

ESTABLISHMENT METHODS AND NICHE CHARACTERIZATION REVEAL EAST AFRICA TAMARINDS (*Tamarindus Indica* L) ON FARM POPULATIONS CONSERVATION STRATEGIES

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Abstract

Past localised population studies results recommended on farm planting of tamarinds, to stem depletion threats that increasing utilisation and habitats loss to agriculture in absence of conservation strategies pause to woodland or riverbanks –wild habitat tamarinds. It was questionable however if and how farmer adoption of this strategy would be applicable for tamarind wide-conservation in East Africa. The current study evaluated a hypothesis that the mean numbers of wild tamarinds is higher than for planted individuals and there are no correlations between tamarind establishment methods and their niches on farms in order to elucidate regionally appropriate on farm tamarind conservation needs and strategies. One

hundred and seventeen tamarinds sampled from farms in East Africa were characterised for establishment methods and niches and for correlations between establishment methods and niches on farms. The results revealed equal regional mean numbers of planted and wild tamarinds ($P > 0.05$) with significant variation ($P < 0.05$) within and among countries. Uganda and Kenya tamarinds are largely planted ($\geq 60\%$) in contrast to 77.7% being wild in Tanzania. The planted individuals are mainly in compounds ($R = 0.912$) or crop fields ($R = 0.577$), the wild are elsewhere on farms ($R = 0.937$). Planted seeds sources were markets, forest and agriculture offices, woodlands, riverbanks and India or Arabic regions. These results imply on farm conservation of tamarinds will mitigate for threatened wild populations. However, farmer centred, localised and not regional conservation strategies are needed for planted and wild tamarinds conservation in the different on farm niches in East Africa.

Keywords; *Tamarindus indica*, germplasm, on farm planting, wild habitats, farmers, conservation

INTRODUCTION

Tamarind and tamarind niche tree species conservation needs and knowledge

Tamarind is a tropical widespread multipurpose fruit tree species of the *Fabaceae*, subfamily *Caesalpinaceae* tribe *Amherstieae*, Genus *Tamarindus* (Leonard 1957, Nagarajan et al 1998, Gunasena and Hughes 2000, El-Siddig 2006). Tamarind products consumed or marketed worldwide includes soft drinks, drugs and drug additives, spices, jute, textile or timber, and environmental services are shade, soil fertility improvement and ornamentals. While tamarind is managed for products in countries like India and Thailand, in Africa its products or product markets and populations conservation strategies are not yet developed. Limited on farm planting is reported despite increasing utilisation and its wild habitats are being converted to agriculture. As a result, population inventories have revealed the African populations are declining and with genetic erosion also expected (Gunasena and Hughes 2000, Muoki et al 2000, FAO 2004, Nyadoi 2005). Farmers recently prioritised tamarinds for conservation and product development (FAO 2004, Jama et al 2005) to ensure populations sustainability for livelihoods in East Africa and some other African countries'. Knowledge of tamarind domestication levels and niches on farms was hence needed to guide identification of conservation strategies. However, at regional levels, the establishment methods and niches of on farm tamarinds have not been characterised, the species is still categorised as a largely wild species in the region with populations' specific conservation needs or strategies, including mechanisms for farmer engagement in the programmes largely unknown. The objective of the current study was to characterise East Africa on farm tamarind populations by their establishment methods and niches in order to generate knowledge of domestication levels and strategies and mechanisms of farmer engagement in tamarind conservation in niches on farms.

Materials and Methods

Study area and data collection

Sites representative of tamarind niches in Island and mainland, different vegetation types, climate-temperature and rainfall zones, lower (South) and higher (North) latitudes below and above equator and on farms, woodlands and riverbank habitats in East Africa were included (Fig. 1). Within study site, the first on farms-tamarind tree encountered was sampled as the first sample, consequent individuals sampling were done at intervals ≥ 500 m depending the distribution and abundance of tamarinds or farms having tamarinds (mainly scattered, ≤ 2 trees per hectare; Nyadoi 2005). For each of the sampled tamarinds (117 -one for each farm), the following data were recorded; niche; i.e., whether the tamarind is in-compound of homes, schools, hospitals or community centres, crop field (where other agricultural crops are growing in the farm) or elsewhere on farms (not in compound or crop field) but within the farm; the farmers' responses on establishment methods; i.e., whether the tamarind was planted and the source of seeds or germplasm planted if known, or the tamarind grew naturally on its own (wild), geographic information of position (GIS)-altitudes, latitude and longitudes coordinates recorded with Garmin model 3A geographic position systems equipment (GPS), environment-habitat, vegetation type and country (recorded on site in pre designed data capture sheets), and sites' mean annual rainfall and temperature data were obtained later from the World Agroforestry Centre -ICRAF GIS laboratory.

Data management and analyses

The data on tamarind establishment methods and niches were entered and organised per country, local site name-district and niche within farm in excel computer programme. Figures and tables showing percentages or numbers of tamarinds in the different establishment methods and niches per country, district and niche on farm were generated from the organised data in excel and the data file imported into GENSTAT 9.0 soft ware package for analysis of variance

(ANOVA). Statistical t tests and associated P values, and Pearson's product moment correlation (R) were generated and their values interpreted respectively for level of significance of observed differences in the means of numbers of planted and wild tamarinds and relationships between tamarind establishment methods and their niches on farms at regional level and among and within countries. Farmer mentioned sources of germplasm for planted tamarinds were tabulated.

4. Results: Tamarind Establishment Methods and Niches in East Africa

Establishment methods and niches data were recorded for 117 tamarinds -one each per farm (Table 1); 13(11.1%) of the tamarinds were in crop fields (Pearson's product moment correlation within countries $R = 0.727$ within country and or $R > 0.5$ at regional level, for tamarind being in crop field and planted (Tables 2 and 3), 55(47%) of the tamarinds were found elsewhere on farms ($R = 0.937$) for tamarinds being elsewhere on farm and wild, 34 (29%) of the tamarinds were found in home compounds and 15 (13%) were in administrative centre compounds ($R = 0.912$) for tamarinds being in compound and its establishment method being planted (Tables 1, 2 and 3).

Overall, 45 (38.5%) of the tamarinds were planted, 44 (37.6%) were wild and for 28 individuals (23.9%) farmers did not know the establishment methods (Table 1). For the 89 tamarinds whose establishment methods farmers knew; 36% were from Uganda, 34% (Kenya) and 30% from Tanzania (Fig. 2) in line with the levels of plantings; Uganda (65.6%, $n= 32$) and Kenya (60%, $n=30$) and below 30% in Tanzania; i.e., Tanzania's 77.7% ($n= 27$) tamarinds were wild (Figures 2 and 3). At the regionally level, the means of numbers of planted tamarinds equal to the means of numbers of wild tamarinds on farms ($t = 0.11$, $P = 0.916$, Table 4). Individually, the planted tamarinds varied significantly ($P = 0.010$) among countries but not within countries

(Table 5), the wild tamarinds varied significantly ($P < 0.001$) both within and among countries (Table 6).

Sources and origin of seeds for planted tamarinds varied (Table 7). Some farmers in Samburu planted tamarind seeds supplied by forestry officers. The forestry officer of Samburu reported that the seeds were collected from wild tamarinds in South Hor forest. Tamarinds in the Catholic nuns' or doctors' compound in Samburu catholic hospital were planted by Agriculture officers and one of the officers reported that the seeds were brought from the Kenya Forestry Resources Research Institute (KEFRI). One Samburu farmer reported he planted seeds from the national market in Mombasa. Agricultural officers in Zanzibar agricultural research station reported that tamarinds in the station were planted long time ago but the people or officials who planted the trees and the source of planted seeds are not known because of lack of records. Some farmers in Lamu Island in Kenya and in Zanzibar Islands in Tanzania reported they planted tamarinds seeds brought from India and Arabic region. Seeds planted in mainland Kenya, Tanzania and Uganda were mainly from local markets, neighbouring districts, forests, riverbanks and neighbour's farms. Tamarinds whose establishment methods were unknown to farmers occurred similarly within and among East African countries ($P > 0.05$, Table 8).

Discussions

Tamarind establishment methods and niches in east Africa

The results show that populations of planted tamarinds equal the wild ones on farms at regional level in East Africa despite more plantings in Uganda and Kenya than in Tanzania. On farm planting may reflect management or domestication levels and also the values farmers attach to a species. For tamarinds in East Africa however, on farm planting may or may not be a good indicator of values farmer attach to tamarinds. It is possible that wild tamarind populations including those in wild habitats (forests, riverbanks) may be insufficient for farmer product needs in Uganda and Kenya and therefore the more plantings done. A local study in Kenya, for example, reported insufficient production from or lack of tamarinds on farms as farmer reasons for planned future planting of more tamarinds and or harvesting fruits from wild (river banks and woodlands) habitats (Nyadoi 2005). In Tanzania wild tamarinds on farms and in wild habitats may be sufficient for farmers' product needs, hence no need for planting and or reflected low levels of on farm plantings.

However, apart from products needs, other factors also affect farmer on farm planting of tree species. For example management constraints and land use priority in case of conservation of tamarinds in crop fields; farmers reportedly cut tamarinds off when agricultural crops that do not withstand shade are planted in the same field (Nyadoi 2005). Whereas, elsewhere niche growing tamarinds (the wild) are particularly targets for timber and charcoal production and are even more vulnerable to changes in land use priority than the crop field tamarinds. Farmers in general are most likely to conserve in compound niche tamarinds even without external interventions; these are usually planted for long term shade services and fruit needs (Nyadoi 2005). On the other hand, crop field and elsewhere niche tamarinds would require specific focussed external conservation interventions. Tamarind products and product market developments, germplasm supply and farmer technical capacity building for tree-agricultural

crop management or including conservation importance campaigns may help. These are known drivers of farmer adoption of species (Aahlback 1995; Temu et al. 2000). In perspective, availability of germplasm or seed sources (local woodlands, riverbanks, market, forestry or agricultural offices, and India or Arabic geographic regions) contributed to current on farm planted tamarind populations.

Findings of this study also show that declining wild habitat (riverbank and woodland) populations or tamarind gene pools are also represented among the planted and on farm wild tamarinds. Hence, on farm conservation would help preserve tamarind genetic resources in the event of total depletion of wild habitat populations or loss of the wild habitats. Secondly, the Indian and Arabic regions, because they are source for some of the planted individuals in East Africa, supports molecular marker elucidated close relationships between these two geographic populations (unp. data; Diallo et al 2007). This finding in particular down plays the need for Asian tamarinds germplasm acquisition to improve African populations as originally thought (except if there is specific need for genetically modified tamarinds like the sweet types reportedly (Gunaseena and Hughes 2000) in USAID project areas in Thailand). The reverse is also true (no need to acquire germplasm from East Africa to improve Asian populations).

Over all, the means of numbers of wild and planted tamarinds on-farms equal regionally and therefore tamarind is no longer a largely wild species in East Africa instead 65.6% of Uganda and 60% of Kenya populations are composed of planted individuals but Tanzania populations are still largely wild (77.7%) despite some plantings (especially in the Zanzibar Islands). Planted tamarinds are mainly in compounds ($R = 0.912$) or crop fields, the wild are in niches elsewhere on-farms ($R = 0.933$). These results mean country or localised population specific and not regional conservation strategies will be applicable for tamarind conservation. They will need to be integrated with incentives to encourage farmer preservation of the wild and planted tamarinds found in different niches on farms.

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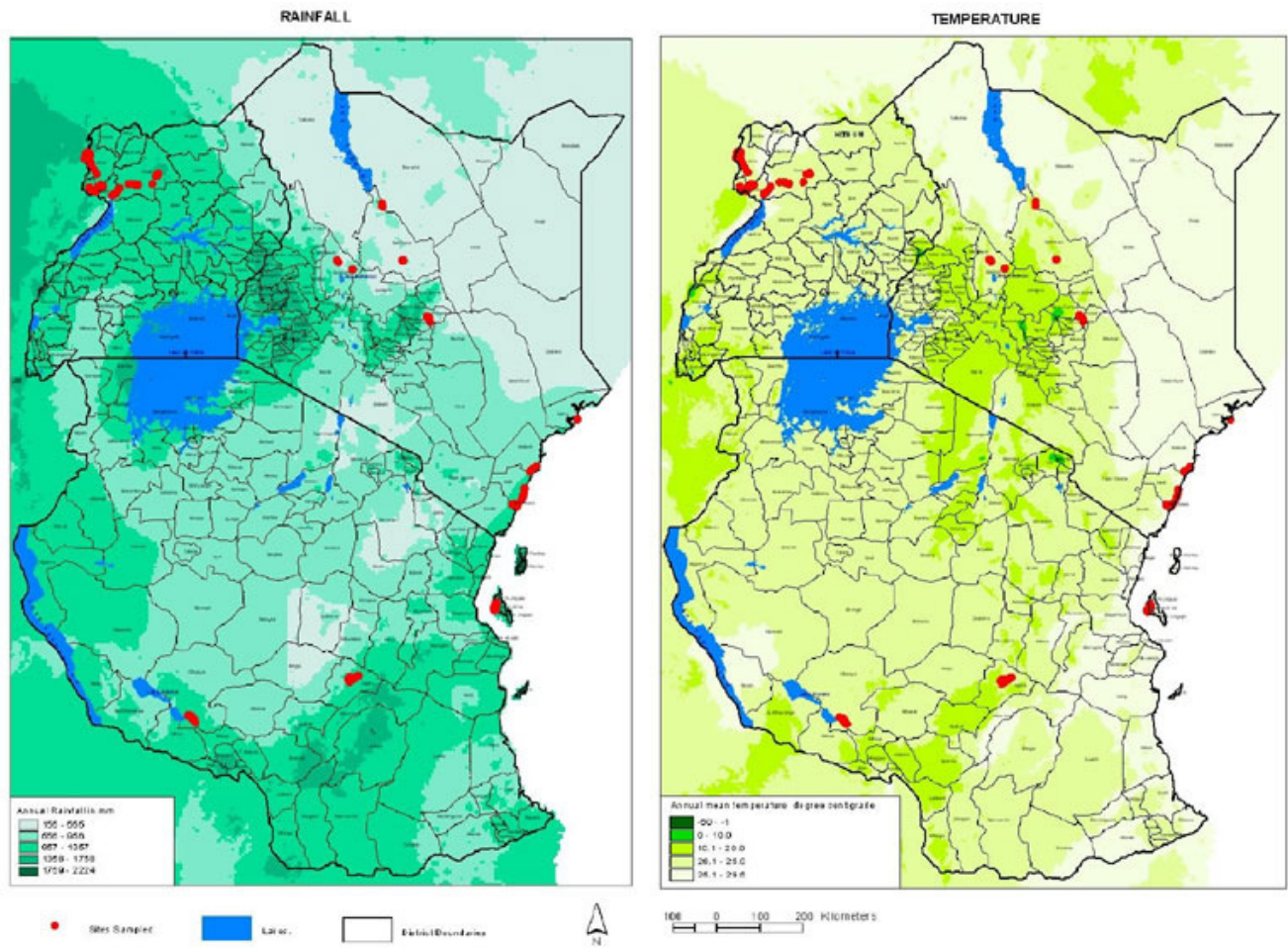


Figure 2. *Tamarindus indica* establishment methods on-farms in thirteen districts in East African countries, N = 117

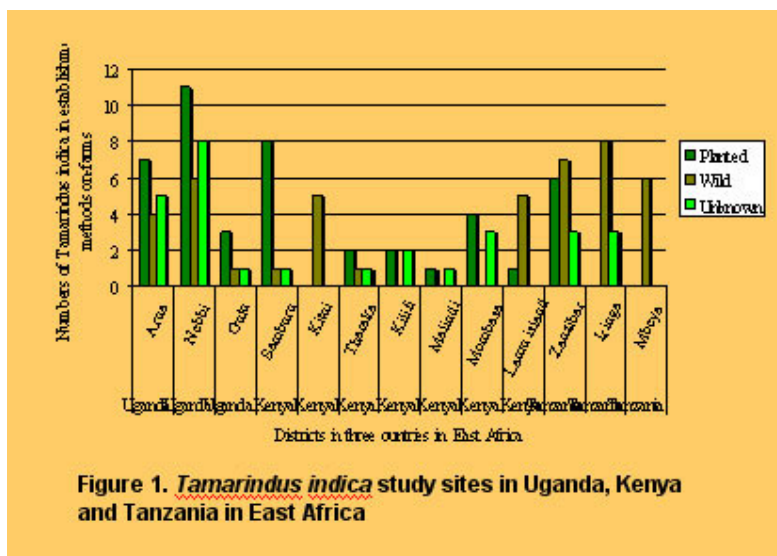


Figure 1. *Tamarindus indica* study sites in Uganda, Kenya and Tanzania in East Africa

Table 1. Tamarindus indica establishment methods and niches on-farms in East Africa

tamarind field refer	Data base code	Phytocoria	Sub county	District	Country	Tamarindus indica niche on-farm	In-crops field	In-compound of homes	In-compound of homes	In-compound offices, schools, hospitals, community centres etc	Establishment method-Planted	Establishment method-Wild	Establishment method-Unknown
1	1	Sudanian regional	Pakwachi	Nebbi	Uganda	hospital cpd	0	0	0	1	0	0	1
2	2	Sudanian regional	Pakwachi	Nebbi	Uganda	On-farm	0	1	0	0	0	1	0
3	3	Sudanian regional	Pakwachi	Nebbi	Uganda	In-compound	0	0	1	0	0	1	0
4	4	Sudanian regional	Pakwachi	Nebbi	Uganda	cassava garden	1	0	0	0	0	0	1
5	5	Sudanian regional	Pakwachi	Nebbi	Uganda	On-farm	0	1	0	0	0	1	0
6	6	Sudanian regional	Pakwachi	Nebbi	Uganda	sorghum garden	1	0	0	0	0	0	1
8	7	Sudanian regional	Pakwachi	Nebbi	Uganda	sorghum garden	1	0	0	0	0	0	1
11	8	Sudanian regional	Pakwachi	Nebbi	Uganda	On-farm	0	1	0	0	0	0	1
13	9	Sudanian regional	Pakwachi	Nebbi	Uganda	crop garden	1	0	0	0	0	0	1
14	10	Guineo conglia-sudanian	Goli	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
15	11	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
17	12	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	On-farm	0	1	0	0	0	0	1
18	13	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	On-farm	0	1	0	0	0	0	1
19	14	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
20	15	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
21	16	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
22	17	Guineo conglia-sudanian	Paitha	Nebbi	Uganda	On-farm	0	1	0	0	1	0	0
24	18	Guineo conglia-sudanian	Nebbi	Nebbi	Uganda	In-compound	0	0	1	0	1	0	0
25	19	Guineo	Nebbi	Nebbi	Uganda	In-	0	0	1	0	1	0	0

		conglia-sudanian			nda	compou nd							
26	20	Guineo conglia- sudanian	Nebbi	Nebbi	Uga nda	In- compou nd	0	0	1	0	1	0	0
27	21	Guineo conglia- sudanian	Nebbi	Nebbi	Uga nda	cassava garden	1	0	0	0	0	1	0
51	22	Guineo conglia- sudanian	Nebbi	Nebbi	Uga nda	On-farm	0	1	0	0	0	1	0
28	23	Guineo conglia- sudanian	Kuchwinyi	Nebbi	Uga nda	In- school cpd	0	0	0	1	1	0	0
30	24	Guineo conglia- sudanian	Kuchwinyi	Nebbi	Uga nda	On-farm	0	1	0	0	0	1	0
32	25	Guineo conglia- sudanian	Kuchwinyi	Nebbi	Uga nda	On-farm	0	1	0	0	1	0	0
34	26	Guineo conglia- sudanian	Madi-okollo	Arua	Uga nda	sorghu m garden	1	0	0	0	0	1	0
35	27	Guineo conglia- sudanian	Vura	Arua	Uga nda	On-farm	0	1	0	0	1	0	0
36	28	Guineo conglia- sudanian	Vura	Arua	Uga nda	banana garden	1	0	0	0	0	0	1
37	29	Guineo conglia- sudanian	Awindiri- arua	Arua	Uga nda	In- compou nd	0	0	1	0	1	0	0
38	30	Guineo conglia- sudanian	Arua municipality	Arua	Uga nda	In- compou nd	0	0	0	1	1	0	0
39	31	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	In- compou nd	0	0	1	0	0	0	1
40	32	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	cassava garden	1	0	0	0	1	0	0
41	33	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	On-farm	0	1	0	0	0	0	1
42	34	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	sorghu m garden	1	0	0	0	1	0	0
43	35	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	On-farm	0	1	0	0	1	0	0
44	36	Guineo conglia- sudanian	Adumi- ayivu	Arua	Uga nda	cassava garden	1	0	0	0	0	1	0
45	37	Guineo conglia- sudanian	Oluvu- maracha	Nyadr i	Uga nda	On-farm	0	1	0	0	0	1	0
46	38	Guineo conglia- sudanian	Oluvu- maracha	Nyadr i	Uga nda	In- compou nd	0	0	1	0	1	0	0
47	39	Guineo conglia- sudanian	Oluvu- maracha	Nyadr i	Uga nda	trading centre	0	0	0	1	0	0	1
48	40	Guineo conglia- sudanian	Oluvu- maracha	Nyadr i	Uga nda	cassava garden	1	0	0	0	0	0	1

50	41	Guineo conglia- sudanian	Kijomoro- maracha	Nyadr i	Uga nda	On-farm	0	1	0	0	0	1	0
57	42	Lake victoria regional	Kochi goma	Amur u-gulu	Uga nda	IDP cpd	0	0	1	0	1	0	0
58	43	Lake victoria regional	Kochi ongako	Gulu	Uga nda	In- compou nd	0	0	1	0	1	0	0
59	44	Lake victoria regional	Kochi ongako	Gulu	Uga nda	In- compou nd	0	0	1	0	1	0	0
60	45	Lake victoria regional	Gulu market in cpd	Gulu	Uga nda	market cpd	0	0	0	1	0	0	1
61	46	Lake victoria regional	Koro gulu	Gulu	Uga nda	On-farm	0	1	0	0	0	1	0
62	47	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
63	48	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
64	49	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
65	50	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
66	51	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
67	52	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
68	53	Somalia- Masai	Wamba	Samb uru	Ken ya	In- compou nd	0	0	1	0	1	0	0
72	54	Somalia- Masai	Nginyang	Samb uru	Ken ya	commu nity ctre	0	0	0	1	0	0	1
77	55	Somalia- Masai	South horr	Samb uru	Ken ya	On-farm	0	1	0	0	0	1	0
80	56	Somalia- Masai	South horr	Samb uru	Ken ya	forestry office	0	0	0	1	1	0	0
83	57	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	In- compou nd	0	0	1	0	0	0	1
84	58	Zanzibar Inhambane	Pandya hospital	Momb asa	Ken ya	hospital cpd	0	0	0	1	0	0	1
85	59	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	In- compou nd	0	0	1	0	1	0	0
86	60	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	In- compou nd	0	0	1	0	1	0	0
87	61	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	On-farm	0	1	0	0	1	0	0
90	62	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	In- compou nd	0	0	1	0	1	0	0
91	63	Zanzibar Inhambane	Kisauni	Momb asa	Ken ya	market cpd	0	0	0	1	0	0	1
93	64	Zanzibar Inhambane	Ntwapa, kilifi	Kilifi	Ken ya	trading centre	0	0	0	1	0	0	1
94	65	Zanzibar	Ntwapa,	Kilifi	Ken	school	0	0	0	1	0	0	1

		Inhambane	kilifi		ya	cpd							
96	66	Zanzibar Inhambane	Shariani	Kilifi	Ken ya	In- compou nd	0	0	1	0	1	0	0
97	67	Zanzibar Inhambane	Kibau	Kilifi	Ken ya	On-farm	0	1	0	0	1	0	0
99	68	Zanzibar Inhambane	Gede forestry office	Malin di	Ken ya	In- compou nd	0	0	1	0	1	0	0
101	69	Zanzibar Inhambane	Mida	Malin di	Ken ya	On-farm	0	1	0	0	0	0	1
103	70	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	In- compou nd	0	0	1	0	1	0	0
104	71	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	On-farm	0	1	0	0	0	1	0
106	72	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	In- compou nd	0	0	1	0	0	1	0
107	73	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	On-farm	0	1	0	0	0	1	0
108	74	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	On-farm	0	1	0	0	0	1	0
109	75	Zanzibar Inhambane	Lamu	Lamu island	Ken ya	On-farm	0	1	0	0	0	1	0
110	76	Somalia- Masai	Mitungu	Thara ka	Ken ya	On-farm	0	1	0	0	0	1	0
112	77	Somalia- Masai	Kithino	Thara ka	Ken ya	On-farm	0	1	0	0	1	0	0
113	78	Somalia- Masai	Tunyai	Thara ka	Ken ya	school	0	0	0	1	0	0	1
114	79	Somalia- Masai	Tunyai	Thara ka	Ken ya	On-farm	0	1	0	0	1	0	0
247	80	Somalia- Masai	Kiwea	Kitui	Ken ya	On-farm	0	1	0	0	0	1	0
248	81	Somalia- Masai	Kiwea	Kitui	Ken ya	On-farm	0	1	0	0	0	1	0
249	82	Somalia- Masai	Kivumbi	Kitui	Ken ya	On-farm	0	1	0	0	0	1	0
250	83	Somalia- Masai	Kivumbi	Kitui	Ken ya	On-farm	0	1	0	0	0	1	0
252	84	Somalia- Masai	Mathange monza	Kitui	Ken ya	On-farm	0	1	0	0	0	1	0
122	85	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	1	0
123	86	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	1	0
124	87	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	In- compou nd	0	0	0	1	0	0	1
126	88	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	1	0
127	89	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	In- compou nd	0	0	1	0	0	1	0
129	90	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	1	0
130	91	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	office cpd	0	0	0	1	0	0	1

131	92	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	workers homes Kizimba ni Agriculi tural researc h station	0	0	1	0	1	0	0
132	93	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	workers homes Kizimba ni Agriculi tural researc h station	0	0	1	0	1	0	0
133	94	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	In-spice garden	1	0	0	0	1	0	0
134	95	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	1	0
135	96	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	In-spice garden	1	0	0	0	1	0	0
136	97	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	0	0	1
137	98	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	1	0	0
138	99	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	On-farm	0	1	0	0	1	0	0
140	10 0	Zanzibar Inhambane	Zanzibar town	Zanzi bar	Tan zani a	By- roadsid e	0	1	0	0	0	1	0
143	10 1	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	0	1
144	10 2	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
145	10 3	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
146	10 4	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
147	10 5	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
148	10 6	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
150	10 7	Zambesia regional	Ruaha kitonga kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	0	1
153	10 8	Zambesia regional	Ruaha mutandika kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
156	10 9	Zambesia regional	Ruaha irindi kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	1	0
157	11	Zambesia	Ruaha irindi	Iringa	Tan	In-	0	0	1	0	0	1	0

	0	regional	kilolo		zani a	compou nd							
159	11 1	Zambesia regional	Ruaha irindi kilolo	Iringa	Tan zani a	On-farm	0	1	0	0	0	0	1
162	11 2	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	On-farm	0	1	0	0	0	1	0
163	11 3	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	trading centre	0	0	0	1	0	1	0
164	11 4	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	On-farm	0	1	0	0	0	1	0
165	11 5	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	On-farm	0	1	0	0	0	1	0
169	11 6	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	On-farm	0	1	0	0	0	1	0
175	11 7	Zambesia regional	Mukwajuni, chunya	Mbey a	Tan zani a	On-farm	0	1	0	0	0	1	0
Tot als	11 7						13	55	3 4	15	45	44	28

Table 2. District level within country, correlation between Establishment methods for tamarinds and their niches on farms in East Africa (N = 117)

Establishment methods	Tamarindus indica niches on-farms			
	Elsewhere On-farms	In-Comp of schools	In-compound of homes	In-crop fields on-farm
Elsewhere on-farms	1.000			
In-Comp of schools	-0.068	1.000		
In-compound of homes	0.119	0.598	1.000	
In-crops fields	0.455	0.490	0.509	1.000
Planted	0.181	0.765	0.912	0.727
Unknown	0.503	0.551	0.667	0.834
Wild	0.933	-0.212	-0.001	0.325

*Mantel test based on product-moment correlations, 100 permutations performed, association between original matrices: 0.8329, Percent permutations with equal or greater association: 0.00

Table 3. overall, correlation between Establishment methods for tamarinds and their niches on farms in East Africa (N = 117)

Establishment methods	Tamarindus indica niches on-farms			
	Elsewhere on-farm	In-Comp of schools	In-comp of Homes	In-crop fields on-farm
Elsewhere on-farm	1			
In-Comp of schools	-0.361	1		
In-compound of homes	-0.603	-0.245	1	
In-crop fields on-farms	-0.333	-0.136	-0.226	1
Planted	-0.393	-0.146	0.577	-0.056
Unknown	-0.167	0.444	-0.271	0.184
Wild	0.541	-0.245	-0.341	-0.106

*Mantel test based on product-moment correlations, 100 permutations performed, Association between the original matrices: 0.2766, Percent permutations with equal or greater association: 0.00

Table 4. Analysis of variance of establishment methods- over all, means of numbers of tamarinds wild and planted on-farms in East Africa (n = 89, N=117)

Level	Degrees of freedom	Mean square	F ratio	Standard deviation	Standard error	95% CI	t-stat	F-probability
Planted-wild overall	116	0.09	0.767	0.876	0.081	-0.152, 0.169	0.11	0.916
Planted-wild btn Countries	2	0.333	180.3	13.43	7.753	-33.03, 33.69	0.04	0.970

Table 5. Analysis of variance of means of numbers of tamarinds planted on-farms among and within countries in East Africa (n = 89, N=117)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio	F-probability
Country	2	1.8965	0.9482	4.85	0.010
District	12	4.1007	0.3417	1.75	0.068
Phytocoria Zones	5	2.7225	0.5445	2.78	0.022
Residual	97	18.9726	0.1956		
Total	116	27.6923			

Table 6. Analysis of variance of means of numbers of tamarinds in wild on-farms among and within Countries in East Africa (n = 89, N=117)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio	F-probability
Country	2	3.2365	1.6183	9.32	<.001
District	12	7.2538	0.6045	3.48	<.001
Phytocoria Zones	5	0.1225	0.0245	0.14	0.982
Residual	97	16.8402	0.1736		
Total	116	27.4530			

Table 7. Farmer responses on source of seeds for tamarinds planted in East Africa

Sample	site	Niche on-farm	Establishment	Source
T3	Pakwachi -Nebi - Uganda	In compound of homes	Wild	Wild
T27	Nebi-Uganda	Crop or cassava garden	Wild	Wild
T38	Arua, Arua in Uganda	In compound of district administration buildings	Plantation or planted	Officials did not know source
T44	Adumi, Ayivu, Arua-Uganda	In crop field or cassava garden	Wild	Wild
T48	Maracha, Nyadri , Arua	In crop field or cassava garden	Planted seeds from Koboko district)	Fruits collected from trees
T62	Wamba-Samburu in Kenya	In compound of home	Planted with seeds	Seeds from Mombasa market
T63	Wamba, Samburu in Kenya	In compound of home	Planted seedlings from forestry office nursery.	Forestry officers planted seeds from South Hor
T 66, T67, T68	Wamba, Samburu in Kenya	Compounds of homes of doctors and nuns in Catholic hospital in Samburu	Planted by forestry officers	Forestry officers planted seeds brought from KEFRI
T109	Lamu Island, Lamu in Kenya	In crop field	Farmer found tamarind on-farm	Arabs may have planted seeds
T 131, T 132	Kizimbani, Zanzibar Islands	Agricultural Research Station compounds	Forestry or agriculture officers planted in 1932-1940	Forestry or agricultural department
T 133	Zanzibar Islands	In crop field or spice farm	Planted	Seeds from India 1977
T 137	Zanzibar	In crop field	Planted	Arabs planted
T 138	Zanzibar	In crop field	Planted seeds	Local market
T157	Irindi-Ruaha, Iringa-tanzania	In compound of home	Wild	Wild
T 159	Irindi, Iringa, Ruaha	In home compound	Planted	Planted by Grand father

Table 8. Analysis of variance of means of numbers of tamarinds of unknown establishment methods on-farms within and among countries in East Africa

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio	F-probability
Country	2	0.3351	0.1676	0.93	0.398
District	12	1.8029	0.1502	0.83	0.615
Phytocoria Zones	5	1.6900	0.3380	1.88	0.105
Residual	97	17.4711	0.1801		
Total	116	21.2991			