of these major crops represents the foundation of the current agricultural economy in Southern Africa. There a great deal of literature which supports movements towards cash cropping of these crops as a strategy for development in Southern Africa. Substantial evidence has been advanced in support of its positive impact, either directly through increased income or indirectly through, for example, synergies at household level that result in increased food crop production [26]. This strategy is embedded within an extensive institutional framework which includes a coherent body of policies, extension services, public and private distribution of seed, agrichemicals, fertilisers and the organisation of production, sale and consumption.

A feature of this embedded institutional framework is a particular system for knowledge management reflected in the extent to which data on major crops can be accessed. This is, in turn, underpinned by their central role in the conventional agricultural paradigm. By contrast, underutilised crops receive little attention in national statistics and are in many cases associated almost exclusively with subsistence [27–29]. Debates about their wider use often conflate livelihood and conservation issues [25,29,30] rather than preceding the large scale commercialisation of crops, the development of protocols and collection of statistical information about crops. The absence of data reflects the current, relatively minor role of underutilised crops as perceived in agricultural policies. This paucity of information about underutilised crops may potentially, at least, perpetuate a situation by which such crops remain neglected.

## 5. The Extent and Nature of the Role of Underutilised Crops in the Region’s Development and Delivery of the SDGs

Growing concerns over the socio-economic and environmental sustainability of the dominant agricultural strategies have contributed to calls for approaches more closely tied to climate resilience and the capacities of smallholders. In this context, and despite the significant limitations on the

available data, in the remainder of this paper, four key areas in which underutilised crops could contribute to the delivery of the SDGs are considered:

- (1) climate change resilience;
- (2) food and nutrition security;
- (3) genetic resources;
- (4) income generation opportunities.

### 5.1. Climate Change Resilience

The agro-ecology of the SADC is dominated by semi-arid to arid environments which are considered to be marginal in socio-economic and agro-ecological terms [31]. Food and income insecurity are common; stemming from the lack of meaningful economic opportunities and an inability to cultivate enough food. Climate change and variability are expected to increase the frequency and intensity of weather extremes in these areas [32]. Alongside natural challenges, these areas suffer significant infrastructural and institutional disadvantages. They often have poor transport and telecommunications links, experience poor standards of human health and experience restricted market access. A feature of farming practices in these areas is that in many cases, they already employ a number of coping strategies in responding to adverse conditions. National data collected during the CFF-CCARDESA review confirmed that underutilised species, including grains, leafy vegetables, root crops and legumes, are employed in a range of inter- and rotational cropping systems. The diverse nature of these crops and use in a wide variety of different systems in different role makes the generation of any general statements about how such crops are used imprecise and potentially misleading. They lack common agronomic characteristics, do not fill specific dietary or agronomic roles, making the development of a generic approach to understanding the current role and opportunities related to these crops highly challenging. Possibly, this also explains why official data concerning identified underutilised crops is so limited.

What we can say, is that a review of available official data confirms the continued importance of varied cropping systems across the region employing many species combinations. Underutilised crops are found in cropping systems across all of the major agro-ecological zones (AEZs) in Southern Africa. Depending on prevailing agro-ecological conditions, there are distinct variations in the underutilised crops used and the way that they are employed. In humid AEZs, main cropping systems involve monocultures of perennial trees and cocoa. Farmers also grow cereals (maize, rice, and wheat), root crops (yams, cassava, sweet potato, potato and taro), legumes and vegetables to supplement perennial crop production giving rise to tree-crop, rice-tree crop, root crop and forest farming systems. According to Dixon *et al.* [33], shifting cultivation and strip cropping are also practised in isolated areas with no land limitation. Underutilised crops in these systems include amaranth, spider plant, jute and black nightshade. In sub humid AEZs where main farming systems include root, mixed maize, cereal—root and commercial commodity systems, cropping practices are more diverse. In wetter areas of the sub-humid AEZ, root crop systems which feature monocropping of cassava, yams, taro, sweet potato and potato predominate. In drier sub-humid zones, dominant cropping systems include cereal, root-mixed, maize-mixed, irrigated and commercial systems. Within the sub-humid AEZs, a diverse range of underutilised crops are used including amaranth, black nightshade, cowpea, *Cucurbit* spp., jute, lablab, pigeon pea, spider plant and wild mustard. The scale of production of these crops has been negatively impacted by the increased production of commercial and major crops including maize and tree crops. In semi-arid AEZs where water is a major issue, farming systems include maize-mixed, agro-pastoral millet/sorghum. Monocrop and/or intercrop systems of maize are practised with a number of crops including beans, pumpkins and groundnuts. It is notable that while maize remains significant, a number of other crops are grown as main crops by farmers, including underutilised crops, such as finger millet, spider plant and okra. While pastoral farming systems dominate, crop production also occurs in arid AEZs. In such areas most major crops fare poorly. While maize is grown, a number of underutilised crops which are suited to these regions also feature prominently.

Exotic major crops (maize, wheat, rice, potato, dry beans, *etc.*) dominate landscapes in most Southern African AEZs in which growth characteristics (and in particular water availability and growing periods) allow for their intensive cultivation. This is mainly in humid and sub-humid AEZs. However, these crops are also grown in AEZs with less favourable conditions; maize for example, is found in all Southern African AEZs. At the same time, while underutilised crops play a more prominent role within the semi-arid and arid AEZ cropping systems, they are also found throughout all of the region's AEZs. However, different underutilised crops feature in different AEZs. For example, drought tolerant crops (e.g., bambara groundnut, wild water melon) are found in drier AEZs while non-drought tolerant crops (e.g. taro and yam) are found in the more humid AEZs. As opposed to the case for major crops, where significant inputs are required to modify local conditions, underutilised crops are produced in the landscapes to which they are adapted.

This has significant implications concerning the capacity of underutilised crops to contribute to agriculture in Southern Africa, generally, and more specifically to the fulfilment of the SDGs. What limited data was available during this review suggests a significant range of locally adapted underutilised crops are still produced in the region, even in situations where major crops predominate. While major crops are found in a wide range of areas where inputs and landscape modification are employed to adapt local landscapes to the crop, publicly available data suggests that underutilised crops tend to be produced in mixed systems in circumstances in which they are suited to local agro-ecological conditions. This suggests that they are cultivated because they require less landscape modification and exert less pressure on the ecologies within which they are produced. Not only does this point to the possibility that underutilised crops support more environmentally sustainable and climate sensitive agriculture but possibly that the presence of such crops as options broadens the food and income security base of producers while also allowing for increases in dietary diversity. Thus, in terms of the SDGs, underutilised crops appear to offer smallholders in marginal landscapes additional cropping options which in turn underpin farming livelihoods, providing an additional crop and spread risks incurred in cultivating major crops.

A related benefit claimed for underutilised crops concerns their capacity to contribute to resilience in agriculture, broadly defined as the ability of both cropping and farming systems to adapt to change. Mabhaudhi [34] argues that the ability of underutilised crops to grow in harsh agro-ecologies with limited inputs confers resilience to the systems in which they are found. By contrast, the promotion of exotic crops like maize, which rely on a more specific set of agronomic conditions reduces the resilience of rural farming and cropping systems. Mabhaudhi [34] concludes that the continued presence of these underutilised crops thus plays a role in maintaining resilience and ensuring food supply when the main crops fails. Again, this is echoed in national data which points to the continued use of such crops in contexts where they receive little or no support from extension services or private sector bodies. Underutilised crops may offer alternatives to major crops which support more sustainable and resilient local agriculture. However, critical to their potential in both respects is the way in which they are employed. The fact that such crops are cultivated in areas to which they are adapted results in more sustainable farming practices and contributes to resilience. In effect, they are employed as part of autogenous resilience strategies by smallholders. It should be noted that while agricultural development in the region is often portrayed in terms of a dichotomy between traditional and modern, or commercial and subsistence agricultural modes, in most cases cropping systems combine major crops with others, some of which are considered to be underutilised. The continued adoption of mixed systems by smallholder farmers which include these crops offers the best means of using them in support of SDGs relating to poverty eradication, ending hunger and supporting life on land. Their potential in this respect lies not so much in the crops themselves as in their role in adaptation strategies often alongside major crops.

### 5.2. Contribution to Dietary Diversity

In Southern Africa, critical issues in relation to nutrition are related to dietary monotony. Malnutrition in Southern Africa in relation to protein and vitamin A deficiency has arisen as the presence of legumes and African leafy vegetables in the local farming has declined [35]. Another widely held perception relating to underutilised crops concerns their perceived nutritional value [36,37]. The wider use of underutilised crops is perceived as a means of broadening the food basket thereby increasing dietary diversity. Again data gathered during the CFF-CCARDESA review suggests that these widely held views are partially reflected in publicly available national data on the region. The range of underutilised crops identified includes a number of plants which are recognised as having positive nutritional characteristics. These include amaranth, bambara groundnut, blackjack, and spider plant. However, the study failed to find extensive information concerning consumption practices and the nutritional composition of underutilised crops. What we can say is that in systems where these crops are produced, a portion of the crop is usually kept for home use, suggesting that their availability in mixed farming systems is more likely to lead to increased dietary diversity. The critical issue here is that this is the case if these crops are part of systems that are both mixed and where a range of produce is available for home use. Underutilised crops thus have potential to improve nutrition for people living in marginal agricultural production areas of Southern Africa. However, this is only likely to be the case in a context where such crops form part of a range of local produce that is available for local consumption. This has significant implications for discussions concerning the potential of underutilised crops suggesting that an approach based on a broader recognition of the role of these crops in mixed farming systems and local economic circuits may be more useful than approaches aimed at enhancing the role of any specific crop through agronomic breeding or market adjustments measures alone.

This by no means suggests that we should adopt a *laissez faire* position in relation to these crops but rather that innovations should be appropriate to, and aimed at, strengthening existing local practices. For example, the communities that cultivate underutilised crops often employ traditional post-harvest handling and storage practices which facilitate the exploitation of underutilised crops to meet their daily needs. In many cases these practices are the basis of specific livelihood capabilities which are important in addressing household needs and/or the attainment of personal, household and community development goals. In the case of some of the crops discussed here, traditional practices offer multiple pathways through which underutilised crops can be used to address needs. The use of underutilised crops in addressing dietary diversity issues thus presents an opportunity to address SDG 2. However, again much remains unknown, and the extent to which they can fulfil this role is dependent on their use in particular forms of farming practices employing appropriate technologies. Measures to promote their use should reflect this.

### 5.3. Underutilised Crops as Genetic Resources

The SADC's 15 member states collectively possess rich biodiversity with South Africa and the Democratic Republic of Congo being considered as mega-diverse countries. At the same time, increasing international attention is being drawn to the value and possibilities of maintaining high biodiversity in agriculture [38,39]. However, the number of crops listed in publicly available sources of information includes only a small fraction of the underutilised crops which are known to grow in the region. Not only does this point to the limited extent of information concerning such crops but also to the limited extent to which the region's indigenous agro-biodiversity is represented in mainstream agriculture.

Of the major crops grown in the region, none (with the exception of palm oil) are native to sub-Saharan Africa. Moreover, in the case of most of these crops, their genetic improvement has been driven by research which has been led from outside of the region. Current agricultural development trajectories in the region, and in particular the production of exotic major crops, may be contributing to the erosion of agro-biodiversity. As with the term underutilised, the issue of agro-biodiversity loss

is surrounded by ambiguity, a situation which is not helped by potentially conflicting conservation and development agendas. Agro-biodiversity loss is regarded in very negative terms from the perspective of genetic conservationists, as well as plant breeders and those concerned with the environmental impacts of biodiversity loss. From a development perspective there may be equally compelling arguments for supporting the adoption of new varieties of more productive crops over existing unimproved varieties. Indeed, it could be argued that the latter view prevails in agricultural development. While the preservation of agro-biodiversity may be an important global priority, there are a range of strategies through which this can be achieved. Fears of agro-biodiversity loss may not in itself represent an adequate justification for promoting underutilised crops in Southern African farming systems.

However, official data does point to the durability of underutilised crops in a wide range of Southern African cropping systems suggesting that for significant numbers of Southern African farmers these crops make a useful addition to cropping systems. This is all the more significant given the limited attention such crops receive in agricultural development. Other research points to the fact that such crops do so with limited inputs in what are sub-optimal agro-ecological conditions. It is important to also note that this is the case for a combination of indigenous underutilised crops such as bambara groundnut and spider plant and exotic underutilised crops, such as blackjack and proso millet. Consequently, it is reasonable to suggest that underutilised crops may represent a stock of genetic resources that support climate resilient agriculture in Southern Africa.

The genetic diversity of this resource base has important value as the basis for breeding programmes which rely on variability as the basis from which beneficial traits can be identified and nurtured. While the long term reduction in genetic diversity in major crops has become a key issue in their breeding and development, underutilised crops retain huge genetic diversity within and among different provenances of landraces [38]. As is evidenced above, many of the cropping systems which can be identified in Southern Africa, reflect two apparently contradictory approaches to the management of genetic resources with genetic homogeneity underpinning major crop production using modern hybrids and genetic diversity underpinning the production of underutilised crops via numerous landraces. The genetic diversity found in Southern African farming systems constitutes an important resource for formal breeding programmes in underutilised crops both within the region and globally. Indeed, an important element of discussions concerning the underutilised crops is the fact that their continued use by smallholders constitutes a *de facto* system of *in situ* conservation despite the fact that there are currently few mechanisms and policies in place to conserve and support it.

While the production of major crops relies on formal seed systems encompassing a chain of actors from researchers and plant breeders through to those involved in the release of certified varieties. The genetic management of underutilised crops is known to be reliant on informal local strategies for the management and exchange of germplasm, and exchange of information concerning seed quality and characteristics, collectively constituting informal seed systems (also referred to as local, traditional or farmer seed systems) [40]. In the case of major crops, the various actors are rewarded through market mechanisms or under public programmes. A complex regulatory system has been evolved to maintain formal seed systems and protect the rights of participants. By contrast, the reward systems associated with informal seed systems are poorly understood. As with the dualism between major and underutilised crops, informal seed systems are largely defined in terms of their differences with formal seed systems. However, the same processes (*i.e.*, variety selection, variety testing, introduction, seed multiplication, selection, dissemination and storage) take place in informal seed systems, though often as integral parts of farmers' production systems rather than as separate activities [41]. Informal seed systems tend to be more diverse and flexible than formal systems, and retain capital within local economic cycles. In addition, such systems retain a significant element of genetic diversity even within improved mixes as seeds are seldom if ever genetically uniform. Again, therefore, the genetic resources that underutilised crops represent are intimately linked to the ways in which they are currently used by farmers. The maintenance of these resources is driven by local technical (indigenous) knowledge

and standards, social structures and norms [40]. While the term underutilised is often taken to mean under-researched and unimproved, it is important to stress that these crops have been significantly improved through farmer breeding, experimentation and innovation. In Southern Africa, the genetic resources that these plants represent are the product of generations of conscious effort by farmers.

Given the significant role that informal systems play, their appropriateness to local needs and the expense involved in establishing formal systems, it may be neither possible nor desirable to replace existing seed supply arrangements with formal seed systems. Indeed, given the complexity of such systems and our currently limited understanding of how these systems influence the genetic development of underutilised crops, it is arguably the case that efforts to alter existing seed systems need to proceed with the utmost caution and without the adoption of questionable *a priori* assumptions about how informal systems work. Given the primary role that SADC farmers have played in developing these crops and protecting these genetic resources within, by and for SADC, it is critical that measures to improve seed systems for underutilised crops safeguard the role and rights of these farmer researchers as the originators and owners of these resources. In this sense, while underutilised crops may provide opportunities as genetic resources. The task of ensuring that these opportunities benefit current users and the nations in which they are found is a challenging one. While integrated seed systems have been proposed to provide mechanisms for securing title for farmer varieties, protecting farmers' rights and providing equitable access to such material for formal research and breeding, a note of caution must be sounded here. As with the use of the underutilised crops themselves, the strengths of local seed systems lies in their differences from formal systems; their flexibility and the ease with which material can be transferred. Simply transposing aspects of formal systems to local seed systems risks undermining the inherent values in the informal sector [42] and, in particular, may result in the loss of local control and wealth which are maintained in the informal system, or in unintentionally disenfranchising the local communities whom have conserved the genetic biodiversity represented by underutilised crops.

The extent to which the genetic diversity of underutilised crops can be employed beneficially in ways which deliver on the SDGs requires careful thought. Underutilised crops represent a valuable pool of genetic resources which can support the SDGs related to food, health and poverty. However, there is a danger that this may be overlooked if there is an overemphasis on the role of farmers in ensuring that they are preserved as an element of biodiversity. While underutilised crops' advocates are quick to point to the genetic value of such crops and the importance of *in situ* (i.e., farmer-led) conservation of these crops, informal seed systems have been the subject of limited in depth analyses. The reward systems that operate within these systems are poorly understood and efforts to compensate farmers for their work as both conservationists and breeders face significant challenges.

Most notably, there is a lack of data concerning the extent to which farmer-led conservation can practically contribute to the overall challenge of protecting biodiversity. There is a need for a realistic assessment of what are in fact three separate issues. The first relates to the potential of underutilised crops as genetically valuable, locally suitable alternatives to major crops. In this case, such crops have, as we have already seen, the potential to play an important role in the attainment of a number of SDGs related to human health and wellbeing. The second concerns the wider question of the wider exploitation of such crops and the development of adequate mechanisms to safeguard the rights of producer communities. This could, in turn, help to address SDGs dealing with equitable growth. The third concerns the question of the preservation of agro-biodiversity as a global social good. While not incompatible, these separate issues require careful balancing and a combination of policies which ensure that conservation burdens and the benefits of genetic improvement are shared equitably.

#### 5.4. Income Generation Opportunities Using Underutilised Crops

Depending on the crop and where it is cultivated, the type of market to which the crop is distributed and the means of doing so may differ. However, at the household level, national data suggests, with the exception of some cash crops, smallholder farmers make little distinction

between underutilised and major crops. In both cases, decisions concerning whether or not to sell particular portions of the harvest reflect household needs and opportunities. Publicly available information confirms, with few exceptions, that poorly regulated informal markets are the main outlet for underutilised crops. However, the way in which specific crops are marketed is highly variable and reflects local needs and capabilities. For example, while pigeon pea is sold on informal markets in Zimbabwe and Swaziland, it is rarely seen in markets in Mauritius where they are mainly cultivated for household consumption. In some cases, informal trade in underutilised crops co-exists with formal markets. In Malawi, pigeon pea marketing is done through local markets and intermediaries who then sell the crop into the formal system. This concurs with Sperling's [43] analyses that in emerging economies, informal and formal markets tend to complement each other. In addition, reported perceptions indicate the view that formal markets are not necessarily regarded as offering better quality. Consumers and farmers often associate informal markets with "fresh" and "cheaper" food while formal markets are associated with "expensive" but better packaged and preserved produce.

As with other aspects of this analysis, perceived dichotomies between informal and formal belie both the complexity and the value of informal mechanisms in relation to the farming practices and income generation strategies of smallholders. In addition, we are again confronted with the problem of assessing the role of underutilised crops in the absence of comprehensive information about these crops reflecting Sperling's [43] observation that most market research focusses on formal markets [43]. This makes it difficult to accurately assess the role of underutilised crops in income generation. As in the case of food security, agricultural resilience and genetic resources, limited knowledge and a lack of appropriate metrics means that informal markets are often treated as inferior markets and lack visibility in national statistics and development programmes. However, the CFF-CCARDESA reviewers found that in relation to Southern African smallholder agriculture, distinctions between formal and informal institutions are complex. For this reason, it may be appropriate to question the extent to which the economic importance of underutilised crops is fully recognised.

When considered in light of the needs of smallholders, informal markets provide a number of potential benefits. Their low entry and exit costs, provide a relatively simple mechanism for smallholders to generate ready cash income from selling of surpluses as well as forming a significant node in formal supply chains. Informal markets survive with little or no government support testifying to their resilience, and the short distances involved entail a significantly smaller carbon budget. Potentially, therefore, such markets, provide appropriate and cost effective ways of enhancing income generating options for farmers who produce underutilised crops. In this sense, underutilised crops and the informal markets to which they are sometimes linked may be a vehicle for small scale entrepreneurship and increased local dietary diversity. As such, interventions which aim to support the development of local markets for underutilised crops may offer a more cost effective avenue for improving income than is currently recognised. Developing comprehensive research employing appropriate metrics to assess the economic value of underutilised crops could potentially provide a basis for simple innovations to support a number of SDGs through improvements in current markets and the wider exploitation of underutilised crops in more specialised niche markets.

## 6. Towards Consensus

Within the agricultural research and development literature, the term underutilised has come to be applied to a range of crops. A number of common features have been ascribed to these crops. They are not regarded as major, they have been the subject of only limited formal research and breeding activities. Generally, they have very limited commercial appeal and are associated with subsistence farming, household consumption and local trading systems. In addition, the advocates of these crops have made significant claims concerning the untapped potential that they represent in the delivery of a wide range of benefits including; resilience, dietary diversity and as a source of income. The fact that many of these crops are produced in marginal agro-ecologies by smallholders adds some weight to these claims. There is, at the very least, *prima facie* evidence that points to the value of supporting

their continued use in support of the post-2015 development agenda. This has been advanced both as a form of *in situ* conservation and in order to support aims related to SDGs addressing poverty and hunger.

However, a review of currently available sources of public information in Southern Africa indicates that knowledge concerning these crops remains extremely limited. There is a lack of clarity concerning the term underutilised crops itself. It describes a wide variety of crops which have little in common other than that they are not regarded as major crops. This includes important local staples (such as bambara groundnut and quinoa), crops which are known and grown only within small areas (taro, dabai) and wild gathered fruits (*Upaca kirkiana*, *Sclerocarya birrea*, *Strychnos species*, *Adansonia digitata*, *Azanza garckeana*, *Parinari curatellifolia*, *Vangueria infausta*) and vegetables (amaranth and wild mustard). Indeed, the term is also applied to exotic crops which are widely cultivated elsewhere. There are further variations in the application of the definition of underutilised crops based on geographic (where?), social (who?) and economic (extent?) factors. The overlapping use of terms such as indigenous, traditional, neglected and orphan adds to the uncertainty surrounding the term.

The term underutilised is sometimes taken to mean under-researched and unimproved. However, in some cases these crops are highly appreciated at national and regional level and are the subject of some formal research, though this is fragmented and makes up only a small fraction of the global budget for agricultural research. Furthermore, many of these crops have been significantly improved through farmer selection, experimentation and innovation over many generations. The use of the term underutilised may lead to this contribution being undervalued or unrecognised. In addition, the inclusion under a single banner of crops which possess different potential may have the effect of drawing attention away from those underutilised crops that have the most potential and inhibit the development of effective policies for such crops. If research is to be done on these crops at a scale that can lead to substantial support for the SDGs then there is a need for a consensus concerning what is meant by underutilised crops and what research needs to be prioritised. Given the fact that many of these crops are grown in a number of Southern African countries, this task may best be undertaken at a regional level. In this paper a number of characteristics which are common to a number of crops commonly considered as underutilised were identified:

- (1) The value of these crops is intimately linked to their integral role in SADC's farming systems and constitute a valuable component of these systems, contributing to farm livelihoods;
- (2) They often possess agronomic and nutritional characteristics which mean they are suited to local farming conditions;
- (3) These crops have been the subject of limited scientific research attention and have been the subject of, at best, limited formal crop improvement efforts;
- (4) They have been the subject of continuous farmer-based development over many years;
- (5) It is difficult to capture information concerning the production, processing, trade and consumption of these crops employing the metrics and methods employed in conventional agricultural, development and economic analysis;
- (6) Their current status within these systems and the utility associated with them suggests that in many cases they could support the attainment of SDGs related to resilience, poverty, income growth and hunger.

## 7. Conclusions

What is clear from this review is that, in addition to major crops, a significant number of other crops are cultivated in Southern Africa. These crops form part of mixed cropping agriculture systems and that it is in this context that they are currently used and valued. The potential of underutilised crops relates mainly to their adaptability to marginal agricultural production areas and their ability to provide dietary diversity in poor rural communities. Their adaptation to harsh agro-ecologies makes them suitable for incorporation into strategies aimed at building resilience. The fact that they remain

underutilised suggests that there is an opportunity to develop new value chains for underutilised crops aimed at niche markets. If local farmers are involved in such value chains, this could lead to sustainable employment creation and autonomous pathways out of poverty. An opportunity also exists to develop integrated seed systems and marketing approaches that will not take away the role played by farmers in conserving underutilised crops. At a regional level, an opportunity exists to develop a regional agenda for including underutilised crops in national agricultural plans. A starting point could be the development of a consensus definition that will allow for the development of national and regional databases of underutilised crops.

For this reason, rather than a focus on underutilised crops, a regional approach to looking at the current utilisation of a wide number of non-major crops within Southern African farming systems may form a more useful way through which the potential of such crops can be appraised and “ranked” in terms of their current and potential for wider use in addressing the SDGs. Such an analysis should allow for a comparison between the likely costs and benefits of promoting such crops as opposed to alternative strategies for attaining the SDGs. To be in anyway meaningful, such an analysis must incorporate the views of the farmers and other stakeholders who know these crops best.

**Acknowledgments:** Crops For the Future (CFF) and the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA) are acknowledge for funding the study. The 14 CFF-CCARDESA Interns from 14 SADC states and Ms. Vimbayi G. P. Chimonyo and Mr. Tinashe Kitchen are also acknowledged for their contributions to the study.

**Author Contributions:** Tafadzwanashe Mabhaudhi did the initial conceptualisation of the paper during his tenure as a Research Associate of the CFF-CCARDESA project. Then together with Patrick O’Reilly and Sue Walker they jointly conceptualised the paper and contributed sections to the paper. Tafadzwanashe Mabhaudhi then led the write-up of the paper and coordinated input from all co-authors. All authors then reviewed and approved of the paper prior to publication.

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

## References

1. Sage, C. Addressing the Faustian bargain of the modern food system: Connecting sustainable agriculture with sustainable consumption. *Int. J. Agric. Sustain.* **2012**, *10*, 204–207. [[CrossRef](#)]
2. Long, N.; van der Ploeg, J.D. New challenges in the sociology of rural development: A Rejoinder to Peter Vandergeest. *Sociol. Ruralis* **1988**, *28*, 30–41. [[CrossRef](#)]
3. Dorward, A. How can Agricultural Interventions Contribute in Improving Nutrition Health and Achieving the MDGs in Least-Developed Countries? *Int. NURT. Achiev. Millenn. Goals Beyond* **2014**, *78*, 93–109.
4. O’Brien, K.; Leichenko, R. Double Exposure: Assessing the Impacts of Climate Change within the Context of Economic Globalization. *Glob. Environ. Chang.* **2000**, *10*, 221–232. [[CrossRef](#)]
5. Stringer, L.C.; Dyer, J.C.; Reed, M.S.; Dougill, A.J.; Twyman, C.; Mkwambisi, D. Adaptations to Climate Change, Drought and Desertification: Local Insights to Enhance Policy in Southern Africa. *Environ. Sci. Pol.* **2009**, *12*, 748–765. [[CrossRef](#)]
6. Ward, N. The Agricultural Treadmill and the Rural Environment in the Post-Productivist Era. *Sociol. Ruralis* **1993**, *33*, 348–364. [[CrossRef](#)]
7. Tovey, H. Alternative Agriculture Movements and Rural Development Cosmologies. *Int. J. Sociol. Agric. Food* **2002**, *10*, 1–11.
8. Rickards, L.; Howden, S.M. Transformational Adaptation: Agriculture and Climate Change. *Crop Pasture Sci.* **2012**, *63*, 240–250. [[CrossRef](#)]
9. Padulosi, S.; Eyzaquirre, P.; Hodgkin, T. Challenges and Strategies in Promoting Conservation and Use of Neglected and Underutilized Crop Species. In *Perspectives on New Crops and New Uses*; ASHS Press: Alexandria, VA, USA, 1999; pp. 140–145.
10. Mayes, S.; Massawe, F.J.; Alderson, P.G.; Roberts, J.A.; Azam-Ali, S.N.; Hermann, M. The Potential for Underutilized Crops to Improve Security of Food Production. *J. Exp. Bot.* **2012**, *63*, 1075–1079. [[CrossRef](#)] [[PubMed](#)]
11. Jaenicke, H.; Virchow, D. Entry Points into a Nutrition-Sensitive Agriculture. *Food Secur.* **2013**, *5*, 679–692. [[CrossRef](#)]

12. Lirio, L.G.; Paing, J.N.; Lan-ew, R.K. Coix Lacryma-Jobi Linn.-an Underutilized Grass for Food Security and Economic Empowerment of Rural Communities. In Proceedings of II International Symposium on Underutilized Plant Species: Crops for the Future-Beyond Food Security, Kuala Lumpur, Malaysia, 27 June 2011–1 July 2011; pp. 285–291.
13. Forsythe, L.; Nyamanda, M.; Mwangwela, A.M.; Bennett, B. Beliefs, Taboos and Minor Crop Value Chains: the Case of Bambara Groundnut in Malawi. *Food Cult. Soc.* **2015**, *18*, 501–517.
14. Mabhaudhi, T.; Chibarabada, T.; Modi, A. Water-Food-Nutrition-Health Nexus: Linking Water to Improving Food, Nutrition and Health in Sub-Saharan Africa. *Int. J. Environ. Res. Public Health* **2016**, *13*, 107. [[CrossRef](#)] [[PubMed](#)]
15. Akinnifesi, F.K.; Kwesiga, F.R.; Mhango, J.; Mkonda, A.; Chilanga, T.; Swai, R. Domesticating Priority Miombo Indigenous Fruit Trees as a Promising Livelihood Option for Small-Holder Farmers in Southern Africa. In *XXVI International Horticultural Congress: Citrus and Other Subtropical and Tropical Fruit Crops: Issues, Advances and Opportunities*; Albrigo, L.G., Galán Saúco, V., Eds.; ISHS: Toronto, ON, Canada, 2002; pp. 15–30.
16. Akinnifesi, F.K.; Kwesiga, F.; Mhango, J.; Chilanga, T.; Mkonda, A.; Kadu, C.; Kadzere, I.; Mithofer, D.; Saka, J.; Sileshi, G.; et al. Towards the Development of Miombo Fruit Trees as Commercial Tree Crops in Southern Africa. *For. Trees Livelihoods* **2006**, *16*, 103–121. [[CrossRef](#)]
17. Jain, S.M.; Gupta, S.D. *Biotechnology of Neglected and Underutilized Crops*; Jain, S.M., Gupta, S.D., Eds.; Springer: Dordrecht, The Netherlands, 2013.
18. Ochatt, S.; Jain, S.M. *Breeding of Neglected and Under-Utilized Crops, Spices and Herbs*; Science Publishers, Inc.: Enfield, UK, 2007.
19. Padulosi, S.; Hoeschle-Zeledon, I. Underutilized plant species: What are they? *LEISA Mag.* **2004**, *20*, 5–6.
20. Chivenge, P.; Mabhaudhi, T.; Modi, A.T.; Mafongoya, P. The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa. *Int. J. Environ. Res. Public Health* **2015**, *12*, 5685–5711. [[CrossRef](#)] [[PubMed](#)]
21. Modi, A.T.; Mabhaudhi, T. *Water Use and Drought Tolerance of Selected Traditional and Indigenous Crops*; Final Report of Water Research Commission Project K5/1771//4; WRC Report No. 1771/1/13; Water Research Commission: Pretoria, South Africa, 2013.
22. Juana, J.S.; Mabugu, R.E. Assessment of small-holder agriculture's contribution to the economy of Zimbabwe: A social accounting matrix multiplier analysis. *Agrekon* **2005**, *44*, 344–362. [[CrossRef](#)]
23. Livingston, G.; Schonberger, S.; Delaney, S. Sub-Saharan Africa: The State of Smallholders in Agriculture. Available online: <https://www.ifad.org/documents/10180/78d97354-8d30-466e-b75c-9406bf47779c> (accessed on 24 March 2016).
24. Mabhaudhi, T.; O'Reilly, P.; Walker, S. The role of underutilised crops in Southern African farming systems: A scoping study. Unpublished work. 2016.
25. Baena, M.; Galluzzi, G.; Padulosi, S. Improving Community Livelihoods by Recovering and Developing Their Traditional Crops. Available online: [https://www.cbd.int/cop/cop-11/doc/vtable/biodiversity\\_Improving.pdf](https://www.cbd.int/cop/cop-11/doc/vtable/biodiversity_Improving.pdf) (accessed on 10 February 2016).
26. Govereh, J.; Jayne, T.S. *Effects of Cash Crop Production on Food Crop Productivity in Zimbabwe: Synergies or Trade-offs?*; Department of Agricultural, Food, and Resource Economics, Michigan State University: East Lansing, MI, USA, 1999.
27. Azam-Ali, S.N. Fitting underutilised crops within research-poor environments: Lessons and approaches. *S. Afr. J. Plant Soil* **2010**, *27*, 293–298. [[CrossRef](#)]
28. Voegel, R.; Padulosi, S.; Bergamini, N.; Lawrence, T. Red list for crops—a tool for monitoring genetic erosion, supporting re-introduction into cultivation and guiding conservation efforts. In *On Farm Conservation of Neglected and Underutilized Species: Status, Trends and Novel Approaches to Cope with Climate Change*; Proceedings of an international conference, Frankfurt, Germany, 14–16 June 2011; Bioversity International: Rome, Italy, 2012; pp. 137–142.
29. Ravi, S.B.; Hrideek, T.K.; Kumar, A.T.K.; Prabhakaran, T.R.; Mal, B.; Padulosi, S. Mobilizing neglected and underutilized crops to strengthen food security and alleviate poverty in India. *Indian J. Plant Genet. Resour.* **2010**, *23*, 110–116.
30. Padulosi, S.; Bergamini, N.; Lawrence, T. On farm conservation of neglected and underutilized species: Status, trends and novel approaches to cope with climate change. In Proceedings of an International Conference, Frankfurt, Germany, 14–16 June 2011; Bioversity International: Rome, Italy, 2012.

31. Nyagwambo, N.L.; Chonguiça, E.; Cox, D.; Monggae, F. Local Governments and IWRM in the SADC Region. Available online: [http://logowater.iclei-europe.org/fileadmin/user\\_upload/logowater/wp3/D3.3\\_LG\\_IWRM\\_report\\_final.pdf](http://logowater.iclei-europe.org/fileadmin/user_upload/logowater/wp3/D3.3_LG_IWRM_report_final.pdf) (accessed on 24 March 2016).
32. Southern African Development Community (SADC). *Regional Water Policy*; SADC: Gaborone, Botswana, 2005.
33. Dixon, J.A.; Gibbon, D.P.; Gulliver, A. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*; Food & Agriculture Organization: Rome, Italy, 2001.
34. Mabhaudhi, T. Drought Tolerance and Water-Use of Selected South African Landraces of Taro (*Colocasia esculenta* L. Schott) and Bambara Groundnut (*Vigna Subterranea* L. Verdc). Ph.D. Thesis, University of KwaZulu Natal, Pietermaritzburg, South Africa, 2012.
35. Faber, M.; van Jaarsveld, P.J.; Wenhold, F.A.M.; van Rensburg, J. African leafy vegetables consumed by households in the Limpopo and KwaZulu-Natal provinces in South Africa. *S. Afr. J. Clin. Nutr.* **2010**, *23*, 30–38.
36. Wenhold, F.A.M.; Faber, M.; van Averbek, W.; Oelofse, A.; van Jaarsveld, P.; Van Rensburg, W.S.J.; van Heerden, I.; Slabbert, R. Linking smallholder agriculture and water to household food security and nutrition. *Water SA* **2007**, *33*, 327–336. [[CrossRef](#)]
37. Wenhold, F.; Annandale, J.; Faber, M.; Hart, T. *Water Use and Nutrient Content of Crop and Animal Food Products for Improved Household Food Security: A Scoping Study*; Water Research Commission: Pretoria, South Africa, 2012.
38. Padulosi, S. Hunger and poverty: the role of biodiversity. In Proceedings of Report of an International Consultation on the Role of Biodiversity in Achieving the UN Millennium Development Goal of Freedom from Hunger and Poverty, Chennai, India, 18–19 April 2005.
39. Pautasso, M.; Aistara, G.; Barnaud, A.; Caillon, S.; Clouvel, P.; Coomes, O.T.; Delêtre, M.; Demeulenaere, E.; de Santis, P.; Döring, T.; *et al.* Seed exchange networks for agrobiodiversity conservation. A review. *Agron. Sustain. Dev.* **2013**, *33*, 151–175. [[CrossRef](#)]
40. Sperling, L.; Osborn, T.C.; Cooper, H.D. Towards Effective and Sustainable Seed Relief Activities. Available online: <http://www.fao.org/3/a-y5703e.pdf> (accessed on 25 March 2016).
41. Wekundah, J.M. Why informal seed sector is important in food security. *Publ. Afr. Technol. Pol. Stud. Netw.* **2012**, *43*, 1–20.
42. Louwaars, N.P.; de Boef, W.S. Integrated seed sector development in Africa: A conceptual framework for creating coherence between practices, programs, and policies. *J. Crop Improv.* **2012**, *26*, 39–59. [[CrossRef](#)]
43. Sperling, L.; Boettiger, S.; Barker, I. Planning for Scale Brief, Integrating Seed Systems. Available online: <http://seedsystem.org/wp-content/uploads/2014/03/Integrating-Seed-Systems-.pdf> (accessed on 16 March 2016).



© 2016 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons by Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).