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Botanical pesticides: a part of sustainable agriculture in Babati District Tanzania



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Abstract

Botanical pesticides are agricultural pest management agents which are based on plant extracts. In modern times these have been used as alternatives to synthetic chemicals in organic pest management. The practice of using plant materials against field and storage pests however has a long history in many indigenous and traditional farming communities across the world. During February and March 2009 a field study was conducted in Babati district in Manyara region, Tanzania to investigate the local use of botanical pesticides. The results from the field study were subsequently analyzed and contextualized in Nicanor Perlas model *The Seven Dimensions of Sustainable Agriculture* which was used as a framework theory. The analysis indicates that there are a variety of thresholds for the use of botanical pesticides in sustainable agriculture in Babati district besides the more obvious practical aspects. The latter parts of the paper discuss the differences between reductionist and holistic, indigenous and scientific ways of achieving knowledge with regard to plant based pesticides. The study concludes that ecological pest management is a holistic method based on the synergy of a variety of farming practices. Indigenous knowledge which is holistic, site-specific and experience based has therefore much to offer modern endeavours to practice a more sustainable agriculture and pest management strategies which consider the welfare of both humanity and the environment.

Key words: botanical pesticides, sustainable agriculture, organic farming, Tanzania, Babati district, neem, ethnobotany

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Background:

The factors that make organic agriculture functional and sustainable are interdependent in relation to each other. Organic pest management being one part of the mosaic is similarly comprised of a great variety of methods, many which also depend on each other to function. Some of these methods are relatively new and derived from modern scientific knowledge in ecology, entomology or even modern non-scientific methods such as biodynamic farming. This knowledge has its origins in the industrialized, often western nations. Small scale traditional agriculture has of course always been organic from the time that it was first conceived of several thousand years ago. Over the generations, site-specific and culturally unique farming techniques have evolved until this day. It is only since the advent of the Green Revolution and its machines, chemicals and plant strain-engineering that the division between organic and conventional agriculture could be made. As it turns out, the Green Revolution is considered a failure in regard to sustainability and people are instead looking for alternative, organic farming practices. This often implies making use of natural processes and materials. In an attempt to substitute unsustainable industrial pesticides with something more in line with organic agriculture, recent scientific research has turned to the biochemical properties of plants as a possible alternative to conventional chemical pesticides.

However, the practice of using plants and their extracts for pest management in agriculture have a long history among traditional farming peoples throughout the world. This also holds true with indigenous farming techniques in Africa, the continent being home to some of the oldest continuing cultures on Earth. Their knowledge is however based on another way of reasoning than scientific thinking. Previously, especially during the glory days of the Green Revolution, this knowledge was often scoffed at by those of a scientific predisposition. In recent times people are however beginning to value indigenous and traditional ways as environmentally sound. Although a fascinating field of inquiry, traditional African pest management strategies such as the knowledge of plant pesticides are not well studied (Abate et al 2000). One recent study from Babati district in the Manyara region of Tanzania (Ekberg 2005) however, briefly mentions some indigenous organic pest management techniques.

East African countries such as Tanzania generally base their economy on agriculture which more

than often is small-scale and subsistence oriented. In regard to the small scale farmer with limited economic resources, botanical pesticides seem to offer several benefits besides being an environmentally friendly pest management strategy. Ideally, botanical pesticides are locally available, low-cost, non-toxic or at least less toxic and non-persistent in the environment.

Purpose:

The purpose of this study is to two-fold; first to survey the varieties of botanical pesticides in Babati district of Tanzania and their farming applications, the origin of knowledge of these and identify possible thresholds for use. Secondly it is to put these in the context of sustainable agriculture through a literature study.

Research questions

- a) What plant species are used as botanical pesticides in Babati district; how are they prepared and applied?
- b) What are the origins of knowledge about botanical pesticides in Babati district?
- c) What are the thresholds for using of botanical pesticides as an alternative to industrial chemicals?
- d) How may botanical pesticides fit into the concept of sustainable agriculture?

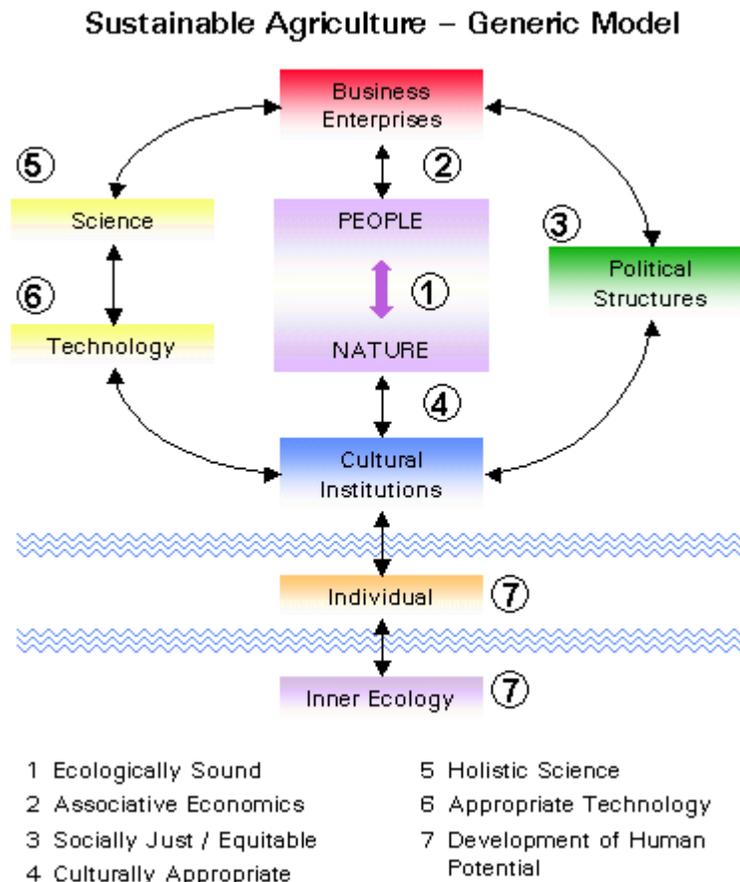
Theory:

The seven dimensions of sustainable agriculture

The term *sustainable* suffers from the lack of specification and a coherent definition. As Perlas points out, the term has even been able to squeeze in things that are normally not perceived as sustainable such as “safe” pesticides and bioengineering. In this study, I’ve chosen a theoretical model that is relevant to conditions in the developing world and tropical agriculture as well as quite explicit in its definition of sustainable agriculture. This model, born in the mind of Nicanor Perlas of CADI¹ (Perlas 1993), aims to structure and explain the factors that are needed in order to achieve sustainable agriculture. I’ve chosen to cite Perlas directly because there would be no

¹ Center for Alternative Development Initiatives

point of reformulating what is already clearly written. The seven dimensions are explained by Perlas in the following way:



Source: Perlas 1993

1. People and Nature → Ecologically sound

“ At the household level, farmers, by the very nature of their profession, have a direct relationship with Nature. ..To be sustainable at this level, the relationship with Nature has to be ecologically sound. Concretely this means the following:

a) Instead of pesticides we use ecological pest management; b) Instead of chemical fertilizers, integrated soil fertility management; c) Instead of monocultures, the harnessing of biodiversity to create polycultures; d) instead of creating chemically addicted seeds, alternative breeding

strategies which produce species adapted to ecologically sound practices; e) instead of erosion and water depletion, soil and water conservation; f) Instead of mass production or factory farming of animals, “humane” animal raising methods; and, g) Instead of a fixation on genes and chemical substances, we work in partnership with the living formative energies of Nature through, for instance, the use of bio-dynamic preparations and other bio-dynamic practices.”
(Perlas 1993)

2. Business and Enterprises → Associative economics

“Associative economics - economic arrangement which fosters interaction among producers, traders, creditors and consumers and where appropriate price, true human needs, poverty eradication, equity and impact on the environment are explicitly addressed in the process”
(CADI online glossary)

3. Political structures → Socially just/ Equitable

“Poverty can only worsen if farmers are not protected by a proper policy environment that insulates them from destructive technologies, abusive creditors, exploitative traders, usurious land tenure arrangements, gender bias, and disempowerment. Sustainable agriculture advocates therefore have to ensure that social justice and equity prevail all the way to the farm household level.” (Perlas 1993)

4. Cultural institutions → Culturally appropriate

“Can farming be sustainable when indigenous knowledge and values are dominated and marginalized? The rural youth are voting with their feet, and the answer is a resounding, NO! The young are migrating away in droves from rural settlements. They leave behind the old who have no choice except to farm. They also say goodbye to the children who have no capability for an independent choice. Modernization has created a social “black hole,” mindlessly destroying anything that smacks of rural culture. To be sustainable, agriculture has to be culturally sensitive and empowering and should nurture the cultural renaissance of the countryside.” (Perlas 1993)

5. Science → Holistic science

Here Perlas and CADI argues for a more holistic science rather than reductionism through the concept of Systems approach:

“Systems Approach – a holistic methodology for complex, multi-issue planning, implementation and assessment. Looks at living organisms and living systems as interconnected and co-dependent entities, rather than as isolated, self-contained units. Related to holistic. Opposite is reductionism.” (CADI online glossary)

6. Technology → Appropriate technology

“Technology development is another favorite activity of larger society that seems far removed from the realities at the household level. But since fundamentally the farmer's relationship with Nature is directly mediated by technology, it is clear that appropriate technology has to be one of the dimensions of sustainability in agriculture.” (Perlas 1993)

7. Individual and Inner ecology → Development of human potential

“Ecological problems, economic challenges, oppressive policies, cultural degeneration, reductionist science, double-edged technology—all these are clarion calls to awaken, to redefine the meaning of human existence, and move away from the disempowering illusion of daily routines. To awaken, however, means that all of us who advocate for sustainability in agriculture must develop our individual and universal human potentials and capacities to the fullest. The problem here can be defined as one of deep sustainability. Transformation at the different levels of sustainability requires being able to enter our inner sanctum, our “sacra,” our inner source of creativity, dedication, and courage. Only then can we avoid “burnout,” overcome hardship and enter into the creative realm of creating alternative futures.”
(Perlas 1993)

This model emphasizes that making agriculture sustainable depends on much more than what is

commonly understood. Here Perlas makes the point that ecologically sound practices are only one seventh of the sustainability concept. Although ecological farming principles may seem relatively easy to grasp, if too much attention is put on this first dimension one risks neglecting the vital importance of social, economic, cultural and even existential aspects. This move from reductionism to holism is perhaps the most important point of the seven dimensions model.

Phases of organic arthropod pest management

This model was used in the paper *Arthropod Pest Management in Organic Crops* (Zehnder et al 2007). It explains a sequence of strategies to manage arthropods, a group of organisms which commonly damage crops. According to this model, botanical pesticides make their entry into organic pest management only at the last phase when all else has failed. Thus, the emphasis according to Zehnder et al is on more indirect methods, such as ecological cultural practices.

4th phase: Approved insecticides
of biological and mineral origin,
and use of mating disruption

3rd phase: Inundative and inoculative
releases of biological control agents

2nd phase: Vegetation management to enhance natural
enemy impact and exert direct effects on pest populations

1st phase: Cultural practices compatible with natural processes,
such as crop rotation, soil management, non-transgenic host
plant resistance, farm/field location

The Seven Dimensions of Sustainable Agriculture will be the framework theory used to analyze the results from the field study. The latter model of organic arthropod pest management is used mainly to reinforce the points mentioned in Perlas first dimension. It will be used as an example of how the strategies of modern scientific organic pest management run parallel to the principles of indigenous, traditional pest management methods in Tanzania.

Operationalization

Pre-field preparations

Understanding that the neem tree is of great cultural and medicinal value in Tanzania (Claes Lindberg, 2009) and that farmers in other parts of the world have used it against agricultural pests the idea to investigate its organic farming applications in Babati district was conceived. I had been told that the species was widely distributed in Tanzania, which made it seem like an attractive botanical pesticide plant to research. Thus the study began as an attempt to investigate the neem tree, *Azadirachta indica*, and its application as a botanical pesticide in Tanzania. A small selection of published scientific articles as well as other written material, with the neem tree as central emphasis, was gathered and read shortly before the beginning of the field period.

Field study

The field study was carried out in-field during three weeks during February and March 2009 in Babati district, Manyara region Tanzania. It soon became clear that the scope should be expanded as to include all plant based pesticides, simply because the local practice of using neem as a botanical pesticide was perceived as so rare that it would be necessary to expand the inquiry to include even other plant pesticide species.

Study area

The informants were found in the following sites:

- Mamire village, Mamire ward.
- Urangini village, Mamire ward.
- Kwaraa village, Mamire ward.
- Office of Agriculture in Babati town.

Other observations and brief questioning also took place in:

- Ayamango village
- Ayasanda village
- Haraa

Informant selection

The sampling of informants was somewhat improvised at the beginning of the study. No material had been found prior to the field period regarding botanical pesticides in Babati district. Nor did any of the field personnel seem to know anything about the matter. There was therefore significant difficulty in making a strategic selection at an early stage. There were however some hints of the existence of organic farming in Mamire ward where as a result, the first interviews were conducted.

After interviewing several informants, found through the guidance of agricultural extension officer Mr. Mshana and field assistants, only “negative”² results were yielded. It therefore became evident that a more methodical approach had to be taken. When gathering information in a, to the researcher, foreign culture, it is often rewarding to adapt to local practice and this case was no different. Taking the more hierarchical nature of Tanzanian bureaucracy into account, an expert on organic farming at the Office of Agriculture in Babati was consulted. This expert, Mr. Msabaha besides providing information about various species and preparation methods, in addition mentioned several locations in which farmers using botanical pesticides could be found. A list of localities was written down and thereafter used to identify informants suitable for interview in consultation with the field assistants. Following this list worked quite well throughout the remainder of the field study period.

In total there were twelve informants, nine of which were interviewed according to procedure. Eight of these were found in Mamire ward and one in Babati town.

Interviews

The interviews were of a semi-structured kind; there was a pre-made set of questions, but other than that, the character of the interviews themselves was that of a relaxed conversation and not a formal, interrogative interview. It was also found that taking written notes on paper during the interview seemed to intimidate most informants. In order to attain the best communication possible between researcher and informant this was therefore avoided to a large extent as possible. Instead, notes were promptly written down following the end of the interview to later be

² Negative in the sense that none of the informants used botanical pesticides

properly transcribed. None of the farmers are mentioned by name in the study simply because it would not be significant and it's probably better to preserve their anonymity. Officials are however mentioned by name and title as they are civil servants.

Two sets of questions were used in this study. One set was directed towards farmers and was of a mainly technical nature. These could be questions such as “What kinds of plants do you use against agricultural pests?”, “How are these plants prepared?” et cetera. Another set of questions targeted officials working with farmers and agricultural training such as agricultural extension officers. This set of questions was of a more qualitative, socio-political nature, aimed at not only finding knowledge of plant species used as botanical pesticides in Babati and the origin, spread and character of this knowledge but also the general state of farming with these agents in the region.

Proper terminology was also of importance during the field study. What were these types of pesticides to be called? There were several potential terms. The term “biopesticides” was both difficult to grasp by the farmer and somewhat misleading. Biopesticides can be of very diverse origins and most often, it is not of botanical origin (*Copping and Menn 2000*). Botanical pesticides are as a term currently difficult to translate and understand by both the interpreter and the informant, although it is the term of choice throughout the written part of the study. During the interviews the terms natural pesticides and plant medicines were used though the terms may be scientifically questionable. Plant medicine was a useful term because it can be almost directly translated into “dawa” which in Kiswahili means medicine. This concept is widely understood among farmers, even the ones with a very limited amount of schooling and also implies a connection between herbs and therapeutic properties albeit that the patients are field crops and not people. Similarly, there was an issue with what to call conventional pesticides. Here the term chemical pesticide was used because most people associate chemicals as something synthetic and industrial. It is somewhat misleading however, because actually botanical pesticides can be seen as chemical pesticides since it is mainly the chemicals in the plant tissues that give them their pest removing properties.

Field observations

There were also visual observations made in the field which have been taken into account mainly regarding the occurrence of plant pesticide species in the field.

Literature study

In order to relate the results from the field study to relevant and comparative theory a literature study was performed as well. Written knowledge was sought in published articles and internet sources on the subject of botanical pesticides, organic agriculture and pest management as well as the theoretical framework provided by CADI and Nicanor Perlas, i.e *The Seven Dimensions of Sustainable Agriculture*, was used.

Critique of the methods used

There are several aspects of the study which could, in hindsight, have been better carried out. First off the subject matter both neem and botanical pesticides as well as organic agriculture should have been more thoroughly researched and a theoretical framework chosen earlier. This could have both aided and improved the interview process as well as the informant selection process. Another of the main weaknesses was the informant selection strategy. The scope of the field study was only actualized a few days prior to commencing field work. This being so, not enough time and energy was directed towards planning the practical part of the field work and developing a methodical approach together with the field personnel. Due to this, the study began in a more or less haphazard fashion. It was discovered however that when trying to identify a rare kind of farmer, such as farmers who use botanical pesticides, this way of doing things is very ineffective, almost like finding a needle in a haystack. What should have been done from the beginning was to contact the appropriate officials who are knowledgeable about the subject and identify informants and localities through them. This is particularly relevant in the case of Tanzania which has a more pronounced and hierarchical bureaucracy than most westerners are used to. Another important factor is the linguistic and cultural barriers that aren't easily broken down in the scope of three weeks in a foreign setting. This leads to a strong dependency on the available network of local contacts and the pool of interpreters which are competed for by fellow

field colleagues. Such a situation can act to limit the freedom of the researcher to conduct the study in a more independent manner. At the end of the day, all one has to work with is what is available.

Results:

General

Although pesticide use was found to be common practice in the field study, studies show that Africa consumes far less chemical pesticides in comparison to the rest of the world. Pesticide use in Africa is mainly used for commercial cash crops such as coffee, with food crops accounting for only about 5% of the total usage (Abate et al 2000).

Botanical pesticides have different areas of use in Tanzanian agriculture; either for pest management in the field, crop protection in storage, seed protection or as a veterinarian treatment. At quite an early stage, one finding became clear. In general, all farmers in the study who used any types of natural pesticide or pest managing substance were using ash; either in storage or in the field. They prepare the ash by incinerating branches, rice husks or cow manure. One of the most common ways ash was used was as a mixing agent with the stored crops themselves, such as in maize bags. When ready to be either sold or consumed, the ash is either sifted or washed away. Other methods related to cow derived materials was the usage of cow urine and cow manure, often as repellents. Fine sand was being used in the same manner as ash.

Plant medicine, a term encountered in Tanzanian farming communities, provides an interesting and alternative perspective on botanical pesticides. In Tanzanian traditional medicine, as in many other indigenous medicinal systems, a variety of plants is used to cure the ailments of humans and even domesticated animals. In Tanzania, this perspective can be further extended to encompass even the treatment of cultivated plants in the field. During the interviews it was found that the Kiswahili term for natural pesticides was the same as the term for human medicine; “dawa”. Although perhaps being unfit for the western academic context, it nevertheless provides an accurate, albeit alternative, perspective on the concept; plants that are prepared as solutions and applied to prevent health problems in crops.

Plant pesticide species encountered in the field study in Tanzania

Neem, *Azadirachta indica*, or *mwarobaini* in Kiswahili is a widely cultivated tree in the Babati district due to its hardiness to the local climate and great variety of medicinal uses. The leaves or the seeds, often in the form of seed cake can be used for preparing the pesticide. One of the oldest ways to use neem in agriculture has origins in India. There, crops are traditionally stored together with neem leaves. The same practice exists in modern day Babati district. The neem leaves are often blended into the previously mentioned ash-crop mixture. Neem leaves or seed cakes can also be crushed, mixed with water, let to soak for several hours or days, strained and then applied, mainly as a preventative measure, against insect attacks.

Neem leaves in Babati district



Source: Author's photograph

Chillies, hot pepper and piri-piri are some of the common names of the *Capiscum* genus. *Capiscum sp* is commonly grown in Tanzanian fields and home gardens, *shambaa*'s, mostly for culinary purposes. A capsicum based pesticide can be prepared by crushing the fruits of the plant, mixing and soaking with water, straining before applying.

Tagetes minuta or Mexican marigold is another plant pesticide species occurring in Africa. During the field study *Tagetes sp* plants were spotted in a couple locations, often as an ornamental. Although no farmer using *Tagetes* species for pest management was interviewed in this study, Mr. Msabha in the Office of Agriculture in Babati tells of its use as a pest repellent.

Tagetes sp in Babati district



Source: Author's photograph

Tephrosia are a genus of leguminous plants which can be found both growing wild and in cultivation in Tanzania. Plants of this genus contain rotenone which is one of the main active compounds in *Tephrosia* based pesticides. According to Mr. Msabaha, who during interview brought a sample of the plant, likely *Tephrosia vogelii*, this plant is very potent and care must be taken to not let *Tephrosia sp* plant parts fall into fish ponds and such. This is because rotenone, contained in the plant, is very toxic to aquatic animals and has traditionally been used as a fish poison (Isman 2000). The plant has historical uses in Tanzania, Zambia and Uganda (Abate 2000).

Tephrosia vogelii growing wild in Babati district



Source: Author's photograph

Euphorbia species are a common sight throughout the Babati district. Often it is grown as a kind of living fence. It is a succulent and can withstand the dry conditions in farming areas with low amounts of annual rainfall. It has two main types of uses; field pesticide and veterinary applications. According to Mr. Mshana, agricultural extension officer in Mamire ward, it can be used to prevent Newcastle disease in poultry which can be fed an extract. It is often prepared by crushing the plant parts and soaking them in water.

Carica papaya, commonly known as papaya, is widely cultivated throughout the tropical world and Babati is no exception. It is often grown in the homestead garden. Besides providing humans with nutritious fruit, it has applications as a botanical pesticide. Both leaf-parts and seeds from the plant can be used. A common way to prepare it is to soak either seeds or leaves in water, sift and then apply the solution to field crops.

Tobacco, species of the genus *Nicotiana*, is often cultivated in the Babati district, at least among those with the means to grow it. As a botanical pesticide, its main active compound is nicotine, the same stimulant found in tobacco products (Isman 2000). It is commonly prepared by soaking either whole or crushed leaves in water, strained and applied as a liquid. According to Mr. Mshana of Mamire Ward tobacco can be used to treat bloat in livestock animals.

Pyrethrum is extracted from plants of the species *Tanacetum cinerariaefolium* (Isman 2000). It is one of the world's most common plant derived pesticides. None of the farmers interviewed used this plant or its derivatives, although it is commonly grown for export in Tanzania.

Gallant soldier or *Galinsoga parviflora* is considered by some to be an invasive species (Stadler et al 1998). Other than that, no secondary sources on its properties or in-situ specimens were found in this study.

Giri giri mo, is a plant mentioned by its popular name by Mr. Mshana of Mamire Ward. According to him, it is used for storage protection. No information through secondary sources on its properties nor in-situ specimens were found in this study.

Mlutulutu was a plant mentioned by a farmer in Urangini village who occasionally uses it. This farmer considers it to be very potent against many pests. Although no in-situ specimens were found, some sources indicate that it is the plant *Cassia absus* (Chhabra 1987).

Interviews with farmers:

Here follows brief condensations of the interviews relevant to the study. It must be emphasized that the views and opinions expressed in the interviews are solely those of the informant.

Mamire village, Mamire Ward

The first farmer farmed organically and was only briefly interviewed during a quick tour of Mamire prior to commencing field work. The four other farmers were interviewed at an outdoor bar, probably without being given prior notice, which could explain their general reserved attitude. As it turns out, none of these four farmers used botanical pesticides and all employ chemical pesticides.

Farmer M1 is an organic farmer. She uses ash, *Capiscum sp* and tobacco as natural pesticides. According to this farmer, it is tedious to use natural pesticides on farmland exceeding ten acres, because the material needed is bulky.

Farmer M2 claims that no farmer in Mamire village uses, nor has any knowledge of botanical pesticides but that sometimes ash is used as storage protection. In the 1980's, he says, the government encouraged the use of chemical pesticides which he has used since even though he considers them to be expensive. According to this farmer, many pests, grasshoppers in particular, become resistant of botanical pesticides over time.

Farmer M3 describes the use of *Capiscum sp* and tobacco as well as methods to prepare and apply them. He used to use these natural methods in the past but nowadays only use chemical pesticides.

Farmer M4 has an agroforestry system. He uses ash both for storage and field protection but takes to chemical pesticides when this method fails. The main problem with natural pest pesticides according to this farmer is that if these fail if applied too late in the season. He grows beans, maize, sunflower and pigeon-peas along with the trees *Cedrela odorata*, *Grevillea sp*, *Acacia sp*, *Euphorbia sp* and *Jatrofa sp*. He intercrops maize and pigeon-peas in January and sunflower and beans in March. He is Iraqw.

Farmer M5 uses ash only to store crops. Other than that he uses chemical pesticides in the field. He grows maize, sorghum, millet and beans. He grows on two separate locations. In one he grows pure-stand maize. In another he grows pigeon-peas intercropped with maize. When the harvest is small he blends it with ash during storage. When the harvest is large he protects it with chemical pesticides. He knows about tobacco as a natural pesticide but he doesn't use it because it's too expensive to purchase. If he could afford it, he would use greater quantities of chemical pesticides.

Urangini village, Mamire ward

The interview with farmer U1 proved to be a great success and contributed greatly to the study.

Farmer U1 grows maize, pigeon-peas, groundnut, watermelon (for mulch and cover) and sunflower. He also grows species used in organic pest management. Intercropping and crop-rotation are integral parts of his organic farming. He uses *Euphorbia sp*, *Capiscum sp*, tobacco,

neem and papaya as well as soap. He also uses a plant called *mlutulutu* which according to some sources is the plant *Cassia absus* (Chhabra 1987). He rates the plants by potency from strongest to weakest as such; *mlutulutu* → tobacco → *Euphorbia sp* → *Capiscum sp*. These are all used in the field. He uses neem only as storage protection. He cultivates all the plants he uses with the exception of *mlutulutu* which he has had to buy. He uses botanical pesticides because of the risk of cancer and illness afflicting his family as a result of chemical pesticide use. Since he stopped using chemical pesticides there has been an improvement in the respiratory health of his children. He was taught the use of botanical pesticides from a LAMP³ seminar in 1999 which spanned for ten days. One of the shortcomings of using botanical pesticides is that you need land and resources to grow the plants needed. He never uses any chemical pesticides anymore. Another difficulty is achieving the correct ratio when preparing the ingredients. The ratio is figured out through a combination between LAMP guidelines and this farmer's personal experience with his land. He has 10 acres of field. He teaches these techniques to other farmers. He is Rangi.

Kwaraa village, Mamire ward

Farmer K1, who has the most thorough knowledge about the farm, is absent and so his wife acts as informant in his place. It seems however as if she is unsure about the details of her husband's farming practices.

He grows maize, beans, sunflower, pigeon-peas, cow-peas, finger-millet, lab-lab and fruit trees such as banana. He uses chemical pesticides in the field but sometimes use neem leaves together with chemicals for storage protection. There is an air-tight storage container on the farm which is not used at the present time. Ash is sometimes used against aphids on cow peas. They were introduced to the use of neem for crop protection by LAMP in 2006 but are generally not well informed about botanical pesticides.

Farmer K2 keeps many different kinds of livestock animals as well as poultry and bees. He cultivates maize, sunflower, beans, finger-millet, pigeon peas, lab-lab as well as pasture crops and different tree species used in an agroforestry system. The pasture crops are used for the animals that are not allowed to graze. The botanical pesticides he uses are piri-piri, tobacco, cow

³ Land Management Programme funded by SIDA, initiated 1988 and ended circa 2005.

urine, papaya and neem (mainly for storage). He sometimes uses chemical pesticides for seed protection, especially against flour beetles which he considers to be especially difficult to manage. He uses *Capiscum sp* against stalk borers on young seedlings. Sometimes he uses sand to suffocate pests on maize plants. For storage protection he blends *Albizia sp* leaves, neem leaves with ash and mixes this together with crops such as maize. He learned these practices partly from his ancestors and partly from the LAMP project. He received LAMP training between the year 1998 and 2000. His farmland is 28 acres in size. Crop-rotation is very important in order to prevent pests. He claims that there are about 20 farmers in Kwaraa village who use at least some of these botanicals or methods and who were educated by LAMP. He is Iraqw.

Ayamango village

Interviewing farmer A1 was both puzzling and difficult. For crop-protection he uses the tobacco plant and industrial chemicals as well. I interviewed him without the consent of the village officer and this was clearly not the way things were done here. A growing group of both curious and hostile looking men were gathering at our location. It seemed that eventually the presence of the other men pressured the elderly farmer to take back his claim of using tobacco in his farming and instead claimed to use only conventional chemicals. Seeing that the interview wasn't leading anywhere, it was promptly ended. Both tobacco plants and a large number of neem trees were observed in the village some of which were protected by fencing. He is Waarusha.

Ayasanda village

Farmer AS1 says that in the old days they used to use ash from manure and the tobacco plant as well. Today they exclusively use industrial chemicals as crop protection.

Interviews with officials

Office of Agriculture, Babati town

Mr. Msabaha is an expert on organic agriculture at the office of agriculture in Babati town. He displays plenty of written material on different botanical pesticide species, some indigenous others imported exotics. He goes on to name several useful plant species, their usage and their method of preparation such as neem, *Tephrosia sp*, *Capiscum sp*, Mexican marigold and tobacco.

Unfortunately I was unable to make copies of this material which would have been very useful. He also mentions the use of ash, sand and cow urine as also having pesticide properties. The idea with natural pesticides isn't necessarily to kill the insect predator per se, but just as much to repel them. There are many beneficial insects that would be counter-productive to kill. He places particular emphasis on the neem tree and shows me a book on the subject. It seems that his main fascination is with this species which he says can be used for virtually all pests. Both leaves and seedcakes can be used, but that seedcakes are more concentrated. One of the problems when using natural pesticides is achieving the correct ratio between ingredients as well as correct dosage when used. The practice of using botanical pesticides in Tanzania is generally unknown because funds are lacking for educating farmers in this practice. Natural pesticides are mainly used for vegetable farming because vegetables with their soft parts are generally more prone to attack compared to harder crops such as maize. He says that farmers using natural pesticides in the Babati district can be found in Mamire, Galapo, Maomairo, Ayamango, Ndakiso and Kwaraa. Whether he refers to villages or wards isn't completely clear.

Agricultural extension office, Mamire Ward

Mr. Mshana is the agricultural extension officer in Mamire ward. He says that there are several natural pesticides used in the ward. *Capiscum sp* is used against army worms. Tobacco is used to protect seeds before planting but also to remedy bloat in livestock. Layers of tobacco leaves can be placed between crop bags as protection against pest. Powdered neem leaves are used for crop storage mixed with crops such as maize. The plant gallant soldier is used to control several types of pests in the field. One way to apply it is to cut the plant into smaller pieces and spread it on the field. The leaves of a local species called “*giri giri mo*” is used for storage protection. *Euphorbia sp* is used to protect poultry against Newcastle disease. Ash prepared from burned manure, rice husks or the upper branches of a tree is used for storing dry crops. Air-tight containers are used to store crops without either natural or chemical pesticides but very few farmers use these.

Agricultural teachers from the Kilimanjaro region introduced the use of air-tight containers in Tanzania. The benefits of natural pesticides are that they are locally available to farmers, biodegradable, non-harming to humans and livestock and less costly. The shortcomings are that they are bulky and tedious to use in large plantings. Pests such as locusts and grasshoppers can't be removed using natural pesticides. Very few farmers use natural pesticides in Mamire ward.

The government has encouraged the use of natural pesticides since the 1990's. Many farmers would like to use natural pesticides since they are concerned about the health hazards of chemical pesticides. No insect resistance occurs when using natural pesticides.

Analysis

The Seven Dimensions of Sustainable Agriculture – The Tanzanian context

In the following analysis Nicanor Perlas (1993) Seven Dimensions of Sustainable Agriculture are used as a framework theory to put the results in context.

1. People and Nature → Ecologically sound

The implications of botanical pesticides are most obviously analyzed in this dimension. What is emphasized here is the direct relationship between farmer and the natural systems. The first point, a), is to use *ecological pest management* instead of chemical pesticides (Perlas 1993). Ecological pest management is comprised of many diverse practices which vary greatly in their directness. According to the four phases of organic arthropod pest management (Zehnder 2007) botanical pesticides are part of the fourth and final phase. Ecological pest management therefore consists of so much more than using these plant extracts, although they do play a significant role, especially as something for farmers to fall back on in case pest attacks occur despite their efforts. Abate (2000) mentions several indigenous African methods such as farm plot location, intercropping, crop rotation, scarecrows, destroying arthropod eggs, timing of weeding, as well as using plants with repellent action. Perlas further reinforces this view in points c), d) and g) and draws inspiration from biodynamic farming methods (1993). During the Ujamaa period a great number of Tanzanian farmers were displaced from their native lands. As a result, many site-specific practices were abandoned or deemed obsolete in a new and unfamiliar environment. This means the severing of the intimate links between land, nature and farmer that may have taken many generations to establish. In such conditions, the influence of the Green Revolution and modernization through development is indeed difficult to resist which often leads to the end of indigenous or traditional ways. This could explain why it was very difficult to find farmers using botanical pesticides in the field study even though Abate (2000) argues that in the absence of

extensive use of industrial pesticides, traditional methods are often used. Displacement combined with short intervals between human generations and the strong influence of development projects flagging the banner of the Green Revolution may have led to the more uninformed situation of today.

2. Business and Enterprises → Associative economics

In this dimension it is argued for the creation of economic arrangements which foster a close relationship between all involved in production, trade and consumption as to better address important issues, such as environmental and social concerns. One of the most important factors needed for the furthering and survival of organic agriculture is creating beneficial economic conditions. This could be done by helping producers market their organic produce better and foster an organic produce market, both for export and national consumption in Tanzania where today none exists. Today there are simply no economically solid arguments for Tanzanian farmers to farm organically. This further illustrates the great idealism of small scale Tanzanian farmers such as farmer U1 in Urangini village who has chosen organic methods despite being at a market disadvantage to other farmers who choose conventional methods. An establishment of an organic market or other market incentives are needed if the use of organic pest management techniques is to increase in the region.

3. Political structures → Socially just/ Equitable

From the interviews, it is understood that the national government through their agricultural offices has sent a very mixed message to Tanzanian farmers in regard to pesticide use. Farmer M2 in Mamire village says that the government encouraged pesticide use in the 1980's. Mr. Mshana however says that the government started encouraging the use of natural pesticides in the 1990's. Although much can happen politically in the span of ten years, farmers in third world countries do not due to economic factors have the ability to quickly switch between farming methods and technologies. The subject of organic farming in the third world is a heavily debated issue and governments are caught in between opposing priorities. On the one hand, nations want to keep up with the growing environmental awareness and sustainable development paradigm. On the other hand there is the pressure of complying with financial organisations like WTO and IMF and their demands of technologization of agriculture as well as the dire need to secure a stable food production and ultimately promote economic growth. The result being that the same Office

of Agriculture in Babati that teaches organic farming also teaches the use of pesticides and chemical fertilizers.

4. Cultural institutions → Culturally appropriate

Modernization has so far only stood in opposition to indigenous knowledge and local cultural values. This according to Perlas fourth dimension is not sustainable. Instead, he calls for a renaissance of the countryside. Although the findings in this study suggest that many of the botanical pesticides used today are modern introductions from projects such as LAMP, the use of ash, livestock waste products and certain local plants in plant protection can be considered indigenous, traditional practices. Whether LAMP simply reintroduced the use of these plants or how great the loss of ethno-botanical knowledge has been through colonization and displacement remains to be investigated. Many indigenous farming practices are traditional such as growing in poly-cultures, crop rotation, choosing hardy crop varieties and growing on a smaller scale and in line with ecologically sustainable agriculture. Whether an indigenous practice is traditional or derived from moderns or foreign sources is not what's important here though (Folke et al. 2000). Indigenous culture is not static and is always evolving and being influenced by other cultures. There is a vital difference however between a culture evolving on its own terms and being forced to assimilate into the global techno-culture. Modernization generally stands in opposition to indigenous ways and prescribes high-tech, "scientific" solutions. One consequence is the younger generations losing interest in the practices of their ancestors and instead seek their fortunes in the cities, far away from the perceived backwardness of the countryside. In order to halt this development, the countryside indeed needs a renaissance (Perlas 1993) in order to keep up with the changing times, provide education and work opportunities while not losing valuable indigenous perspectives and traditions. Botanical pesticides, with further research and adaptation to local conditions could very well be part of this process.

5. Science → Holistic science

Both conventional science and indigenous, traditional knowledge have yielded knowledge of how to use plants as pest management. One of the main differences is that while agricultural and biochemical science is generally reductionist, indigenous knowledge is holistic. The reductionist perspective risks of putting too strong an emphasis on chemical components and their potency or this or that technology's efficiency. The indigenous perspective instead builds on trial and error

and experience gained over time (Folke et al 2000). Whether science should complement indigenous knowledge or the other way around can be disputed. It seems however that there is great promise in the cooperation between the two.

6. Technology → Appropriate technology

Appropriate technology is technology that takes into account the socio-economic, environmental and cultural aspects in the place it is used. This is opposed to high-technology which simply is the technically most advanced at the present time. Therefore, appropriate technology can be something which is seen as low-tech in the eyes of the technocrat, but nevertheless is both elegant and efficient. The use of botanical pesticides require only simple utensils and mainly locally available materials, but involve detailed and intimate knowledge of plants, the local environment and microclimate as well as intuition and experience gained over time. As many anthropologists have noted, the lack of technologies and machines do not equal the lack of knowledge. On the contrary, many low-tech societies have over generations developed precise and detailed techniques for solving problems which in some cases rival modern technological alternatives.

7. Individual and Inner ecology → Development of human potential

A farmer who feels helpless against outside forces such as the market, government or nature, is not likely to apply organic techniques which are generally less straight-forward than the quick, easy but nevertheless unsustainable Green Revolution solutions. According to Perlas, the key to achieving sustainability in this dimension is to “*enter our...inner source of creativity, dedication, and courage*” (Perlas 1993). In the end, much depends on the way the individual farmer perceives him or herself and their place in this world. Those who consciously choose and practice organic farming often do so in part as a moral standpoint; to avoid harming the natural world as well as protecting their children and future generations. Sincere and stable moral commitments only come from people who feel internally strong enough to dedicate themselves to these. Although not demonstrable through any statistics or numbers the general impression of the interviews in this study give an interesting indication on this matter. Many of the genuinely organic farmers who used a variety of botanical pesticides in this study were very proud of their farms, families and projected an image of peace and happiness. Conversely, some of the more difficult interviews were held with introvert and suspicious farmers who were also using only chemical methods.

Discussion

Finding a term that works

Finding a working term for pesticides derived from plant material is currently not a simple undertaking. Although various terms for them exist, they are not all truly appropriate or to the point. Some examples are biopesticides, natural pesticides, plant-based pesticides, plant medicines, botanical pesticides or simply ecological pesticides.

Biopesticide, a commonly used term in organic agriculture, can be defined as a pesticide deriving its properties from living organisms (Copping and Menn 2000). This could be anything from live bacteria, fungi, isopods, nematodes or insects to pesticide solutions derived from minerals or plants. Natural pesticides is a convenient and easily grasped term although somewhat lacking in scientific accuracy. Using the word natural in this way can be both self-contradicting and inappropriate. What really is a “natural” pesticide? Many proponents of organic farming would perhaps claim that having to use pesticides, is in itself a failure and that proper organic practices such as growing in poly-cultures and crop-rotation can prevent attacks from ever happening in the first place. One could simply argue however that natural in this case indicates that the components are produced through a non-synthetic process, e.g. in nature through plants. Also, there are some materials of natural origin, such as sand, livestock waste products et cetera that can be used in the manner of pesticides but are neither plant derived nor directly living as in the case of many biopesticides. Plant-based pesticide is as a term in comparison to the ones previously mentioned, far more specific and to the point. Despite this, it is somewhat grammatically unrefined and difficult to use as a term, particularly when used in field interviews, databases and as a key word. Considering the issues mentioned above, the term botanical pesticide was preferred in this study due to its simplicity and specificity. It shows that what is specified is of botanical, e.g. plant origin and has the properties of a pesticide. Although still not widely used, it is somewhat regularly occurring when discussing organic pest management strategies such as in the paper by Isman (2000), which uses the term “botanical insecticide”. It remains to see which term is to become dominating in times to come.

Neem - A plant species holding great promise

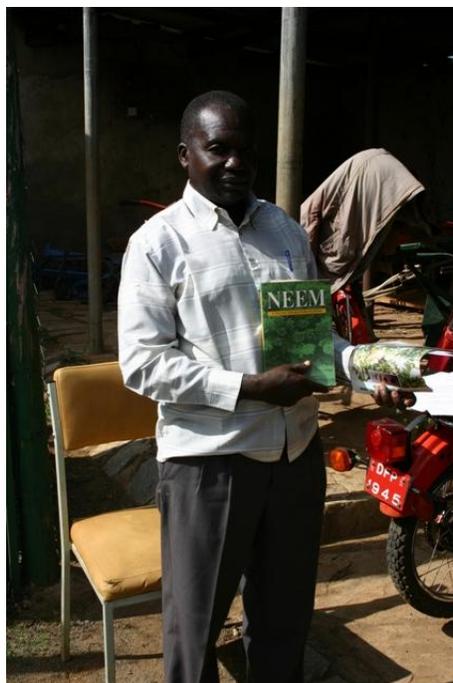
Out of all species mentioned the neem plant *Azadirachta indica* seems to hold great promise, at least within the Tanzanian context. There are several convincing arguments for this. In comparison to many other plants used in botanical pesticides, neem is much less toxic. Besides being safer for the farmer and the environment, this also means that the risk of killing beneficial insects is reduced which is in line with holistic, ecological pest management. The value of this was emphasized by Mr. Msabaha in Babati. The species is locally available almost everywhere in the Babati district, even to people living in more remote regions, such as Ayamango village, where at least one protected group of trees were found.

Neem trees protected by fencing, Ayamango village



Source: Author's photograph

It is considered to be a very hardy species, able to withstand the searing equatorial sunlight and extended periods of drought (Ahmeed and Grainge 1986). It is considered as a plant of great medicinal and perhaps even mystical importance in many parts of Tanzania's diverse cultural spectrum. It is truly multi-purposed, as opposed to other botanical pesticide species. Being a tree it can provide protection against erosion, provide shade and creating a less harsh microclimate. It possesses many other valuable properties which unfortunately can not fit into this study. Ahmeed and Grainge (1986) elaborate on this subject in their paper and Isman (2000) discuss the biochemical properties in higher detail.



Source: Author's photograph

Cultural implications and perspectives

One interesting finding in this study was the cultural perceptions of pesticide use. In the world's core countries, the lack of terminology for plant based pesticides is a consequence of both the way pesticide use is viewed, as well as the practically non-existent use of botanical pesticides. Pesticides as a word imply poison and killing and this is how they are conventionally applied in industrial agriculture. This view is the result of centuries of glorifying human culture and demonizing natural forces, primarily through Semitic religion such as Christianity. According to this view, pesticides are part of the great arsenal against nature. Keeping with this view, the only logical thing is to always prefer the industrial, the synthetic i.e man-made, to that which comes more directly from nature itself. If nature is indeed the enemy, then what value do botanical pesticides possess? So far, the industrial mindset has only approved of compounds synthesized from plant chemicals. By contrast, the case is very different in Tanzanian traditional agriculture. Although most Tanzanians nowadays ascribe to either Islam or Christianity, the traditional and indeed still much prevailing world view is animistic. In this view, the boundary between culture and nature is not drawn in the same way or as sharply. When translating the term botanical pesticide from English to Kiswahili the word "*dawa*" which means medicine is more than often used. This tells much about the cultural view of how these substances are to be used. Just as

people in traditional cultures often turn to the therapeutic properties of medicinal plant species, the same can hold true for the cultivated plants that humans care for. Just as a person can drink cardamom tea to relieve digestive problems a plant can be treated with certain plant extracts against whatever is threatening its health be it larvae, aphids or other. In sustainable agriculture over the world, this perspective can have great value, not only for the people of Tanzania. Perceived this way, the use of pesticides whether botanical, natural or chemical, can be made much more moderate than it historically has been. Instead of applying vast amounts of pesticides to high-yielding but very weak plant varieties as in industrial agriculture, one could follow the traditional Tanzanian example. Here traditionally, many steps are taken to ensure protection against pests such as growing in poly-cultures, rotating crops and leaving fields to fallow. Should infection occur, despite these steps, then pesticides may be brought into use, be they synthetic or natural. This Tanzanian perception is one example of how traditional and local views can contribute to the furthering of sustainable agriculture. This could also explain why there have been many problems with the introduction of chemical pesticides in traditional, third world countries. If medicines are considered as intrinsically good, then there is a risk of incorrect dosage, disregard for safety procedures and harm to both humans and nature. There is a real danger here of combining the views held in traditional society with the powerful chemical pesticide technology which has its origins in the western industrial perspective, i.e. the Green Revolution paradigm. This is primarily however a problem pertaining to the highly toxic and concentrated industrial synthetic pesticides. Botanical pesticides are in contrast made up of many different interacting compounds which are comparably less toxic, less concentrated and more importantly non-persistent in the ecosystem.

Conclusion:

There is evidently much more to organic, sustainable farming than the use of botanical pesticides. Nevertheless, botanical pesticides could play an important role in taking indigenous farming practices into a new and sustainable future. Not only are they considerably safer, both for humans and the environment, but could contribute to the fusion of the traditional and the modern, the indigenous and the global. With the realization that the Green Revolution has failed, the future of agricultural pest management focus should instead of looking to chemicals, high-technology and

industry, be on the farmer's natural instincts and acquired experience. Botanical pesticides could no doubt be part of this shift to appropriate technology.

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