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Diversity and genetic erosion of traditional vegetables in Tanzania from the farmer's point of view

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Abstract

Traditional vegetables in Tanzania have been underutilized by farmers and neglected by research and development programmes. In the framework of the project 'Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa' led by the World Vegetable Center (AVRDC) and partners, focus group meetings were conducted in 10–12 villages in each of four districts of north-east Tanzania, which differed in ethnicity as well as in altitude, climate and soil conditions. Farmers named 10–34 different traditional vegetables per village, summing up to an overall of 102 in all four districts, about half of which were only identified by local names. The number of wild traditional vegetables used was always greater than the number of cultivated traditional types, with ratios of wild to cultivated vegetables ranging from 11:9 in an urban highland district to 59:11 in a rural coastal district. Some wild traditional vegetables were found to be threatened with genetic erosion due to changes in land use and eating habits. The degree of urbanization and the availability of infrastructure contributed more strongly to genetic erosion as compared to climatic conditions. Farmers' training encouraged exotic vegetable cultivation and reduced traditional vegetable diversity. At the same time, indigenous knowledge on how and where to collect, cultivate and prepare traditional vegetables was disappearing.

Keywords: focus group meetings; genetic erosion; indigenous knowledge; Tanzania; traditional vegetables; vegetable diversity

Introduction

The conservation of genetic variability within indigenous and traditional plants and their wild relatives has received minimal attention in research and development programmes, contributing to genetic erosion (Slikkerveer, 1995). In fact, only a few widely grown crops receive attention through the development of appropriate varieties and agronomic research, while there is a tendency for rarely cultivated crops and varieties to disappear (Schippers, 2002). With the onset of global market economies and modernization of agriculture in Africa, attention has been given to crops that offer a potential for export. As a result, high-yielding exotic vegetables have become more valued than traditional vegetables, and the latter are threatened with extinction (Maundu *et al.*, 1999b).

In this study, 'traditional' vegetables are defined as those 'indigenous or exotic species which, due to long use, have become part of the culture of a community' (M. O. Abukutsa Onyango, unpublished). Traditional vegetables are especially important to the countries of sub-Saharan Africa, being better adapted to the low-input environments of smallholder agriculture than the introduced commercial vegetables.

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Furthermore, traditional vegetables are affordable and represent rich sources of nutrition for large parts of the population in both rural and urban areas (Chweya and Eyzaguirre, 1999). In fact, almost all of these vegetables are good sources of micronutrients, which include iron and calcium as well as vitamins A, B complex, C and E. For example, vegetable amaranth is much more nutritious than green cabbage (International Plant Genetic Resources Institute, 2003), which is exotic to Tanzania and increasingly is replacing traditional vegetables in the diet.

Mwasha (1998) reported that vegetables are typically grown on a rather small scale in Tanzania. Horticultural crops usually generate higher earnings per unit area compared to cereal crops and can provide a valuable source of income to growers. The government of Tanzania had historically considered vegetables to be luxury products and of lesser importance compared to cereal crops. But vegetables are attracting more attention due to the expansion of export markets and the increasing role of vegetables in economic growth.

Some 450 plant species of African origin are consumed as a vegetable (Schippers, 2002). Therefore, a project on 'Promotion of Neglected Indigenous Leafy and Legume Vegetable Crops for Nutritional Health in Eastern and Southern Africa' was launched by the World Vegetable Center's Regional Center for Africa (AVRDC-RCA) and partners, in whose framework this study took place. The main objective was to collect baseline information on the current consumption and production status of traditional vegetables in Tanzania. Information was gained directly from farmers in four different agro-ecological regions of north-eastern Tanzania to identify producers' and consumers' views on preferred traits of traditional vegetables, favoured species, processing technologies applied, and constraints to production and consumption.

Materials and methods

To gather information directly from farmers, a baseline survey was carried out from July to September 2003 in four research districts that differed not only in their agroecological conditions, such as altitude and climatic conditions, but also in ethnicity of the population as well as in their setting (rural or urban) (Table 1).

Kaplowitz and Hoehn (2001) concluded in a comparative study that focus groups and individual interviews are not substitutes for one another; but rather, are complementary. Consequently, within this project, both methods were applied, namely qualitative focus group meetings (FGM), which are reported here, as well as quantitative individual interviews (reported by Weinberger and Msuya, 2004).

Focus group sizes ranged between six and 30 participants with a mean size of 14.5. On average, 2 h were spent in each of the 43 FGMs, while individual meetings lasted between 1 h 10 and 2 h 45 min. In each of the four districts, 10–12 FGMs were held. Half of the groups interviewed were women groups, the other half mixed groups consisting both of women and men. Furthermore, a broad age representation was aimed at. The socio-economic status of FGM participants was recorded while they were individually interviewed (Weinberger and Msuya, 2004; K. Weinberger *et al.*, personal communication). Most FGM participants were engaged in farming activities (96%), producing vegetables in most cases for both subsistence and local markets. The wealth of participants was assessed by a number of wealth parameters, which showed FGM participants in Arumeru district to be better off than in the other three districts (Fig. 1). Likewise, expenditure on food was almost double in Arumeru compared to that in the other districts, which showed participants from Singida to be less well off (Table 1).

Table 1. Characterization of four research districts in Tanzania

Region	Arumeru	Singida	Kongwa	Muheza
Location in Tanzania	Northern highlands	Central Tanzania/ Central semi-arid lands	Central Tanzania/ Southern Maasai Steppe/arid lands	Northern coastal areas/ Northern coast
Mean annual rainfall (mm)	1000 (humid)	700 (semi-arid)	500–700 (semi-arid)	1700–1900 (humid)
Altitude (m asl)	1000–1500	1500	500–1000	200–1000
Location	Urban	Urban	Rural	Rural
Main ethnic groups	Arusha, Maasai, Meru	Nyaturu	Gogo, Kaguru	Bondei, Shambaa
Mean weekly per capita food expenditure (TSh)[a]	1167	500	677	657

Sources: Hathout, 1983; Anonymous, 1998.
[a] Weinberger *et al.*, personal communication: survey conducted by AVRDC in co-operation with HORTI-Tengeru, 2003. $N = 359$ respondents. About 1200 TSh = 1 €.

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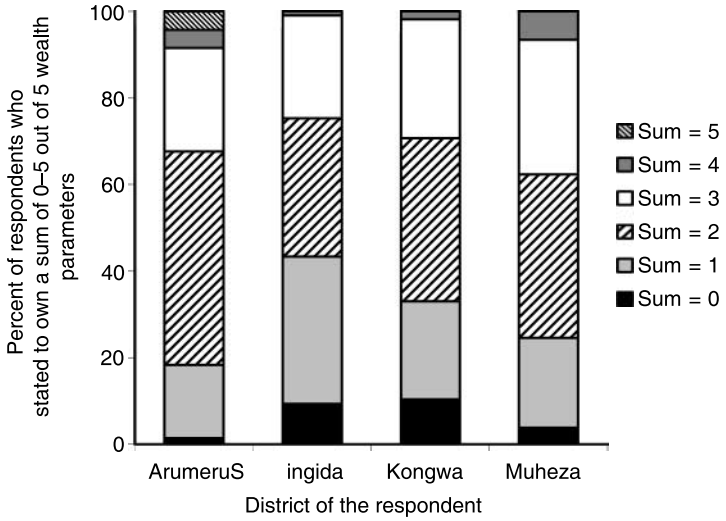

Fig. 1. Distribution of wealth (%) expressed as the sum of five wealth parameters (radio, chicken, bicycle, mobile phone, electricity) per household in four districts of Tanzania.

The main task of the semi-structured questionnaire was to guide the discussion and, therefore, began with some closed and continued with open questions. The questionnaire consisted of three main parts. The first questions aimed to determine the most important traditional vegetables and whether they were either cultivated or gathered. In the second and third parts, either consumption issues (with women groups) or production issues (with mixed groups) on the most important traditional vegetables were considered. FGMs were conducted in Swahili and largely directed by staff from the Tanzanian governmental institution HORTI Tengeru (Horticultural Research and Training Institute, Tengeru, Arusha).

Since farmers named traditional vegetables by Swahili or English names, scientific names of cultivated vegetables were determined according to vegetable descriptions by farmers and compared with Schippers (2002) and Maundu *et al.* (1999a), while wild vegetables were determined from Ruffo *et al.* (2002) and with assistance from the researchers from HORTI Tengeru. Despite these various sources, a considerable number of vegetables mentioned by farmers remained unidentified and *post hoc* verification of their identity was impossible because no material was collected during the FGMs. In this case, we chose not to assign scientific names as this might have led to wrong interpretations. Thus, some overestimation of diversity might have occurred due to potential double counting of species and/or varieties known only by their local names. In addition, taxonomic relations are often insufficiently studied in many underutilized species, and hence taxonomic identification may be uncertain.

For data analysis, the long-table approach was applied. This widely used low-technology option is suitable to identify themes and categorize results (Krueger and Casey, 2000). Replies from FGMs were organized according to (i) vegetables and (ii) questions and/or themes. Answers and comments made by farmers were then analysed according to frequency, specificity, emotion and extensiveness. When ranks of individual vegetable species or types were provided, the median was taken, to prevent a skewing of data when very large extreme values existed.

To compare the districts with regard to availability of traditional vegetables, Sørensen's coefficient was calculated. Vegetables were counted as distinguishable 'units' rather than as species, varieties or types, since only local names were available for 44 out of 102 different vegetables mentioned by farmers. Sørensen's coefficient was calculated according to Dierßen (1990), while Shannon's and Simpson's diversity indices, which are used to characterize species diversity in a community in terms of abundance and evenness, were calculated according to Beals *et al.* (1999, 2000). Furthermore, a cluster analysis of the vegetables was performed, using those vegetables that were ranked at least once under the most important six in at least one village. The resulting 14 vegetables were characterized for each village either by '1' meaning 'ranked among most important six', '2' meaning 'named but not ranked under the first six' or '3' meaning 'not named at all in this village'. The Euclidean distance and average linkage were applied by the statistical program SYSTAT 11.

Results

Nomenclature: naming traditional vegetables

When farmers provided local names for their most important vegetables or when they named characteristics, they

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obviously applied their own local classification system, with local names often having descriptive meanings. The criteria applied to describe a vegetable referred to different characteristics, such as morphology, place of origin, culinary traits or time until harvest (Table 2).

Diversity of traditional vegetables

The total numbers of traditional vegetables communicated by farmers in the research districts are listed in Table 3. While overall only 24 and 21 different traditional vegetables were mentioned in Arumeru and Singida districts, respectively, 35 were distinguished in Kongwa and more than double (74) in the coastal Muheza district. Similarly, the mean number per village increased from Arumeru and Singida districts to Kongwa and Muheza districts.

All vegetables that were gathered (not cultivated) were considered 'wild' even if some of them grew on cultivated rather than on uncultivated or waste land. In all four districts, more wild than cultivated traditional vegetables were named by FGM participants. A few vegetables were both cultivated and collected from the wild. One of these was amaranth, as there were different amaranth cultivars or landraces as well as wild forms of amaranth available (Table 4). Since the taxonomy of cultivated amaranth is not yet resolved (Dehmer, 2003), it was often difficult to identify the species from farmers' descriptions.

Only 12 common vegetables were named by FGM participants to be used in all four districts (Table 5). These included cultivated indigenous types and traditionally cultivated but non-indigenous types, such as pumpkin, sweet potato and cassava leaves. The remaining vegetables and their status will be further discussed in the section on 'Preference: ranking traditional vegetables'.

The two districts with the most similar traditional vegetables (Sørensen coefficient of nearly 60) were Arumeru and Singida (Table 6). Other districts sharing relatively similar traditional vegetables were Kongwa with Singida (46.4) and Kongwa with Arumeru (46.2); whereas Muheza differed most from the other districts. In fact, the number of common vegetables was highest for Muheza/Arumeru and Muheza/Kongwa, but this was affected by the high number of vegetables that occurred exclusively in Muheza district.

Shannon (H) and Simpson's (D) diversity indices showed that Singida and Arumeru districts were lowest in diversity ($H = 2.83$; 2.93), while Muheza district was the most diverse ($H = 3.84$) (Table 7). Shannon's evenness increased from Singida district ($E_H = 0.56$) to Muheza district ($E_H = 0.68$), indicating a more even distribution of units together with the increasing number of vegetables. However, evenness for all districts was rather intermediate (1 = complete evenness).

Table 2. Examples of names referring to different traditional vegetable characteristics as mentioned by farmers in four districts of Tanzania

Characteristics according to:	Example
Morphology	• 'Tambaa' = cowpea or jute mallow type with spreading plant habit • 'Wima' = cowpea or jute mallow type with erect plant habit • 'Pamba' = cotton (an okra with flowers resembling those of cotton) • 'Ngogwe nyeupe ndogo' = African eggplant with white, small fruits • 'Mchicha mweusi' = black amaranth seeds
Organoleptic	• 'Ngogwe si chungu' = a non-bitter African eggplant
Place of origin	• 'Mnavu wa Kenya' = African nightshade from Kenya • 'Ex-Hai' = vegetable origin in Hai region, Tanzania • 'Kienyeji' = local • 'Kisasa' = introduced
Time until harvest	• 'Miezi moja uanze kuchuma' = 1 month until ready for harvest

Table 3. Portrait of traditional vegetable diversity in four districts researched in Tanzania

	Arumeru	Singida	Kongwa	Muheza
No. of traditional vegetables in district	24	21	35	73
Ratio of identified: unidentified traditional vegetables (scientific names)	20:4	15:6	22:13	46:27
Mean no. of traditional vegetables per village (range)	14 (11–19)	14 (10–17)	17 (14–22)	25 (18–34)
Ratio of wild: cultivated traditional vegetables	11:9 (= 1.2)	11:6 (= 1.8)	24:8 (= 3.0)	59:11 (= 5.3)
Traditional vegetables both cultivated and collected	4	4	3	4

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Table 4. Species and forms of *Amaranthus* traditionally used as leafy vegetables in four districts researched in Tanzania

Scientific name	(District[a]) Local name	Status[b]
Amaranthus blitum L.	(A) Mchicha kienyeji	w
	(M) Mchicha mweusi, mzizima	w, c
Amaranthus dubius Mart. ex Thell.	(A) Mchich mweusi	c, w
Amaranthus graecizans L.	(S) Mughaa	w
	(K) Fene, ifene, mpana, chakaya	w
Amaranthus hybridus L.	(A) Mchicha kisasa/kizungu	c
	(S) Mchicha, kijani, wakupanda	c
	(K) Mchicha mwekundu	c
	(M) Mchicha kizungu/kigeni, bwache	c, w
Amaranthus hypocondriacus L.	(A) Mchicha mweupe/wunga/lishe	c
	(K) Mchicha lishe/jeshi	c
	(M) Magereza	c
Amaranthus cruentus L.	(A) Mchicha mpana	c
	(S) Mchicha kawauda	c
	(K) Mchicha mweupe	c
	(M) Mweupe, magereza	c
Amaranthus spinosus L.	(A) Mchicha mwekundu, mabreka	w
	(S) Mchicha mwekundu	w
	(K) Mchicha wa miiba/damu	w, c
	(M) Bwache chamiwa, bwache	w
Not identified	(M) Mchicha kulima	c
Not identified	(M) Bwache buuza	w
Not identified	(M) Bwache	w

[a] A, Arumeru; S, Singida; K, Kongwa; M, Muheza.
[b] c, cultivated; w, wild; if both, in order of importance.

Simpson's evenness was even lower and did not differ to a great extent among the four districts.

Preference: ranking traditional vegetables

After listing all traditional vegetables commonly produced and/or consumed, focus group participants further ranked six vegetables (Table 5), which they perceived as most important, in order to discuss them in more detail. Constraints in production of traditional vegetables were certainly important in determining ranking. When comparing different constraints, pests and diseases were by far the main restrictions for vegetable cultivation in all districts. Water availability was another crucial factor, while other constraints were of local importance, for example, the availability of seeds was not a key factor in Muheza but was in the other districts (Fig. 2).

From the main traditional vegetables discussed in the four districts (Table 5), only amaranth stood out as one of the most important vegetables in all districts. Okra and sweet potato leaves were among the most important vegetables in three districts, but they did not rank as the first or second most important vegetable in any district. The most important vegetable in a given district was usually important in only one or two districts. Although African nightshade and African eggplant were commonly named in all districts, they were only of high importance in Arumeru (ranking first and third, respectively) and Muheza (African eggplant ranking fifth). Both nightshades and eggplants comprise different complexes of related *Solanum* spp. (Table 8) that currently remain taxonomically undefined (Dehmer and Hammer, 2004).

It is interesting to note that in the semi-arid district of Singida the most important vegetable, jute mallow (*Corchorus* spp.), was mentioned as first by all focus groups without exception, yet it was not cultivated. The second most important traditional vegetable, the local cucumber 'bur gherkin' (*Cucumis anguria*), was mainly gathered from the wild and sometimes cultivated in Singida district, but it was not common in the other districts.

Despite some similarity in terms of preferences for traditional vegetables among the villages within each district, great variability occurred in the ranking of vegetables. Therefore, a cluster analysis was performed for the 14 most important vegetables (Table 5, all vegetables except 'uyoga'/local mushroom). The dendrogram (Fig. 3) shows different patterns for the four districts: the villages in Arumeru district split up into two groups, whereby in one group, villages showed more similarity than in the other. In contrast, in Singida district 10 villages formed one group, while the 11th village was more similar to a group of Kongwa villages. The Kongwa villages again split up into two groups, which both showed marked differences in terms of vegetable

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Table 5. Most important vegetable species, their status and overall rank as mentioned by 43 farmer groups in different villages (n = number of villages) of four districts researched in Tanzania

Most important vegetable species	Status[a]	Overall rank (median) of most important vegetable species[b]			
		Arumeru ($n = 10$)	Singida ($n = 11$)	Kongwa ($n = 10$)	Muheza ($n = 12$)
African eggplant (*Solanum* spp.)	c	3	+	+	5
African nightshade (*Solanum* spp.)	c, w	1	+	+	+
African spiderflower (*Cleome gynandra, C. hirta*)	w	+	+	3	+
Amaranth (*Amaranthus* spp.)	c, w	2	4	4	2
Bitter lettuce (*Launaea cornuta*)	w	+	+	+	1
Bur gherkin (*Cucumis anguria*)	w	−	2	−	−
Cassava leaves (*Manihot glaziovii, M. esculenta*)	c	+	6	+	+
Cowpea (*Vigna unguiculata*)	c	5	+	1	+
Ethiopian mustard (*Brassica carinata*)	c	4	−	+	+
Jute mallow (*Corchorus olitorius, C. trilocularis, C. tridens*)	w	+	1	2	+
Okra (*Abelmoschus esculentus, A. caillei*)	c	6	5	+	3
Pumpkin leaves (*Cucurbita pepo*)	c	+	+	5	6
Sweet potato leaves (*Ipomoea batata*)	c	+	3	6	4
Watercress (*Rorippa nasturtium-aquaticum*)	c, w	+	+	−	+
'Uyoga'/local mushroom (not identified)	w	+	+	+	+

[a] c, cultivated; w, wild.
[b] +, named but not ranked under first six; −, not named at all in the district.

Table 6. Sørensen's coefficient for six pairs of research districts in Tanzania concerning the availability of common traditional vegetables

	Arumeru	Singida	Kongwa	Muheza
Arumeru	–	59.6	46.2	36.2
Singida	59.6	–	46.4	27.1
Kongwa	46.2	46.4	–	29.8
Muheza	36.2	27.1	29.8	–

preferences. One Kongwa village deviated from all others and resembled mostly those of Muheza district and one group of Arumeru villages. In Muheza district, 10 villages formed one group, which showed medium to high similarity. However, two of the 12 Muheza villages varied to a great extent from all the others.

Genetic erosion: lost vegetables of Tanzania

Focus group participants addressed issues of genetic erosion and identified several reasons for traditional vegetables to disappear (Fig. 4). In nine out of 10 FGMs in Arumeru district, farmers named several traditional vegetables that had vanished or were no longer consumed regularly (Table 9). While particular landraces or forms were mentioned for cultivated vegetables, wild species were referred to in general. Genetic erosion was also stated by groups in the other districts, but to a lesser extent. Farmers named 16 and 15 vegetables to be lost or decreasing in number in Muheza and Singida districts, respectively. However, when this number of lost vegetables was put in relation to the total number of traditional vegetables known to have been consumed in a district, the greatest losses were experienced in Singida (45%) and Arumeru (31%) (Table 10). One mixed farmer group from a lower region in Arumeru district argued that no genetic erosion was experienced and all crops were still available. In fact, farmers stated that the new generation ate vegetables now, while 'in former times mainly meat and beans were preferred'.

According to FGM participants, six major threats to vegetable diversity existed, these differing depending on whether the vegetables were cultivated or wild.

Table 7. Shannon's and Simpson's diversity and evenness indices for four districts researched in Tanzania

	Singida	Arumeru	Kongwa	Muheza
Shannon's diversity index H	2.83	2.93	3.24	3.84
Simpson's diversity index D	15.70	16.71	21.87	36.18
Shannon's equitability (evenness) E_H	0.56	0.60	0.63	0.68
Simpson's equitability (evenness) E_D	0.10	0.12	0.13	0.12

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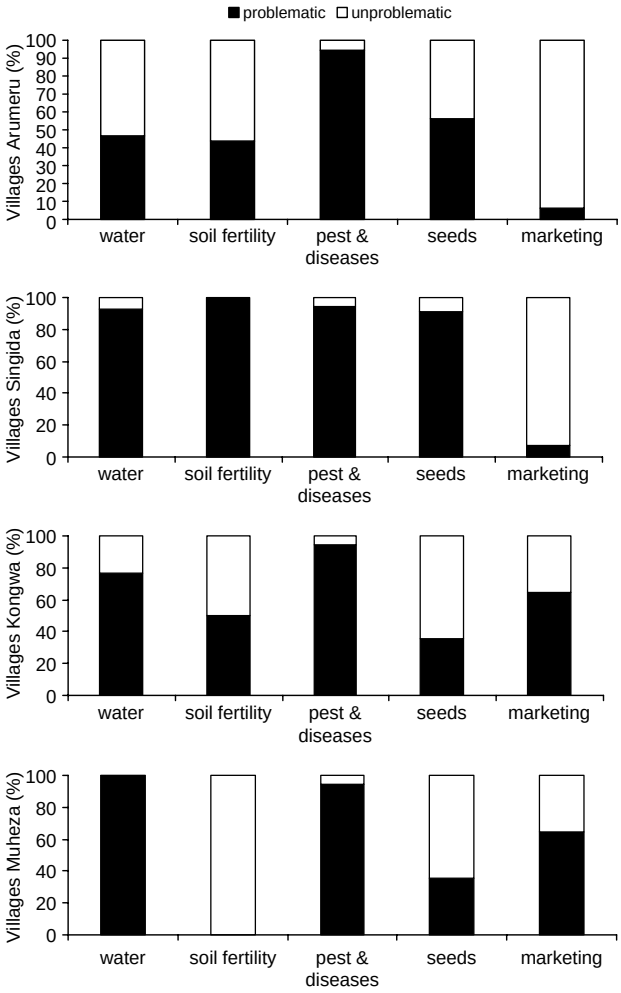

Fig. 2. Constraints perceived by farmers when producing traditional vegetables in four districts researched in Tanzania (percentage of villages assessing a constraint as problematic/unproblematic).

Table 8. Species and forms of *Solanum* traditionally used as vegetables in four districts researched in Tanzania

Scientific name	(District[a]) Local name	Status[b]
African nightshades		
Solanum villosum	(A) Mwembamba, mnavu wa kienyeji/kawaida	c, w
Solanum scabrum	(A) Mpana, kisasa, mnavu wa Kenya/kisasa	c
Solanum americanum	(M) Zinge	w, c
Solanum 'eldoretii'	(A) Ex-Kenya, Ex-Hai	w, c
	(M) Puche	c, w
Not identified	(M) Mnavu kiau/gana	w, c
African eggplant		
Solanum aethiopicum—Gilo group	(A) Tengeru white, ngogwe si chungu, ngogwe mshumaa	c
	(M) Mshumaa, mviringo kubwa	c
Solanum aethiopicum	(A) Manyere green	c
Solanum aethiopicum	(A) Ngogwe nyeupe ndogo	c
Solanum aethiopicum	(M) Mviringo	c
Solanum macrocarpon (?)	(M) Nyeupe	c
Solanum anguivi (?)	(M) (Fruit bitter, very small, green, ribbed)	c

[a] A, Arumeru; M, Muheza.
[b] c, cultivated; w, wild; if both, in order of importance.

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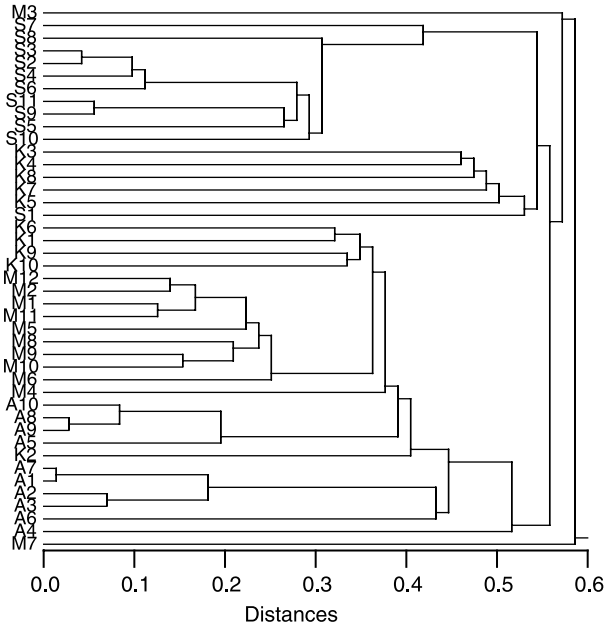

Fig. 3. Dendrogram of similarity for the 14 vegetables ranked as most important by farmers from villages of Arumeru (A1–A10), Singida (S1–S11), Kongwa (K1–K10) and Muheza (M1–M12) districts, Tanzania.

Respondents, however, did not necessarily relate the status of a vegetable to a particular threat. These included in order of importance:

- introduction of new or exotic vegetables (this affected both cultivated and wild traditional vegetables);
- climate change, especially the increased incidence and severity of drought (mainly wild);
- change in food habits (cultivated and wild);
- loss of habitats (mainly wild);
- lack of systematic transmission of knowledge from one generation to another on indigenous vegetables, resulting in a loss of indigenous knowledge (cultivated and wild);
- politics (mainly wild).

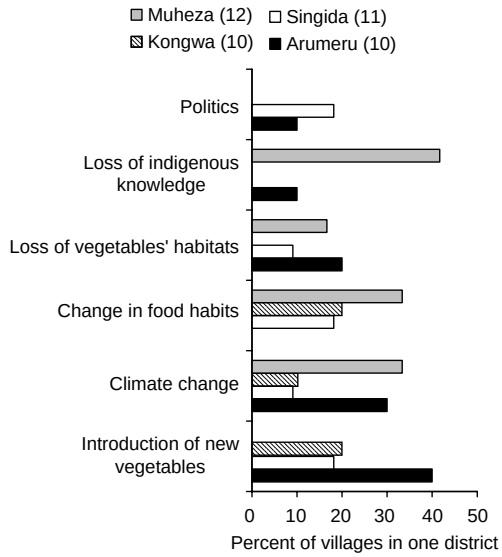

Fig. 4. Threats to traditional vegetable diversity as perceived by farmers in different villages of four different districts researched in Tanzania (number of villages per district in brackets).

The importance of these various threats differed among districts (Fig. 4). The individual threats will be illustrated in more detail below.

Introduction of new vegetables

In Arumeru district 'ngoomba', a *Brassica* species, and certain cowpea types were mentioned as being no longer available. Yet, newly introduced varieties of cowpea were used. The wild vegetable 'ngoomba' did not vanish but was reduced in amount when new crops were introduced to Arumeru district. Newly introduced vegetables included selected or improved varieties of amaranth, African nightshades and Ethiopian kale—all traditional vegetables—as well as white cabbage, Chinese cabbage, spinach and carrots. Two farmer groups reported that they were concentrating on those crops 'which are consumed in town and with which we can earn money'.

The introduction of early maturing, new varieties of cowpea and sweet potato, which were promoted by the government in Singida district, displaced old varieties. On one hand, this was perceived as an improvement, on the other hand, farmers blamed themselves that they had not taken any initiative to preserve displaced old varieties and, consequently, genetic material may have been lost. Interestingly, the problem of newly introduced vegetable species replacing old traditional ones was not mentioned at all in Muheza district (Fig. 4).

Politics

In Singida district, farmers reported that the introduction of new vegetable varieties was backed up by politics, for example, new varieties were advertised with special slogans. Thereby, farmers were influenced in their choice of vegetable for cultivation. It also happened in Muheza district that farmers were no longer allowed to farm in the forest. Consequently, a *Solanum* species that occurs only in the forest was not used any more.

Changing food habits

Farmers reported that eating habits changed with the young generation and, consequently, traditional vegetables and especially wild ones were not used any more, because 'young people do not go to the forest and look for wild vegetables' (Singida). A change in preferred taste was also experienced and, for example, an unidentified green vegetable, 'suludia', was used less

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Table 9. Cultivated and wild traditional vegetables reported as lost by farmers in four districts researched in Tanzania

Scientific name	English name (explanation)	Local name	Status[a]
Brassica carinata	Ethiopian kale	Sukuma wiki	c
Brassica carinata	(Local kale/mustard)		c
Brassica sp.		Ngoomba	c
Ipomoea batatas	(Local sweet potato)	Matembele viazi	c
Vigna unguiculata	Cowpea	Kunde	c
Cucumis sp.	(Local cucumber)	Matungu	c, w
Nasturtium officinale	Watercress	Saladi	c, w
Solanum spp.	African nightshade	Shanumbe, mnavu	c, w
Asystasia gangetica	(Perennial herb)	Tikini	w
Celosia trigyna	(Annual herb)	Fungumsanga	w
Cleome gynandra	African spiderflower	Mgagani	w
Corchorus spp.	Jute mallow	Gafuro, mntee, ngulele, trente, mkhala, mtae	w
Justicia heterocarpa	(Annual herb)	Nkobo, unkobo	w
Launaea cornuta	Bitter lettuce	Mchunga	w
Myrsine africana	Cape myrtle	Zuma	w
Opilia amentacea	(Evergreen shrub)	Mtulu	w
Sonchus luxurians		Songa	w
Vicandra physaloides	(Annual herb)	Kibwabwa	w
Not identified		Golo	w
Not identified		Itindimbui	w
Not identified		Kitini	w
Not identified		Kiumbu	w
Not identified		Kungujulu	w
Not identified		Mamamai	w
Not identified	(Used like local cucumber)	Mkayundu	w
Not identified	(Creeper found in valleys)	Mnkoswe	w
Not identified		Mtafuta	w
Not identified	(Green vegetable)	Suludia	w
Not identified		Zinge	w

[a] c, cultivated; w, wild.

due to its perceived bad taste and due to many other green vegetables being available (Kongwa).

Even if some farmers did not experience a loss of traditional vegetables, they often stated that a shift in consumption and eating habits had happened. For example, sardines, meat, exotic vegetables and processed foods were preferred over traditional vegetables and meals hand-prepared using fresh ingredients (Muheza). The amount of meat consumed in Muheza district dramatically increased recently since one could buy meat in the shop nowadays, while in the past it had to be hunted by men and was used only as a special food item, according to one female farmer.

Loss of indigenous knowledge

In one village of Arumeru district, it was argued that all traditional vegetables were still available but 'young people do not know about them'. While this statement was made by senior participants, young people did not disagree and often could not name traditional vegetables being gathered from the wild. Apparently, there was a lack of systematic transfer of knowledge on traditional vegetables from one generation to another. Similarly, in Muheza district only a few old people still knew certain traditional vegetables and had the knowledge of how to use them. A male farmer in one village argued that the new generation of women

Table 10. Loss of traditional vegetable diversity perceived by farmers in four different districts researched in Tanzania

	Arumeru	Singida	Kongwa	Muheza
Villages recognizing genetic erosion	9/10 (= 90%)	5/11 (= 45%)	4/10 (= 40%)	4/12 (= 33%)
Vegetables lost or decreasing in number[a]	8/(24 + 2) (= 31%)	15/(21 + 12) (= 45%)	7/(35 + 2) (= 20%)	16/(73 + 1) (= 22%)

[a] Calculated as number of traditional vegetables lost or decreased divided by number of traditional vegetables in current use plus those lost.

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did not know how to prepare traditional vegetables and, therefore, they did not eat them any more. Consequently, children did not get used to and did not learn anything about them. This was confirmed by a female farmer who used to eat 'kungujulu' as a child but did not cook it nowadays.

Climate change

In all four districts, one reason for the loss of traditional vegetables was the change in weather perceived, and particularly the increased incidence and severity of droughts. Due to this, swampy areas and river beds, which served as habitats for vegetables such as watercress in the past, had become drier or had disappeared (Muheza). In Arumeru district, farmers reported that certain vegetables had vanished from their village but could still be found in other areas, for example, at higher altitudes.

Habitat loss

In Arumeru district, farmers reported that more land is being cleared for use as farmland. Consequently, the natural habitat for wild vegetables was disappearing, causing the number of wild vegetables to decline. For example, a wild *Solanum* species called 'shanumbe' was formerly found on uncultivated land but has vanished as more lands became cultivated (Arumeru). An old variety of vegetable cowpea, which was not specified any further, was lost due to deforestation (Arumeru) as was a wild traditional vegetable called 'zinge' (Muheza).

The clearing of land near homesteads for cultivation has caused uncultivated bush lands to become more distant. For example, farmers in Singida district explained that some old jute mallow types used to be collected in the bush, but the bush was now too far away from their settlements and, therefore, the jute mallow was not gathered any more. Male farmers in Muheza district claimed that traditional vegetables were still available but not close to their homesteads and that women were not willing to walk long distances to obtain these vegetables.

Discussion

Vegetable diversity

As Tanzania comprises nine different agro-ecological zones (Anonymous, 2004c) and represents one of 26 hotspots of biodiversity in the world (Anonymous, 2004b), a high diversity of traditional vegetables was to be expected in this country. In the event, it was less a question of whether vegetables were available but rather which and how many vegetables were in fact used by farmers.

The fact that Muheza differed to such an extent from the other districts in terms of vegetable composition may be largely attributed to its distinct coastal climate with high biodiversity in general. Muheza district involves parts of the Eastern Usambara Mountains that are, in turn, part of the Eastern Arc Mountains belonging to the 26 biodiversity hotspots in the world (Anonymous, 2004b). Furthermore, it is located much further from urban centres compared to the other districts and, in general, does not enjoy easy access. It has been recognized that market distance can have a positive effect on landrace diversity (Smale *et al.*, 2004). Diversity of vegetables collected in the wild was particularly high in Muheza, confirming earlier data from this remote district (Vainia-Mattila, 2000). Similar findings have been observed among remote indigenous tribes in the Himalayas (Sundriyal *et al.*, 2004).

The similarity between villages of Arumeru and Singida districts can be explained by the contribution to infrastructure of their urban centres, especially in terms of marketing and information systems resulting in a similar, limited set of vegetables used by farmers. This is striking, as other features of these two districts were rather distinct. Although they are situated at similar altitudes (1000–1500 m asl), Arumeru has a rather humid climate, while Singida has a semi-arid climate, and thus the two districts are suitable for a different range of vegetables (Table 1). Furthermore, while in Arumeru the culture of vegetable cropping was only about 170 years old and people had been pastoralists in the past (Gulliver, 1969), in Singida district Nyaturu people practised agriculture with cattle integrated into the farming system since ancient times (Koponen, 1988). Cultural traditions can be responsible for consuming certain plants or plant parts. For example, the population of Mara region in northern Tanzania had little cultural tradition of eating underground portions of plants, and edible wild roots and tubers were unrecognized by people (Johns *et al.*, 1996). This would suggest a different preference for vegetable species and types in the two different districts. However, the degree of urbanization and the infrastructure available in both Arumeru and Singida districts were obviously the overriding decisive factors for diversity and species composition.

Arumeru also differed from the other districts in terms of traditional vegetable cropping and collecting: more than 50% of respondents cultivated vegetables year round in Arumeru as compared to less than 20% of respondents from other districts (K. Weinberger *et al.*, personal communication).

While vegetable diversity differed among the four districts, evenness in terms of distribution of traditional vegetables was found to be similar and in general not very high for all districts. This was presumably due to relatively high differences among the villages within one district (Table 6; Fig. 3). Only a few common vegetables

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were used in all villages, yet, quite a number of vegetables are known and used in individual villages. Different factors might have created this variability within one district, for example, the altitude of villages varied strongly in Arumeru and Muheza; whereas in Kongwa only four of the 10 villages investigated had irrigation systems available. This pattern is reflected in the dendrogram (Fig. 3), where villages of Kongwa district are widely separated from one another. While Sørensen's coefficient and the diversity indices take all vegetables mentioned into consideration, only the 14 vegetables that were ranked at least once among the most important six were included in the cluster analysis (Fig. 3). In terms of these most important vegetables for farmers, all four districts showed a level of similarity within the district and thereby distinguished themselves from the other districts. However, this inter-district diversity might also be an artefact because different local names could have been applied for the same vegetable because of the different ethnic groups prevalent in the four districts (Table 1). Caution is, therefore, necessary if such an appreciation of diversity is only based on the names provided by local people without verifying their taxonomic identity (Cox and Wood, 1999).

In terms of infrastructure, farmers' knowledge was an important factor in which the information system of each district was reflected. For example, farmers in Arumeru district, living close to HORTI Tengeru and AVRDC-RCA as sources of training and information, were knowledgeable about specific facts, such as the nutrient content of certain vegetables or their preservation methods (although these were not commonly practised). Furthermore, more exotic vegetables were cultivated, such as tomatoes, which represent an important research and development target of AVRDC-RCA. In contrast, in the rural Kongwa district, FGM participants asked for more information about vegetables since they seldom were reached by advanced training programmes for these particular crops. Thus, access to knowledge determined the type of vegetables and rationale for their cultivation. In this case, newly acquired knowledge obviously stimulated exotic vegetable cultivation and reduced traditional vegetable diversity. Likewise, a study in Swaziland has demonstrated that in a market-based and urbanizing economy, the loss of agrobiodiversity occurs extremely fast. Specific government policies that favour this process have played an important role (Malaza, 2003).

Genetic erosion

The utilization of traditional vegetables enhances food security and the conservation of their genetic resources may contribute to new ideas and products of value to society in the future (Lachkovics, 2001). In this study, the level of genetic erosion of vegetables was fairly high in all districts, especially in Arumeru district.

The introduction of new vegetables was a major factor driving genetic erosion and, in general, it has been acknowledged that, when new varieties find their way into traditionally diverse agro-ecosystems, the number of landraces as well as associated local knowledge is diminished (Rhoades and Nazarea, 1999).

While the positive qualities of traditional vegetables, such as their high nutrient content, may have long-term benefits to farmers, the positive qualities of exotic vegetables, such as high yield, fast growth and less perishability, had short-term benefits that were easily perceived in the form of increased income. As low living standards are prevalent in Tanzania, with 19% of the population living below the food poverty line and 36% living below the basic needs poverty line (Anonymous, 2001), it is understandable that exotic vegetables are becoming popular. Farmers have become more market-oriented, favouring only a few species as cash crops that have been specifically developed for this purpose. Consequently, the diversity of vegetables cultivated has been and may continue to be reduced.

Another important factor driving genetic erosion is changing food habits, which is closely linked to loss of indigenous knowledge and the introduction of new vegetables. Maundu (1995) reported that a change in food preference, which was affected by westernized markets, education and urbanization, tended to reduce the attention for indigenous or traditional plant species. A so-called 'nutrition transition' documented in industrialized countries is now especially affecting urban populations in many developing countries (Millstone and Lang, 2003).

Besides infrastructure (including knowledge from 'outside'), indigenous knowledge on how to collect, cultivate and prepare traditional vegetables and their variable taboos and applications, for example as medicines, was regarded of high importance. The loss of indigenous knowledge has been recognized as one of the general factors affecting biological diversity in Tanzania (Anonymous, 1998). The relationship between loss of indigenous knowledge on food plants and the reduction in dietary diversity has also been observed in Kenya (Maundu, 1995). Likewise, together with the indigenous plants, farmers' knowledge on how to breed, manage and select these resources will be lost (Slikkerveer, 1995).

During the FGMs, women were accused of being responsible for less consumption of wild vegetables since, for example, they were not willing to walk long distances for gathering. Similarly, farmers stressed that young women did not know how to prepare traditional vegetables and did not teach their children. This gender aspect suggests that women were mainly responsible for traditional vegetables and played the

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most important role in their cultivation, processing, passing knowledge on to younger people and, ultimately, their conservation.

Farmers also identified habitat loss as a reason for genetic erosion. Wild vegetables being less known, valued and available in Arumeru and also Singida district could be attributed to the extent of urbanization and population density, which diminished the area of uncultivated land as a habitat for wild vegetables. It has been acknowledged that species extinction is regarded as one of the major consequences of deforestation in tropical Africa (Lacher *et al.*, 1999).

The reason for 'settlements being too far from the bush' was not necessarily only due to more land being cleared for cultivation, but probably also to government settlement policy. In Tanzania, which was declared as a one-party state in 1965, the policy of African Socialism culminated in the 1967 Arusha Declaration. The latter set the principles of 'Ujamaa': collective, equal opportunity and, above all, self-reliance. 'Ujamaa' villages regrouped farmers in specific areas for specified types of production (Anonymous, 2004a). Although they settled close to each other to share infrastructure, they were moved far away from their original lands and were too far away from the bush or uncultivated land to gather wild traditional vegetables. Additionally, the economic autonomy of women, who have been mainly responsible for traditional vegetables, was negatively affected by the 'Ujamaa' policy, since this empowered a small number of men with new rights over land use (Brain, 1976).

Besides the threats to horticultural biodiversity mentioned by the farmers of this study, there are other reasons for traditional vegetables to be lost, such as area-specific consumption, lack of organization of farmers for marketing and limited seed supply (Anonymous, 1998). Nevertheless, in some of the villages researched, no genetic erosion of traditional vegetables was perceived by farmers. For example, in Singida district, one farmer group highlighted the fact that the traditional vegetables 'bur gherkin' and jute mallow, which were used a long time ago, were still available. Apparently, farmers have been able to conserve these vegetables through consumption and production. In another village, a wild amaranth type called 'mughaa' was mentioned as being still available. This amaranth plays an important role in times of famine, when the wild plant is cooked with flour and consumed as a main dish instead of its normal use as a relish.

As shown by these positive examples of conserving vegetables, agrobiodiversity is ultimately controlled by farmers' decisions—they will choose what crop species to exploit and also select their mix of varieties (Gollin and Smale, 1999). In general, farmers have several reasons to grow traditional varieties alongside modern varieties, and this was also practised by the farmers interviewed in all four regions of Tanzania. Motives for this include farmers' risk aversion, learning behaviour or experimentation, and differentiation of varieties seen as different commodities (Brush and Meng, 1998; Gollin and Smale, 1999).

Prospects

When comparing diversity among the four districts, socio-economic conditions seem to dominate over environmental determinants regarding on-farm conservation of traditional vegetable diversity. This agrees with similar findings in cereals as reviewed by Smale *et al.* (2004). This implies that Arumeru would be the district most threatened with genetic erosion. Therefore, an effort should be made to collect the remaining key traditional vegetables from this district and conserve them *ex situ*. In Kongwa, on the other hand, traditional vegetable diversity may be less threatened and farmers will continue to grow them because they have no alternative under the drought-prone ecological conditions. Thus, on-farm conservation is already being practised *de facto* (Brush and Meng, 1998) and may be stable as long as no major irrigation or marketing infrastructures are developed. For Kongwa, improvements in agro-ecologically adapted materials could be made by participatory breeding approaches so as to improve farmers' livelihoods. Tolerance to pests and diseases of vegetables should be particularly targeted. A promising crop is vegetable cowpea since it is strongly preferred and cultivated throughout this district. So far, little attention has been given to improve cowpea as a leafy vegetable although this use is extensively appreciated in many African countries (Barrett, 1990; Kitch *et al.*, 1998). In Muheza, potential infrastructural changes could lead to a rapid loss of traditional vegetable diversity as there would be few obvious constraints for intensifying crop production. Monitoring of infrastructure and economic developments will be essential for detecting change in both Kongwa and Muheza.

Most of the research that values farmers' variety choices and preference ranking has focused on cereals such as maize and wheat (Brush and Meng, 1998). In principle, there is no reason to believe that farmers' genuine preferences would change if non-staple crops would be concerned. However, there is a need to understand the rationales underlying farmers' decision making and choice of species and varieties within a commodity group that usually accompanies cereals or other starchy staples. The balance of different factors, such as risk aversion, transaction costs, environmental constraints or demand for quality characteristics (Brush and Meng, 1998; Smale *et al.*, 2004), which drive these decisions may be different for vegetables.

Finally, this study revealed that wild traditional vegetables play a more important role than the cultivated veg-

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etables originally targeted by the project. Similarly, High and Shackleton (2000) reported from a case study in South Africa that such wild resources had a significant economic and nutritional role in rural livelihoods. Some popular wild types have potential for greater utilization as cultivated crops. For example, jute mallow is especially preferred in the semi-arid districts of Singida and Kongwa, and agronomic studies could be undertaken to promote the cultivation of this vegetable. As a future crop, it may even satisfy the demand of the urban population that has migrated from rural areas, and thereby link them with certain food traditions of their ancestors.

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