Draft Report
Urban agriculture in Da Nang and the utilization of by-products from waste water and solid waste processing for urban agriculture

In the framework of the regional GIZ-project:
Integrated Resource Management in Asian cities: the Urban Nexus
Deutsche Gesellschaft für International Zusammenarbeit (GIZ) GmbH
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2015
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CHAPTER 1

1 Integrated resource management in Asian cities: the Urban Nexus

Per annum 44 million people migrate from rural areas to cities merely in Asia. This impetuous urbanization causes several problems, especially in the three Nexus sectors: energy, water and food security (agriculture). The rising number of city dwellers causes a higher demand of resources (water, energy and food) and a higher accumulation of waste in growing cities. To overcome these problems, it is essential to identify synergies and interactions, to reduce trade-offs and increase efficiencies across these sectors.

The project “Integrated resource management in Asian cities: the Urban Nexus” tries to address these issues.

Ten cities in six Asian countries (Vietnam, Thailand, Indonesia, Mongolia, China and Philippines) are participating in the project (2013-2015). The project is commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by GIZ. The United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) is the political partner organization, the International Council for Local Environmental Initiatives South East Asia (ICLEI SEA) is acting as a co-implementing organization.

The project’s focus is on the topics of secure water supply and sanitation systems, energy security and efficiency, land use, physical planning and agriculture in cities. Moreover, an exchange of knowledge, experiences, and the cooperation between public, private and civil-society stakeholders is essential. Strategically, the project will focus on two core elements. On the one hand, it will be key to identifying and developing nexus initiatives that will demonstrate in an exemplary way how to integrate the nexus approach into urban planning and development processes. On the other hand, it is planned to ensure that the regional exchange and dissemination of successful practical approaches to integrated resource management is undertaken through an efficient network (Erlbeck 2013).

Figure 1 Bangkok and pictures of the three nexus sectors
Within the framework of this study the food security, in particular urban agriculture, is prioritized. A major task is to set more light on Da Nang’s urban agriculture and evaluate the synergies from urban agriculture with the energy and water sector in the city. Moreover, the risks and chances of using this synergies in order to cope with the urbanization and its consequences should be identified. Up to the present, the household organic waste in Da Nang is above all mixed with other domestic wastes, landfilled and its nutrients, which can be a useful fertilizer for agriculture, are lost. It should be a major goal for a future “environment-friendly city” to establish at source separation of waste and a proper recycling process for as many waste constituents as possible. Even energy production, if it is reasonable for Da Nang’s environment and financially achievable.
CHAPTER 2

2 Literature

2.1 Urban Agriculture in general

By 2020, 55% of the world population is expected to live in urban areas, and this percentage will increase up to 60 and 70% in 2030 and 2050, respectively. In emerging economies and developing countries a remarkable growth of urban population will be observed.

The poor management of resources in urban areas leads to a reduction of the standard of living in urban areas and poverty is increasing dramatically in urban areas. The development of urban agriculture is one of the major strategies that is being spontaneously adopted in developing countries to address urban poverty and improve well-being of city dwellers by international development agencies.

These trends effects urban planning and inter alia the fresh food supply. The urbanization brings several negative consequences, which vary from the reduction of fertile land to deforestation, water and air pollution, reduced drainage of the rainfall, and the creation of peri-urban areas where socio-economic constraints are exalted and poverty is condensed. The poor management of resources in cities leads to a depletion of the opportunities of living in urban areas. Measures that could improve the situation of poor people are often not available and may explain the dramatic increase in poverty in urban areas. The intervention of international development agencies in this field is relatively new. The expansion of urban agriculture is one of the major approaches to support the reduction of urban poverty and to enhance the standard of living there.

Improving health conditions enables the development of a more sustainable and stable economic growth at both family and community levels. In peri-urban and rural areas of the tropics, human health issues are frequently related to malnourishment of the population affecting more than 2 billion people in 2000. Vegetables and fruits are an important part of a balanced nutrition and delivery minerals, vitamins and other antioxidant compounds in human nutrition. Besides their dietary benefits, fruits and vegetables are high value crops that can often provide excellent income generating opportunities for small-scale farmers and especially women.

Agriculture has always been linked with the imaginary of the rural environment within it is conducted. Based on this, the rural crop production has been seen as sufficient to feed the urban population for long time to feed the urban population. Principally, as a consequence of the scarce infrastructures (transports, roads, markets, etc...) and for the low purchasing power of the urban population in developing countries, this turned out to be false. The increase of poverty and high unemployment rate, on the one hand, together with the opportunities that the city, on the other hand, can offer such as food demand and the vicinity to the markets, have encouraged the development of agricultural activities in the home or plots in urban or peri-urban areas - mainly specialized in the production of fresh vegetables, milk, eggs and chicken.
Urban agriculture describes both plant cultivation and animal rearing for own consumption and selling in cities and their surroundings, and this at any scale from rooftop gardens, which are located on the roof of a building, to larger cultivated open space. At the present urban agriculture is complementary to the rural production, mainly by providing perishable products such as vegetables, milk, and eggs and nowadays it is well established that it improves food systems for city supply.

A recent study from Thebo et al. (2014) estimates the world’s total area occupied by urban agriculture around 67.4 million hectares. This counts around 5.9 % of all croplands on the planet, whereof 23.6 million hectares are irrigated and 43.8 million hectares are rain fed cropland.

According to a study from Zezza & Tasciotti (2010) using survey data from fifteen countries across the four principal development regions, i.e., Asia (Bangladesh, Indonesia, Nepal, Pakistan, and Vietnam), Africa (Ghana, Madagascar, Malawi, and Nigeria), Eastern Europe (Albania and Bulgaria), and Latin America (Ecuador, Guatemala, Nicaragua, and Panama)—the shares of urban households that earn income from agriculture differ from 11 % in Indonesia to almost 70 % in Vietnam and Nicaragua. In eleven of the fifteen countries in dataset, the share of households participating is over 30 % (Orsini et al. 2013; Hamilton et al. 2013; Sansonetti 2010).

In numerous cities of developing countries, urban agriculture significantly contributes to food and nutrition security of urban dwellers. It is expected that this agricultural activity will gain in recognition for its benefits and services in a near future since towns and cities, especially in the
developing world, are growing on an unprecedented scale and rural-urban migration is still on the rise.

Urban agriculture can be very beneficial for the urban environment. At the same time, when using poor practices, it can have a negative impact on human health and the environment. The main strengths and weaknesses of urban agriculture are summarized in the next paragraphs:

### 2.2 Risks and benefits from urban agriculture

The main profit of urban agriculture is the supply with locally produced and fresh food. Urban agriculture provides the poorest with food and the opportunity for them to earn money. An easier access to safe and nutritious food helps to improve the health condition of the urban population. Although urban agriculture in polluted urban areas may harm the producer’s, market vendor’s and consumer’s health.

Many urban poor making a living doing agricultural activities and this enables them to reduce the costs for food purchase, since they grow their own food and provide food for their families and thereby reduce the costs of food purchase. Urban farming creates job opportunities and stimulates the growth of enterprises in the related activities (e.g., farming inputs, food processing, packaging, marketing, etc.).

In many cities urban agriculture is an important mean for the integration of disadvantaged people or social groups (e.g., immigrants, indigent or left women, unemployed, elders, disabled, etc.), since it promotes and facilitate their participation in the social texture and provides them with better living conditions.

For instance the Mercy Centre Bangkok, which supports homeless people and especially children with HIV in Bangkok, established with the support of the World Vegetable Center (AVRDC) a vegetable garden at Mercy Farm’s Cultural Learning Centre in Saphan Sung, Bangkok. This garden provides the orphans with fresh vegetables and fruits, which are produced by themselves. Besides the nutritional benefits, these garden also offers the opportunity to learn how to grow vegetables and it is also a way to spend their leisure time properly (Dr. Fenton Beet, oral communication).

Another example for the social benefits of UA is the project “NECTEC Plant”, initiated by the National Electronics and Computer Technology Center (NECTEC) on the Thammasat University campus (figure3). Two years ago employees founded a rooftop garden on the NECTEC building, where they produce their own vegetables. Reasons are besides the supply with fresh vegetables, to build up a team spirit between colleagues in NECTEC and to deflect from their daily working routine. The initiators see in this project the opportunity to make NECTEC’s employees more efficient and concentrated in their jobs and to incite a pleasant working environment within the center, which is beneficial for both, the employees and the employer.
The fast growth of cities and the resulting pollution bear negative impacts for the environment, the ecology and the public health. In particular, waste management is a tricky challenge in expanding cities. Of a paramount importance is waste management that represents a serious concern in most cities worldwide. Urban agriculture can help to keep the environment clean and use waste as a resource for fertilizing and thereby reduce the amount of waste through the production of compost from organic wastes and the recycling of inorganic wastes (such as, for instance, the use of plastic bottles, tanks, and car tires for soilless cultivation). The extension of green land within urban areas improves their microclimate and is also advantageous for the biodiversity, since it can serve as habitat for many species. Trees and herbaceous species reduce the suspended dust and the air pollution rate of many compounds, like nitrogen dioxide (NO₂). Furthermore due to the proximity of the production location and the end consumer, emissions for transport, packaging, storage, etc., can be reduced significantly.

A good example for reuse the by-products of the waste management is the rooftop garden on the Laksi district office, Bangkok. This garden is owned by the district office Laksi and is part of the Bangkok metropolitan area initiative to increase the green space in Bangkok. The garden’s budget depends completely on the sale of the crops and fertilizer, produced on site. Vegetables (climbing vines and salads...) and herbs and mushrooms are grown on 440 m² on the rooftop (figure 4). The vegetable rooftop garden offers free trainings and workshops about urban agriculture for private and commercial purposes. The raw materials for the production of fertilizer and substrate are organic wastes from restaurants, food industry, households and gardens in the district and surrounding area. Several
types of fertilizers, with different ingredients, are produced for the different vegetable species on the site and for sale. Other ingredients are: molasses, banana rhizomes, coconuts, pineapple husks, yogurt, soybean residues, shrimp residues, animal manure, etc.. It is an organic garden and external inputs are just tap water, seeds, some ingredients of fertilizers and plant protection means. This garden is an ideal example for a sustainable recirculation of by-products without a lot of external inputs and gives the unused rooftop space a reasonable additional function.

Figure 4 Rooftop garden on the Laksi district office building in Bangkok

In many cities agriculture is conducted on underutilized and degraded lands, such as those areas located below electric lines or along water courses or railways. But these advantages resume proper agricultural practices, otherwise the wrong application of fertilizers and pesticides may be a menace for water below and upon the ground.

Urban agriculture includes various production systems among which cropping activities are more common than livestock rearing and horticulture represents the major component. Especially, the cultivation of short cycle and highly perishable crops are very popular among urban farmers, while in peri-urban areas medium or long cycle crops and orchards are dominating. The localization of the gardens near the markets also reduces the need of conditioning and storage infrastructures and reduces post-harvest losses, which can be as high as 30 percent.

Leafy vegetables, such as *Amaranthus* spp., Chinese cabbage, leafy cabbage, lettuce, coriander, and chive, are preferred crops worldwide from many urban farmers, since those products have a limited shelf life and the proximity to the customers is very favorable therefore.
The urban population strongly influences the amount of vegetables (especially leafy veggies) that is exchanged in the markets in developing countries. Based on this, urban horticulture becomes an ideal counterpart to the rural production, crucial for the city food supply.

2.2.1 Urban agriculture in Asia

In Hanoi, 40-80% of consumed vegetables are produced in the city and urban agriculture is a crucial vegetable provider (see Table 1), 70% of Hanoi’s urban production and supply is devoted to leafy vegetables. Leafy vegetables have a short shelf life (about 1 day) and, as most consumers in Asian countries do not have refrigerators, freshness and proximity of the grower to market is paramount.

26 types of vegetables are regularly produced in large quantities within Vietnamese cities. Urban gardens occupy an area above 7,000 ha. In Hanoi and in Shanghai, China, the vegetables are grown on more than 10,000 ha. In Baguio, Philippines, following a governmental plan for nutrition (Philippines Plan of Action for Nutrition), between 1994 and 1998, 27,000 gardens in schools, 42,000 community gardens, and 1,600,000 family gardens were established. A study of the vegetable peri-urban production in Ho Chi Minh (Vietnam) highlighted that the net daily income from a vegetable-grown hectare was equal or two fold higher than a hectare rice, and allowed employment levels that were at least five times higher (Jansen et al. 1996).

Table 1 Rate in % of urban horticulture contribution to the city supply (Orsini et al. 2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Leafy veggie</th>
<th>Tomato</th>
<th>Total vegetable</th>
<th>Corn</th>
<th>Banana, plantain</th>
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<tr>
<td>Cambodia</td>
<td>Phnom Penh</td>
<td>100</td>
<td>0-50(^a)</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
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<tr>
<td>Cameroon</td>
<td>Yaoundé</td>
<td>80</td>
<td>25</td>
<td>n.d.</td>
<td>90</td>
<td>60</td>
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<tr>
<td>Congo</td>
<td>Brazzaville</td>
<td>80</td>
<td>20</td>
<td>65</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Ghana</td>
<td>Kumasi</td>
<td>90</td>
<td>60</td>
<td>n.d.</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>Bissau</td>
<td>90</td>
<td>50</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Laos</td>
<td>Vientiane</td>
<td>100</td>
<td>20-100(^a)</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Mauritania</td>
<td>Nouakshott</td>
<td>90</td>
<td>10</td>
<td>n.d.</td>
<td>n.d.</td>
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<tr>
<td>Central Africa Republic</td>
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<td>Senegal</td>
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<td>60</td>
<td>n.d.</td>
<td>n.d.</td>
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<tr>
<td>Tansania</td>
<td>Salaam</td>
<td>n.d.</td>
<td>n.d.</td>
<td>40-80(^a)</td>
<td>n.d.</td>
<td>n.d.</td>
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<tr>
<td>Vietnam</td>
<td>Hanoi</td>
<td>70</td>
<td>0-75(^a)</td>
<td>40-80(^a)</td>
<td>n.d.</td>
<td>n.d.</td>
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\(^a\)...according to the season  
n.d. non defined

These findings highlight the relevance of urban agriculture in Asia and its function as key food provider for the urban population.
2.3 Access to natural resources and labor

There is a very high demand for building sites in expanding cities. As a result of this, the land value is extraordinary high. Land access for urban farmers becomes therefore tough, that is why land is the most important limiting factor for urban agriculture. This insecurity forces many farmers grow on marginal lands with low fertility, which reduces the choice of the cultivated species to short-cycle crops (e.g. leafy vegetables). This affected farmers do not take actions to restore soil fertility for a long term cropping strategy, since they do not know the duration of using those areas.

Cities are known as sinks for pollutants in soil, air and water. Urban crops are cultivated under high SO\(_2\), NO\(_2\) and ozone atmosphere concentration through car traffic and the contamination with heavy metals, hydrocarbons and pesticide residuals in soils is another imminent danger. To produce for health acceptable products under these circumstances is very complicated and often not possible. Besides the end users, also market vendors and producers are in danger, when they get in contact with the contaminated materials (e.g. fertilizer, products, and irrigation water).

The heavy metal contamination is a result basically when production sites are located in former industrial areas, on lands irrigated with water and/or, on solid contaminated industrial or mining wastes. Avoiding cultivation in such areas is a possibility to alleviate the risk of contamination. Another measure is crop choice, because the accumulation varies among, species, cultivars and even plant parts. It is a fact that leafy vegetables are stronger accumulators as compared to fruit vegetables or vegetables cultivated for their seeds, and therein, in critical contexts cultivation could satisfactorily be re-addressed to the latter.

2.4 Waste water for irrigation

More than 70% of the total global water consumption is used for agricultural irrigation (UNESCO-WWAP 2003). There is a big potential for the utilization of treated waste water for irrigation purposes, although the amount of waste water satisfies just partly the required amount of irrigation water. Waste water reuse can be united with fertilization by using the nutrients accumulated in waste water, such as Nitrogen and Phosphorus. The use of treated wastewater in agriculture has been practiced for centuries. Today the usage of treated wastewater in agriculture is common and meant to be without environmental or human risks.

The most important risks in the agricultural use of treated urban waters are connected to human and environmental health aspects in particular the health of agricultural workers. Other potential problems caused by waste water irrigation are the salinity, water infiltration rate in the soil, heavy metal accumulation and pollution caused by nutrient leaching.
Secondary treated waste water contains dissolved solids, heavy metals and residues from pesticides and pathogens that can endanger the agricultural production, groundwater quality, soil quality and human health, in addition to the nutrients that are beneficial for agriculture up to certain concentrations. The current solution for these concerns is a waste water treatment process, consisting of different treatment steps, that is capable to produce effluents suitable for agriculture production. Besides the application of such techniques it is not enough to obtain a proper water quality for agricultural irrigation, the definition and the compliance of irrigation water quality standards is essential as well. For that, it is not only necessary to define irrigation water quality standards but also to evaluate whether such standards are met with the application of specific treatment techniques.

In the urban and peri-urban areas of most developing countries, where water for irrigation is required, there is often no other choice than the use of wastewater. The reasons for the deliberate use of raw wastewater in these countries are the supply of nutrients and lower cost. The use of waste water is a result of the high water demand from agriculture and the absence of inexpensive fresh water resources along with funding problems for the construction and maintenance of waste water treatment plants. In more than fifty countries treated waste water is used for irrigation and is therefore fundamental in the water resources management.

The Middle East, south and south-eastern Asian countries including Pakistan, India, Vietnam and parts of China will probably become dependent on waste water irrigation in the future. In Hanoi city, wastewater is used for irrigation, but estimates on wastewater use across Vietnam are hardly found in literature probably due to the lack of integration of reuse practices in regional or national plans. In most developing countries, diluted, untreated, or partly treated wastewater is used for irrigation (Norton-Brandão et al. 2013).

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1 refers to the treatment of wastewater to remove dissolved solids (e.g. sugars) from the wastewater; this is done using micro-organisms to consume the wastes in aerated tanks, followed by settling of the micro-organisms and associated solids in a clarifier (a quiet settling tank) or pond.
2.4.1 Proper use of waste water

Especially excreta-related pathogens and toxic chemicals can reduce the quality of waste water irrigated products significantly. If no treated waste water or fresh water are available or very limited, there are ways to reduce the health risks of untreated waste water for farmers, market vendors and consumers. For example the pathogen infection risk can be easily lowered if the food is cooked before consumption, but not on the presence of toxic chemical compounds. The following health protection measures can contribute to a risk reduction:
- wastewater treatment,
- crop restriction,
- wastewater application techniques that minimize contamination (e.g. drip irrigation),
- withholding periods to allow pathogen die-off after the last waste water application,
- hygienic practices at food markets and during food preparation.
- health and hygiene promotion,
- produce washing, disinfection and cooking,
- chemotherapy, immunization and Oral Rehydration Therapy (Winpenny et al. 2010).

2.5 Sludge and organic waste for fertilizing

The utilization of sewage sludge as fertilizer is a way to return the nutrients, extracted by the plants, to the soil. Furthermore it is from an economic point of view the cheapest way of

Sewage sludge contains advantageous nutrients and organic matter for agricultural soil and can be applied as fertilizer. In late 1990s concerns arose that sewage sludge bears, besides beneficial effects for crop development and soil structure, threats for human, animal and environmental wellbeing. Reason for that is the potential contamination with inorganic and/or organic constituents. The accumulation of these pollutant in soils and plants can cause severe problems

Additionally it is a cheap way of get rid with sewage sludge. However, sewage sludge are also considered as a sink for domestic and industrial chemicals that accumulates during waste water treatment (WWT). The presence of detectable concentrations with different pollutants has been well documented and has led to concerns that land application\(^2\) may lead to contaminated soils and subsequently lead to translocation via the food chain to humans. This menace resulted in strict laws and pollutants threshold in many countries all over the world. There is no global common opinion about this issue and opinions are controversial (Egan 2013).

\(^2\) distribution of fertilizer on agricultural land
2.5.1 Contaminants in sewage sludge

Following compounds can be found and are named as pollutants in sewage sludge: Inorganic pollutants (e.g. heavy metals as lead, mercury, cadmium, organic pollutants (e.g. dioxin, polychlorinated biphenyl (PCB), residues from pharmaceuticals, antibiotics and pesticides, pathogens,

According to the coalition agreement of the German government the land application should be stopped in Germany in near future. In some other countries the application is limited to a few applications in a certain timeframe and just on particular crops. Nonetheless in many developed and also developing countries the land application is a common method to dispose sewage sludge, since it contains valuable nutrients, it is rather cheap and huge amounts of it can be obtained in urban areas.

A common alternative is landfilling, but it is not desired method anymore. In several European countries including Germany landfilling is forbidden. Reasons, because landfilling is recognized as not sustainable and wasting of resources.

Recently several alternate options, besides land application and landfilling, for the management of sewage sludge have been promoted and applied: Energy recovery (anaerobic digestion, incineration and combustion, supercritical water oxidation, pyrolysis), reuse of ash residues from combustion (construction material production, nutrient recovery) found in (Wang et al. 2008).

Land application has played the most important role in the beneficial use of sewage sludge and will remain in many countries.

Currently, in the developed and developing world it is widely applied to land, due to its low costs and complete nutrient and organic matter recycling in soil. However, due to a growing awareness of potential risks and a resulting in a critical public perception, this method was banned or stricter quality criteria restrictions were introduced.

Up to date, methane production from anaerobic digestion provides by far the most effective proven energy recovery from sludge. Additionally anaerobic digesters can be used as a good pre-treatment for fertilizer production by removing readily decomposable organic material that can harm on soil functions. If digested sewage sludge is not used as fertilizer, further treatment, such as dewatering, and final disposal options need to be found.

The other approaches mentioned above are mostly quite novel and whether these technologies are economically feasible and energy efficient is not completely plain yet and has to be proven. An indirect energy production through the application of sewage sludge based fertilizer for bioenergy crops can be achieved. Using this approach, the potential of contaminating the food chain is eliminated.

In general, the contamination of sewage sludge should be avoided, independently of the further management or utilization of sewage sludge. It should not be considered as waste, but as resource and a part of the nutrition cycle (Wang et al. 2008)(UN-HABITAT 2008).
2.6 Organic waste as fertilizer

The management of solid organic waste (SOW) is a crucial subject. This fraction may have a high ratio of total amount of SW and therefore contributes significantly to urban pollution, if no proper handling is conducted. Besides urban pollution, if SOW is just dumped on landfills, large nutrient amounts are lost and may harm the environment. A solution to circumvent these problems is composting in order to produce organic fertilizer. Composting can be combined with biogas production to get, additionally to the fertilizer, energy. In contrast to imported mineral fertilizers, OW are usually locally available and OW fertilizer production and application have several benefits: Improves soil properties (biological-, chemical- and physical-properties), higher yields, income generation, reduced landfills of OW and the related avoidance of pollution.

But the utilization of compost has also some constraints. Unlike mineral fertilizer or other organic fertilizers, compost has a lower macro-nutrient content. One common approach is to blend it with e.g. N-rich chicken manure or even mineral fertilizer (Hargreaves et al. 2008). The low nutrition content does not facilitate to merchandise this product. Therefore it is essential to convince putative customers of the extra effects, such as it beneficial effects for soil structure and the prevention of soil erosion.

There are different forms of composting: anaerobic and aerobic: Complexity and scale of these systems differ noticeably. A very convenient method is to make static piles, while bin/barrel composting or open windrow is more sophisticated and laborious.

In Africa several attempts to establish compost production and subsequent application failed due to several reasons (Linzner & Wassermann 2006). Similar problems occurred in Da Nang, several efforts to establish the reuse of compost for fertilizing failed due to financial reasons.

Composting projects in the past decades focused on large-scale composting plants, but the majority of these composting plants were unsuccessful, because of waste characteristics (like impurities, hazardous substances or material properties that hindered the degradation process), seasonal variations (problem of continuous supply of input material), lack of technical education and training, lack of (funds for) maintenance, variations in water and power supply and the status of waste management in politics and administration. Major problem for large scale plants is the funding of construction and equipment and supply with OW. Seasonal variations and feasibility of transport have to be considered in this context. An important prerequisite is a proper compost demand to create sufficient revenues.

In the last two decades more and more small scale decentralized composting projects initiated by NGOs or communities have been introduced. Characteristically for decentralized composting are the small number of people involved and the relatively low costs.

The location of the composting facility should be close to both the point of origin of the input material and the place of land application.

Independently, whether a small or large scale composting facility is planned, first of all a sufficient evaluation of input supply, compost quality and existing and potential markets for compost is mandatory. A proper market evaluation provides information on the potential compost users and the existing fields of application, e.g. agriculture, parks, horticulture, silviculture etc. and on the estimated value of the product for the user (willingness to pay, ability to pay, price of competing products).

Transport and seasonal variations affect both the quantity and the composition of the input material. Collection schemes for certain waste types may already exist. The purity of the input
material has a major influence on the quality of the produced compost: source separated organic material improves the quality of the compost.

Local governmental or other institutions can support such a project by educating the people, providing land for the facility, assisting with start-up costs, transporting and disposing of rejects to local landfills, and using the final compost in public parks. These small-scale operations depend mainly on human labor. The start-up costs for these facilities involve low capital input as almost no machinery is used. The running costs are also low, because human labor is comparably cheap in low-income countries. Due to high fuel prices in low-income countries, it is important to minimize transport costs.

Several studies, dealing with the usage of OSW as fertilizer for agriculture, showed that besides advantageous effects, as mentioned above, land application of OSW fertilizer may bear negative impacts for soil, plant and consumer health. Therefore the proper testing and monitoring of the feedstock is essential to avoid threats for environment, humans and livestock. Worth mentioning is that also in mineral fertilizer traces of heavy metals are found Effects of municipal solid waste compost and mineral fertilizer amendments (Carbonell et al. 2011).

Other harmful impurities, which can occur in OSW, are so called persistent organic pollutants. These compounds are highly chlorinated and known to be persistent in the environment. Composting can be an effective way to reduce levels of these compounds. Feedstocks which provide organic pollutants are pesticides, household wastes such as oil and solvents, and paper products because of printing ink. The best approach for minimizing the risk of contamination of OSW is early source separation, perhaps requiring separation to occur before or at curbside collection. The method used e.g. in Korat, Thailand, where unseparated or mainly badly separated MSW is used as feedstock for anaerobic digestion and just afterwards the OW fraction is separated from MSW and sold as fertilizer to farmers and households should be absolutely avoided, since it is likely to cause contamination in the compost (Figure 5). Blending with sewage sludge should also be avoided, since sludge may be abundant with heavy metals and/or other pollutants (RUAF 2010).
Some mega urban agglomerates, such as Bangkok, exploit municipal organic waste as resource for several purposes. Organic wastes from households, industry and restaurants are daily collected by the Bangkok Metropolitan Administration (BMA), a division of the Department of Environment, as well as the green waste from public green spaces. The organic waste collected by BMA is primarily used for fertilizing the trees and ornamental plants in parks and other public green spaces. Besides collecting organic waste, the BMA has launched a campaign to minimize waste and promote waste separation (3R Campaign – Reduce, Reuse, Recycle) in households, schools, organizations and other public institutions. According to the representatives BMA is setting a high value in reducing the amount of waste and the proper separation. People have the chance to attend trainings organized by the BMA, in which the learn how to reuse organic and as well other solid wastes. In several training centers people can study the sustainable utilization of organic waste.

There are different ways of the utilization of organic waste are promoted in Bangkok:
- Fertilizer
- Fodder (people can give their organic waste to farmers)
- Biogas production
- Substrate (for planting trees)

The BMA and the Ministry of Energy also installed biogas plants in cooperative markets (using market waste) and many schools in Bangkok. The sewage sludge from households, public places and mobile toilets is collected and transported to two treatment plants in Bangkok, where it is processed using biological treatment systems – microorganisms. These two plants have the capacity to treat 1200 m$^3$ sludge/day.
Sludge is mixed with yard waste and then used for fertilizing. The BMA has two compost facilities, which have the capacity to produce 80 tons/day. The wastewater is treated and then released in the public stream.

2.7 Anaerobic digestates as fertilizer

Anaerobic digestion converts municipal organic waste and also sewage sludge into two economically useful by-products: biogas, a renewable energy resource and the anaerobic digestate, a potential fertilizer and soil amendment. In recent times, the production of a safe digestate suitable for fertilizing in agriculture has become as important as producing the maximum yield of biogas.

Similar to undigested organic waste, digestives also may contain pollutants which can harm environment, livestock and human. Therefore the quality should also be regularly monitored and a proper handling is also, as for all fertilizers, required.

After anaerobic digestions the nutrient remain in the solid phase and in the liquid phase, the leachate and carbon is converted in methane and CO₂.

Regarding to the organic matter content it can be deduced following: The solid fraction has a greater potential as soil amendment than the liquid fraction, whereas the latter has a greater potential as fertilizer than the former; (b) the nature of the source material (feedstock) is one of the major determinant of the qualitative value and the potential use of the end-product (digestate).

Relative to mineral commercial fertilizers, many studies across the world have shown that anaerobic digestates were at least as effective as mineral fertilizers. For instance, in vegetable production in Japan, a digestate produced from household OW was shown to be a quick-release nitrogen fertilizer comparable to inorganic synthetic fertilizer and did not lead to contamination by bacteria (coliform groups, *Escherichia coli*, fecal streptococci and *vibrio parahaemolyticus*) in the soil and on spinach (*Spinacia oleracea L.*) and Komatsuna (*Brassica rapa var. perviridis L. H.*) leaves.

Haraldsen et al. (2010) revealed that a liquid anaerobic digestate, from source separate household wastes, had the same effect on barley as a mineral NPK fertilizer. Numerous studies from all over the world are in agreement that the chemical compositions of anaerobic digestates fit most European laws of an organic fertilizer. Moreover their fertilizer performance lies between raw organic manure and commercial inorganic fertilizer (Nkoa 2013).

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3: is any material which, upon addition to the soil, would improve or maintain its physical, chemical or biological properties
2.8 Important tasks before introducing a compost project

Before starting a compost project or also wants to sale other organic fertilizers, several preparations must be done and considered (Rothenberger et al. 2006):

1. Identification of stakeholder and their interests relevant stakeholders involved in your project
   - Potential project partners
   - Potential communities for project implementation
   - Potential composting sites in these communities
   - Potential risks for the project and possible mitigation strategies

2. Assessing target community interests and land availability
   - How to approach and inform the community?
   - How to evaluate the willingness of the community to participate in the project?
   - Ideas and concerns of the beneficiaries
   - Local conditions in the target area
   - Community willingness to cooperate and to what extent
   - Important criteria required to identify potential composting sites in these communities

3. Data Collection about waste feedstock
   - The amount of waste generated in the selected community
   - The waste components and other important waste characteristics
   - The natural environment of your community

4. Preparing a Business Plan and Financial Projections
   - Develop an appropriate management model to implement the composting project
   - Assess the financial viability of the project by calculating the benefit-cost ratio
   - Set up a contract or agreement with the project partners
5. Development and Design of Collection System

- The most appropriate vehicles and the number required
- How to ensure the participation and support of the community served
- How to promote waste segregation at source (in the household)

6. Design and Construction of Composting Facility

- How much space is required by a composting facility treating three tons of waste per day
- Fundamental construction rules for the two composting processes presented
- Useful construction material and equipment
- How to divide the available space into functional compartments to enhance the workflow.

7. Operating and Maintaining a Composting Facility

- The different steps of a composting process
- The required quality criteria for input material and additives
- How to measure important process parameters such as temperature and moisture
- How to maintain the compost plant
- Which are the typical problems of the composting process and how to solve them
- The most important quality criteria and how to control them.

8. Marketing of Compost

- How to approach and relate with potential customers
- About some potential sales strategies and which may be the most suitable for the business
- About the important quality criteria to ensure satisfied customers and long-term sales
3 Da Nang

3.1 General

Da Nang is a major harbor city and the largest city in central Vietnam. The city is spread over 1,283 km² and according to the Statistical Yearbook of Da Nang City in 2011, the total population of Da Nang city was about 951,864 and the population density 740.36 people per km², with 87.07 % in urban areas.

With the fourth largest seaport in the country, Da Nang is an important gateway city to the Central Highlands of Vietnam, Laos, Cambodia, Thailand and Myanmar. After relatively slow population growth (1.7 % annually) between 2000 and 2007, Da Nang appears to grow quite fast within the next ten years, primarily due to migration from rural areas.

By 2020, Da Nang is expected to become one of the country’s major urban centers with a population of about 1.65 Mill.. With 70km of beautiful coastline and many tourist sites close by, Da Nang is getting more and more popular for tourists. For 2015, Da Nang is No. 1 travel “Destination on the Rise” by the online travel portal TripAdvisor (Luong 2014).

Figure 6 Map of Vietnam (left) (Source: http://www.business-in-asia.com/factory_in_vietnam_danang.htm) and of Da Nang (right) (Source: http://www.vietnammarkets.com/maps/showmap.php?id=5)
Da Nang is divided in six urban districts, one rural, Hoa Vang, and one island district. Its gross domestic product (GDP) growth rate has been higher than the country’s average rate. Between 2000 and 2007, Da Nang’s regional GDP grew 12.3% annually, totaling 1.48 billion US Dollars (USD) in 2009 (Ostojic et al. 2013).

3.2 Climate

Da Nang has a typical tropical monsoon climate. The city’s weather bears the combination of the north and the south climate characters with the inclination to the former. There are two seasons: the wet from August to December and the dry season from January to July. The average temperature is about 26°C and the average annual precipitation is 2,505 mm/year which occurs mainly from October to November as shown in the climate chart below (Da Nang Portal).

Figure 7 Climate chart of Da Nang (Source http://thedevelopmentadvisor.com/danang-hotel-development-and-investment-market-overview/)
3.3 Water resources

The water for Da Nang City is supplied primarily from the two main rivers Cu De and Han River. According to the survey results of Planning Water Resource Association 709, the underground water in Da Nang City is quite shallow, various and complicated. The underground area exploited for water supplying are in Hoa Hai and Hoa Quy commune, both in Ngu Hanh Son district with a depth about 20-35 m and the total average water volume of 5,000-10,000 m³/day, in Hoa Khanh, Lien Chieu, with the depth about 30-90 m and total average water volume of 20,000,000 m³/day for industrial places.

In general, the water source of Da Nang City is quite abundant. However, in the dry season (May and June), the water source is salted because of tidal influence. The quality of water was quite good and might be used for life activities and developing economics (Linh 2013). In the summer, the weather is hot and due to water shortages, the crops yield low. In the rainy season, flooding has caused frequent production interruptions.

Da Nang faces water supply problems during dry season. Due to the saltwater intrusion into the rivers, water has to be pumped over long distances to Da Nang.

Figure 8 Han River in Da Nang
3.3.1 Irrigation

The irrigation systems in Da Nang City include two big water reservoirs (Hoa Trung, Dong Nghe), 21 small and medium water reservoirs, 27 spillways and 27 feed-pump stations, 13 km seawalls and 630 km canals (452 km interior field canals). Total capable design of irrigation systems is 12,500 ha; real capability of irrigation is 8,500 ha (68% of total design capacity) that satisfies 72% of the cultivated area. There are 139 km permanent canals (71% of total canals). (Linh 2013). The infrastructure for irrigation is mostly old fashion except a few places like La Huong vegetable growing center. Often water is distributed manually to the fields or old pumps with a high energy consumption are used. According to the Center for Extension of Fishery – Agriculture – Forestry, service water is free of charge in Da Nang for urban farmers.

3.4 Economics

The economic structure of Da Nang has changed over the last 14 years. The importance of the agricultural sector in terms of the GDP decreased from 7.9% in 2000 to 3.91% in 2010 (see table 2). 4.74% of Da Nang’s inhabitants were jobless in 2011 and 38,000 people (8.5%) were working in the agricultural sector, including forestry and fishery (Statistical Yearbook 2011).

<table>
<thead>
<tr>
<th>Economic Sectors</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>50,9</td>
<td>44,68</td>
<td>51,51</td>
</tr>
<tr>
<td>Agriculture, forestry and fishery</td>
<td>7,9</td>
<td>5,13</td>
<td>3,91</td>
</tr>
<tr>
<td>Industry and construction</td>
<td>41,3</td>
<td>50,19</td>
<td>44,58</td>
</tr>
<tr>
<td>Other</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

3.5 Solid waste management

Da Nang Urban Environment Company Limited (URENCO) is in charge of the solid waste management in the city. 268,000 tons of solid waste were collected in Da Nang in 2013 and the collection rate in 2012 was 92% (table 4). According to URENCO the amount of solid waste in the city is increasing. The solid waste in Da Nang is unseparated collected and disposed on Khanh Son landfill, a sanitary landfill, which will be fully occupied by 2020, if the collected waste will not be treated further (JICA 2014).

A pilot project with 2,000 households involved on source separation was conducted in Nam Duong Ward was conducted. The supportive attitude of local residents for this project was reported. However, this model could not be continued due to missing financial support improve, organic waste and recyclables after separation could not be treated properly due to the lack of treatment facility (JICA 2010).

Medical and industrial solid wastes are collected and processed separately, using incineration at Khanh Son Landfill, from domestic. The ratio of organic waste of total domestic waste is (2010) ca. 75% (200,000 tons in 2010) as shown in table 3. Currently no further treatment is done.
except landfilling. For the future the utilization of organic waste for the production of biogas and fertilizer is planned according to URENCO, but apparently there are funding problems. URENCO offers an opportunity to the farmers to collect pesticide containers and combusts them. But it depends on the farmer’s consciousness whether they use this service.

Table 3 Waste composition 2010 (URENCO)

<table>
<thead>
<tr>
<th></th>
<th>in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>5,16</td>
</tr>
<tr>
<td>Organic household waste</td>
<td>74,65</td>
</tr>
<tr>
<td>Wood</td>
<td>0,67</td>
</tr>
<tr>
<td>Clothes and textiles</td>
<td>3,18</td>
</tr>
<tr>
<td>Leather</td>
<td>0,83</td>
</tr>
<tr>
<td>Rubber</td>
<td>1,29</td>
</tr>
<tr>
<td>PET</td>
<td>0,07</td>
</tr>
<tr>
<td>PVC</td>
<td>0,62</td>
</tr>
<tr>
<td>Nylon bags</td>
<td>11,58</td>
</tr>
<tr>
<td>Multicomponent plastics</td>
<td>0,42</td>
</tr>
<tr>
<td>Ferrous metals</td>
<td>0,18</td>
</tr>
<tr>
<td>Nonferrous metals</td>
<td>0,01</td>
</tr>
<tr>
<td>Construction waste</td>
<td>0,55</td>
</tr>
<tr>
<td>Glass</td>
<td>0,74</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>0,03</td>
</tr>
<tr>
<td>Medical waste</td>
<td>0,02</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4 Total waste collection in Da Nang per year (URENCO)

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>in tons</td>
<td>191002</td>
<td>194000</td>
<td>209663</td>
<td>228700</td>
<td>238156</td>
<td>258938</td>
<td>269390</td>
</tr>
</tbody>
</table>
3.6 Waste water treatment

In Da Nang no proper septage management is in usage and only 16 % of all households are connected to the combined sewer system. The majority of households use septic tanks to collect black water, which are not emptied and maintained regularly. The sewage sludge remains in septic tank and contaminates the soil and groundwater by exfiltration, and the air by emitting methane gas. Furthermore septic tanks often emits bad odor and decreases life quality. Waste water treatment plants receive only a highly diluted WW and the further treatment or utilization of the sludge is not efficient or feasible. The city’s storm drainage network is used for collection and conveyance of rain water and also for municipal wastewater collection. Septic tanks are not a state of art anymore and should be substituted with a modern system.

Due to the population increase, wastewater production is increasing rapidly and the general increase of economic activity. A substantial rise in wastewater capture is necessary to limit its negative impact on the environment. Contamination of the soil, groundwater and Han River with coli bacteria has been reported. According to ADB (2012) commissioned study the three weak points should be addressed and change in the current system: (i) the very low connection rate; (ii) the low service coverage; and (iii) the limited effectiveness in capturing wastewater during the rainy season.

Due to the diluted WW and low connection rate, all WWTP’s in Da Nang operate far below their capacity and the treatment process are not properly working and efficient.

The limited effectiveness in capturing wastewater during the rainy season results in serious pollution events at the east coast’s beaches the most important tourism zone with in the city, and subsequently the sea water. The tourism industry is dominating Da Nang’s services sector, and the East coast beaches are the city’s prime assets on which the tourism industry is building. The most serious impact of pollution events occurs when a rain storm occurs during the dry season, which is the main tourism season in Da Nang. This reduces the attractiveness of the beach severely (Anon 2012).

Treated water can be reused in urban agriculture in the future, if the water quality complies with the regulations. As described above water for the irrigation is primarily exploited from the groundwater wells. Because of the brisk construction activity in Da Nang, the capacity to renew the groundwater is declining significantly. At least a part of the groundwater could be substituted with treated wastewater for irrigation, since it is through the whole year available. According to Mohr (2014), it is feasible to remove not all nutrients from the wastewater and use them besides irrigation for fertilizing the crops in the city. The local farmers should be trained and informed about this opportunity in order to avoid over fertilization and the subsequent harmful effects for environment and humans. Guidelines are required which regulates the proper utilization of the nutrient rich water.
3.7 Environment-friendly city by 2020


That means by 2020, 100 % domestic and industrial waste water should be treated to meet the environmental standards, 70 % of solid waste should be recycled and 25 % of the water would be re-used. Furthermore, the urban green space should be augmented to around 9- 10 m$^2$ green space/ person by 2020.

3.8 VietGAP

The Vietnamese Good Agricultural Practice (VietGAP) certificate aims to ensure a safe and sustainable production of crop, livestock, and fishery. The certificate should set standards and preventing the risk of hazards which occur during the production, harvest and postharvest handling. The characteristics covered in VietGAP include food safety, produce quality, environmental impacts and health, safety and welfare for Vietnamese workers.
VietGAP is a standard and guideline which helps individuals and organizations, producers and consumers to provide/buy products produced in consideration of food safety, product quality and fair labor conditions for workers, proper harvest and postharvest management of crops. Additionally, these also serves to protect environment and use for product identification, traceability and recall.

Many premises have to be fulfilled to get a certificate:
The sites and their soils for cultivation, planting material, fertilizers, pesticides, water for irrigation, infrastructure, produce treatment and safe working conditions have to fulfill the requirements and many details must be recorded for monitoring.

Chapter 4

4. Urban Agriculture in Da Nang

4.1 Overview

According to the appraisal from Dinh et al. (2013), data about urban agriculture in Vietnam is not consistent. Based on calculations of the Dr. Le Van Truong, the ratio of the contribution from urban agriculture to the total amount of agricultural products consumed in several Vietnamese cities is as follows in the table 5 below.

Table 5 Ratio of urban agriculture's contribution in % to the total demand in 5 Vietnamese cities (Dinh et al. 2013)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Fruits and vegetables</th>
<th>Meat</th>
<th>Seafood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanoi</td>
<td>33</td>
<td>55</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Hai Phong</td>
<td>85</td>
<td>65</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Da Nang</td>
<td>23</td>
<td>30</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Ho Chi Minh City</td>
<td>10</td>
<td>18</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>Can To</td>
<td>100</td>
<td>70</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

This data reveals the crucial role of urban agriculture for food security in Vietnam’s cities, even though it is not consistent with literature cited in chapter 2. Even in the capital city Hanoi, urban agriculture contributes significantly to meet the city’s food demand. In Da Nang 23 % of all agricultural products origins from the city and 30 % of all vegetables and fruits are produced here. This emphasizes the importance of urban agriculture for Da Nang and its people.

Figure 10 Urban agriculture on Son Tra peninsula, Da Nang
4.2 Area and location of urban agriculture

4.2.1 Area under cultivation

The land used for agriculture can be divided into officially declared agricultural land and non-officially declared agricultural land. As non-officially declared agricultural land used for agriculture are:

- balconies, terraces or rooftops of residential buildings
- gardens in residential areas
- public land, such as abandoned construction sites or other marginal lands

Table 6 Land-use and land-cover change (LULC) calculated for Da Nang (Linh 2013)

<table>
<thead>
<tr>
<th>LULC class</th>
<th>1979</th>
<th>2003</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Area (ha)</td>
<td>Area (ha)</td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Agriculture area</td>
<td>12048</td>
<td>9512</td>
<td>7294,7</td>
</tr>
<tr>
<td>Barren land</td>
<td>4312,2</td>
<td>1771</td>
<td>1708,9</td>
</tr>
<tr>
<td>Urban area</td>
<td>6315,3</td>
<td>10900,7</td>
<td>17298,5</td>
</tr>
<tr>
<td>Forest</td>
<td>61972</td>
<td>60233</td>
<td>57936,2</td>
</tr>
<tr>
<td>Shrub</td>
<td>9785,2</td>
<td>11169,4</td>
<td>9575,8</td>
</tr>
<tr>
<td>Water surface</td>
<td>2384,6</td>
<td>3231,2</td>
<td>3003,6</td>
</tr>
<tr>
<td>Total</td>
<td>96817,2</td>
<td>96817,2</td>
<td>96817,7</td>
</tr>
</tbody>
</table>

According to the Center for Extension of Fishery – Agriculture – Forestry of DARD the area designated as agricultural land under cultivation is currently around 8000 ha in Da Nang. Abandoned land and fallow land used for agricultural activities are not included in this estimation, since it is hardly feasible to calculate or estimate its dimension. Empty public land is managed by the responsible ward authority. People have to ask for permission to use it for UA and have to prepare it for their purposes on their own, that means they probably have to clean it and take other actions to use it.
<table>
<thead>
<tr>
<th></th>
<th>Total area</th>
<th>Agricultural, forestry land</th>
<th>Non-agricultural land</th>
<th>Unused land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ha</td>
<td>ha</td>
<td>%</td>
<td>ha</td>
</tr>
<tr>
<td>Total area</td>
<td>128342,24</td>
<td>76722,27</td>
<td>59.8</td>
<td>49154,99</td>
</tr>
<tr>
<td>Hai Chau</td>
<td>2135,42</td>
<td>26,06</td>
<td>1.22</td>
<td>2088,42</td>
</tr>
<tr>
<td>Thanh Khe</td>
<td>936,3</td>
<td>17,78</td>
<td>1.9</td>
<td>903,53</td>
</tr>
<tr>
<td>Son Tra</td>
<td>5932</td>
<td>4078,79</td>
<td>68.8</td>
<td>1815,92</td>
</tr>
<tr>
<td>Ngu Hanh Son</td>
<td>3858,93</td>
<td>1188,28</td>
<td>30.8</td>
<td>2037,56</td>
</tr>
<tr>
<td>Lien Chieu</td>
<td>7912,7</td>
<td>4197,32</td>
<td>53.1</td>
<td>3235,72</td>
</tr>
<tr>
<td>Cam Le</td>
<td>3375,85</td>
<td>1010,93</td>
<td>30</td>
<td>2242,42</td>
</tr>
<tr>
<td>Hoa Vang</td>
<td>73691,04</td>
<td>66203,11</td>
<td>89.8</td>
<td>6331,42</td>
</tr>
<tr>
<td>Hoang So</td>
<td>30500</td>
<td>0</td>
<td>100</td>
<td>30500</td>
</tr>
</tbody>
</table>

There is a detailed study about the change in land use in Da Nang over the last 30 years by Linh (2013). Urban area increased from 6.5 % in 1979 to 17.9 % in 2009 of the total city area. Meanwhile agricultural land was reduced from 12.4% to 7.5% (see table 6 and figure 11). The drop of agricultural land in Da Nang is logical, since urbanization is progressing in Da Nang and is also, according to all stakeholders, the main constraint for UA in the city. Based on these calculations, the city has still a lot of potential for enlarging the urban area.
4.2.2 Locations of urban agriculture in Da Nang

Agriculture is scattered across the city in the following urban districts Hai Chau, Thanh Khe, Son Tra, Lien Chieu, Ngu Hanh Son and Cam Le and especially in the rural district Hoa Vang. The majority of agricultural land is not close to industry zones (IZ) and official declared agricultural land has never been used for industry.

In my opinion for the cultivation of crops on public land it cannot be precluded that it is in proximity and/or even on former or current IZ, but apparently this so called “guerrilla gardening” is just taking place in residential areas. Furthermore most of the official agricultural land in Da Nang, lies in the peri-urban district Hoa Vang (Table 7).

4.3 Rooftop gardening

There are rooftop gardens in Da Nang, but no data about distribution and frequency within the city is available. It is mainly for the self-supply of households with fresh food. People grow sprouts vegetables, mushrooms, sprouts, flowers and other ornamental plants, on their balcony, terrace or even on the roof of residential buildings. Surplus goods, which exceed their own needs, are sold to family members or neighbors. Reasons for the rooftop gardening are the demand for fresh and safe products. People produce it on their own, so they are sure they get clean products and also can earn additional income from selling part of their products.
Furthermore, these rooftop gardens enlarge the green area within city and contribute positively to the city’s microclimate.

4.4 Ownership structures of urban agriculture

In Vietnam, land belongs to the people of Vietnam. The State is the representative owner and the state decides land use purposes by passing decisions and by considering and approving land use zoning and land use plans. The land use planning is government’s responsibility and has a key role by the establishment of economic and industry zones. People are the user of the land and have the right to use, sale and inherit land, unless the land is requested for other purposes by the government. Then people have to resettle (Thi & Ngoc 2014). According to law, the state is the representative owner and the citizens are the user. Agricultural land can be “leased” for up to 20 years or even longer and a very low rate. If the agricultural land is needed for other purposes, such as construction, the farmer loose the right use it. But the city authority will compensate it. According to Mr. Ti, vice rector of the According to the Center for Extension of Fishery – Agriculture – Forestry, the compensation for farmers per 1000 m² agricultural land are 200.000.000 Vietnamese Dong (VND), paid by the city authorities.

Concerning public land: Utilization for agriculture is allowed until the land is used for other purposes. The public land is managed by the responsible ward authorities. Basically, there is no leasing rate for using public land, just in case the crops produced on this public land leave high profits a small leasing rate has to be paid, amount of leasing rate is negotiable with the ward.

4.4.1 Organizational structures of urban agriculture

Agriculture is organized in two forms of associations in Da Nang: Farmer associations and agricultural cooperatives. A farmer association is a civil organization to support farmers on all levels. The organization is a member Vietnamese Fatherland, an umbrella group of pro-government "mass movements" in Vietnam, but it is not a governmental organization. Cooperatives are managed by Economic divisions of wards where they are located. Approval from district’s people’s committee (PC) form a cooperative is necessary. Cooperatives are founded by the municipality and are legal organizations with official stamps.
4.4.2 History of agricultural cooperatives (AC)

In the past Vietnam had a socialist central-planning economy based on the Soviet model. For agriculture this meant that private farming disappeared and agriculture had been into agricultural production cooperatives (APC) focusing on annual crops and into state farms focusing in general on perennial crops.

In 1986 policy changed and economic reform called “Doi Moi” changed the economic system of Vietnam completely.

Vietnamese farmers had the chance to invest their labor and capital for their own production. The farm land of the APCs was distributed among all farmers and from this time the farm households substitutes the APC as basic unit of agricultural production. Private farming was re-emerging and also the function ACPs changed. Before Doi Moi, APCs were production units and afterwards changed to a provider of different services for their members, private farmers (Wolz & Duong 2008). In 2005, countrywide 6.9 million farmers or farmer households were organized in APC that means 57.6 % of Vietnam’s farmers are organized in APCs.

The offered service are diverse and ranging from irrigation service construct and manage irrigation canals and pump system reaching 80.5%, plant protection service 57%, inputs supply 46.2%, extension service 46.3% and 43.2% for electricity service. More and more APCs offers farm product processing and marketing, internal credit, clean water supply and waste collection.

APC are depending on the funding of their members, some get loans from banks, but the government does not support APC financially. During my survey I noticed several ACPs with a different focus offering services to their members:
- vegetables (provides fertilizer and pesticides)
- planting service
- aquaculture
- mushrooms
- pig production
- spring sprout production
- flowers and ornamental plants

A membership has many advantages. It is a chance for small households to cooperate with each other and work on a professional level together in order to meet the big market demand.

Besides these two organizations there are two subdivision of DARD, which support the local farmers. To a certain extent the economic divisions of the districts support the farmer s (Nghiem 2006).
4.5 Economics of agriculture in Da Nang

Basically, it is difficult to quantify the total number of people involved in urban agriculture in Da Nang. In 2011, 38,000 people were working in agriculture, but I hypothesize that more people are working in agriculture, but probably in addition to another job or are retired citizens. For most of the urban farmers agriculture is a side job, just a few earn their total income from agriculture. The majority of farming activities are conducted by private farms and not by state owned farms. The gross output of state owned farms is 4,762 Mill. VND and for non-state owned farms 2,612,040 Mill. VND in 2011. For instance in Hai Chau: 1,000 people are working according to the local farmer association in urban agriculture. Especially senior citizens are employed in urban agriculture and earn an income from it. The income ranges from 1 Mill. VND per month for vegetables or rice cultivation and 2-3 Mill. VND per month for growing mushroom (Economic Division, Ngu Hanh Son District).

According to the Center for Extension of Fishery – Agriculture – Forestry the average income for a person is 1,000 USD (21.32 Mill. VND) per year in Da Nang. Compared to other farmers in Vietnam it is quite high. A farmer in the Mekong delta focusing on rice cultivation earns 529 USD per year (Thanh 2011). The gross output from agriculture rose from 285,576 Mill. VND in 2007 to 974,546 Mill. VND in 2011. This is a 3.5 fold increase and is very likely a result of Da Nang urban farmers changed their strategy recently and switched from staple crops like paddy rice and corn to more valuable crops like vegetables, mushrooms or ornamental plants, since these products make more profit. Da Nang farmers are cultivating their crops the whole year round and plant in several cycles. E.g. rice is cultivated and harvested two times per year. The farmers sell the products directly or through market vendors on the markets or streets in the inner city (figure 12). Customers also visit the farm and buy the products there. Many people also cultivated crops for self-subsistence and if the produced amount is exceeding their own needs, they sell it to the neighbors or relatives. Many varieties of vegetables need a short period to be ready for harvest (from few days to a few weeks) and can be provided throughout the year.

To stock retail and whole sale industry is difficult, since those market actors demand large quantities, which small farmer households cannot deliver. But in Vietnam supermarkets are not as important as in other countries in Asia like Thailand for food distribution (Moustier et al. 2010) and street markets are still very important.
Due to the rapid urbanization in the city, available land for UA is decreasing and is besides the limited financial means for UA activities the main constraint of agriculture in Da Nang. Farmers grow their crops on official agricultural land on abandoned and empty land within the city. This practice is tolerated by the authorities, but the farmers have no legal security.

4.6 Plant pathogen and pest management

The main threats farmers are facing in Da Nang are rodents, such as rats and mice, snails, insects and worms in rice; Insects, like leaf miners (Liriomyza spp.), virus diseases and worms in vegetables; Rats, wood miner worms and insect larvae in corn. In addition to common pesticides, farmers also apply alternative control measures, such as traps for rodents and snails, ducks as antagonist of snails. Farmers also try to combat pests and pathogens according to the integrated pest management (IPM)⁴ and the Agency for Cultivation and Plant Protection is promoting this approach and offers training for it (see section below about extension services in the city).

Nonetheless pesticides are a common method to protect the crop plant. The utilization of pesticides bears risks for user, consumer and environment. Pesticides are available in shops and the markets. The Agency for Cultivation and Plant Protection sets a high value to care for a proper and safe application of pesticides. Shops which offer pesticides are obliged to attend

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⁴: means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (source FAO).
Trainings about pesticides. There are also training opportunities for farmer groups or individuals in the wards, and according to the Agency for Cultivation and Plant Protection many farmers are attending, except among senior citizens the participation rate is lower. If the farmers have problems to get rid of a certain disease or pest, they can contact the Agency for Cultivation and Plant Protection to ask for advice. Employees from this agency visit then the farm and helps the farmer to identify the problem and also consult how to overcome it.

Across the city collection bins for empty pesticide containers are distributed, but not everywhere is an occasion to dispose them properly. The collected containers are collected by URENCO and incinerated.

4.7 What kind of crops are mainly cultivated

Urban agriculture is, as mentioned before, decreasing in Da Nang in context of the area occupied by agriculture. However, the variety of agricultural goods produced in Da Nang is wide. According to different stakeholders, there is a change in the crop choice. Although rice is still the dominating crop with 34,440 tons in 2011 in Da Nang, but recently high value crops like ornamental plants, vegetables, mushrooms and flowers are replacing rice more and more. The profit from these alternative crops is higher than from rice. The planted area with rice decreased from 8003 ha in 2005 to 6,426 ha in 2011. Simultaneously the area occupied by vegetables decreased also from 2,257 ha (2005) to 1,005 ha (2011). This data is contradictory to the opinion of representatives of different state organizations mentioned above, but as mentioned before not only officially agricultural declared land is used for agriculture, but also random unoccupied land and rooftop gardens are used for crop production and these areas are not included in the official data set.

Table 8  Area occupied by different crop species (Statistical Yearbook of Da Nang 2011)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in ha</th>
<th>Production in tons in 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>6426</td>
<td>34440</td>
</tr>
<tr>
<td>Maize</td>
<td>786</td>
<td>4424</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>429</td>
<td>2613</td>
</tr>
<tr>
<td>Cassava</td>
<td>276</td>
<td>1839</td>
</tr>
<tr>
<td>Vegetables</td>
<td>1005</td>
<td>19244</td>
</tr>
<tr>
<td>Beans</td>
<td>253</td>
<td>182</td>
</tr>
<tr>
<td>Peanut</td>
<td>704</td>
<td>12213</td>
</tr>
<tr>
<td>Sesame</td>
<td>297</td>
<td>155</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>339</td>
<td>13560</td>
</tr>
<tr>
<td>Tobacco</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>other annual crops</td>
<td>225</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10758</td>
<td></td>
</tr>
</tbody>
</table>
In addition to the species mentioned above other crops are cultivated in Da Nang, but apparently on a smaller scale:
- All kind of vegetables, especially leafy vegetables
- Flowers and ornamental plants, bonsai
- Mushrooms (see Figure 13)
- Fruits (coconut, cashew nuts...)

Figure 13 Mushroom cultivation at Mr. Ri’s farm, the chairman of Dong Thuan Cooperative, in Lien Chieu

4.7.1 Livestock

Except for one urban district, Lien Chieu and Hoa Vang livestock is banned from Da Nang. It is forbidden to rear livestock in the city, due to environmental issues. Besides these two districts, in some parts, in the peri-urban areas of Da Nang livestock production is also conducted, but just small scale, as shown in table 9. The majority of farm animals are in Lien Chieu and Hoa Vang district.
Table 9 Number of buffaloes, cattle, and pigs in Da Nang and its districts in 2011 (Statistical Yearbook of Da Nang 2011)

<table>
<thead>
<tr>
<th>District</th>
<th>Buffalo</th>
<th>Cattle</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>2040</td>
<td>12194</td>
<td>58568</td>
</tr>
<tr>
<td>Hai Chau</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Than Khe</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Son Tra</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ngu Hanh Son</td>
<td>49</td>
<td>654</td>
<td>5591</td>
</tr>
<tr>
<td>Lien Chieu</td>
<td>30</td>
<td>2321</td>
<td>2620</td>
</tr>
<tr>
<td>Cam Le</td>
<td>21</td>
<td>362</td>
<td>1388</td>
</tr>
<tr>
<td>Hoa Vang</td>
<td>1940</td>
<td>8857</td>
<td>48969</td>
</tr>
</tbody>
</table>

458.566 chicken are kept in Da Nang in 2011. Moreover people raise chicken across the city but just on a small scale and for own consumption. Da Nang’s farmers use the faeces of their farm animals as fertilizer for their crop plants and reuse the nutrients, contained in the dung, sustainably. According Center for Extension of Fishery – Agriculture – Forestry, it is planned to increase livestock production in Da Nang.

Figure 14 Cattle in Lien Chieu district
4.8 Fertilizer and chemicals used in urban agriculture

Many different types of fertilizer are used in Da Nang for urban agriculture. All fertilizer which are offered for sale, have to fulfil VN quality regulations. I could not get any data about the ratio of organic and inorganic fertilizers, but many farmers produce crops according to VietGAP standards and therefore prefer organic fertilizer for their crops.

The following types of fertilizers are used in Da Nang:
- N-P-K fertilizer (mineral)
- organic fertilizer:
  ✓ animal manure
  ✓ mushroom and crop residues
  ✓ sewage sludge
  ✓ human urine and struvite (Adachi n.d.)

According to the Center for Extension of Fishery – Agriculture - Forestry, there was a factory in the city which converted sewage sludge into fertilizer, but this factory was shut down. 20 years ago humid sewage sludge from septic tanks was a common fertilizer source, which was unprocessed applied, in Da Nang. Sewage sludge is still used for fertilizing in Da Nang nowadays, but it is dried and filled in bags. The price is as high as for other common available fertilizer types. According to the Center for Extension of Fishery-Agriculture-Forestry and Economic Division of Ngu Hanh Son district, the current used sludge is produced in Northern Vietnam and also Quang Nam province (south of the city).

Organic waste
According to Ngoc Phuong a prior GIZ project, dealing with the transformation of organic waste in fertilizer, failed due to too high transport costs for the collecting organic waste from households.
Japanese investors also tried to launch an organic waste fertilizer project in Da Nang, but a project never started. Reason for this was a too high price of organic fertilizer production and it could not compete with other kinds of fertilizers available on the market.

All different kind of fertilizers are sold in shops, from producers directly to farmers or farmers produce it themselves, like Mr. Ri in Lien Chieu district (see Figure 15). He uses the residues from mushrooms and prepares fertilizer for his crops (mushrooms, ornamental plant and different vegetables).

5 REAGULATION ON FERTILIZER PRODUCTION, TRADING AND USE (Promulgated together with the Agriculture and Rural Development Minister’s Circular No. 36/ 2010HT-BNNPTNT of June 24, 2010)
Current state using of by-products

Nowadays the by-products of waste water treatment process and solid waste treatment are not exploited. But based on the information I got from a representative of the Department of Natural Resources and Environment (DoNRE), the city authority wants to enhance the recycling rate of urban wastes in order to become an environmental friendly city in 2020. To reach this goal, the city needs to recycle 70 % of the total waste amount. People of Da Nang should be encouraged to produce their own organic fertilizer. Alongside with fertilizer, biogas should be used for energy production in future.

4.9 Advisory service

In Da Nang there are two declared extension services:
- The Agency for Cultivation and Plant Protection
- Center for Extension of Fishery-Agriculture-Forestry

Moreover, farmer association and cooperatives in the wards support farmers also in a similar way, but not on the same scale than the two institutions mentioned above. Farmer association cooperates with center for extension, but makes just administration
Center for Extension of Fishery-Agriculture-Forestry

The Center for Extension of Fishery-Agriculture-Forestry, a subunit of DARD provides a couple of services for farmers. Especially trainings and technology transfer are main activities. Besides introducing new technologies to the farmers, it also tests new agricultural technologies in field trials and demonstration events. Furthermore the center provides farmers with new crop varieties (seeds and seedlings). If, for instance, a fertilizer company launches a new type of fertilizer, they cooperate with the center to inform and train the farmers about the new product. Additionally the center will test the product on demonstration fields and compare it to on the market established products.

Trainings offered by the center are to the following topics:
- new technologies
- livestock
- new VietGAP standards
- crop production

Agency for Cultivation and Plant Protection

The Agency for Cultivation and Plant Protection, a subdivision of DARD, supports farmers in the regard of plant health and protection. This agency supports Da Nang’s farmers in different ways: The offer a wide range of different trainings for farmers and other stakeholders in the following topics: IPM, ICM, pesticides application, introduction to produce clean vegetables with VietGAP standards, safe production, technology transfer.

It is a nexus between farmers and industry in terms of technology transfer. That means they support farmer to apply a new technology (fertilizer, seeds...), they have demonstration fields to compare old and novel technologies practically. Farmers can observe these fields and be convinced about the difference between new and old technology.

They assist farmers to get a VietGAP standard certificate and certificate with safe production and sanitation (VSATTP).

They monitor regularly the crops, especially rice fields, across the city and test for pollution and contamination by sampling plant tissues from farmer’s fields. The center also provides forecasts and inform farmers whether farmers should treat their crops with measures against pests and pathogens. If the crops are already infected they support farmers with advice and other services. Furthermore the regularly make field visits to check the condition and pathogen and pest infection level of the crop plants and advice farmers if they have to set actions.
4.9.1 Promotion mechanisms

Several governmental organizations on different levels (ward, district and support urban farmers in different ways. Farmers, who grow rice get a compensation of 500.000 VND per hectare.
To a certain extent the government issues credits for farmers (see section Credit Support Service) in cooperation with. They provide Economic divisions consult and support the District’s People’s Committee (PC) in regard of urban agriculture. E.g. that PC should buy seeds for farmers and the water for irrigation is free of charge. Furthermore public land is mostly free of charge or a very small fee is demanded.

4.9.2 Credit service support

Government

A small ratio of credits is issued from the country and city government. According to the Center for Extension of Fishery-Agriculture-Forestry, credits are allowed for farming equipment. A prerequisite is that the equipment is produced domestically in Vietnam. But this is not always possible. In the first three years there is no interest rate and from the fourth year on a very small interest rate. Households can apply to the government directly or via a farmer or woman association.

Vietnam Bank for Agriculture and Rural Development – Agribank

The Agribank is the biggest commercial bank in Vietnam in terms of capital, assets, workforce, operating network and customer base. It is state owned and along with commercial banking activities, the bank sets a high value on investment for the agricultural sector and rural areas by providing medium and long-term loans for infrastructure development, particularly agriculture, fishery, forestry, contributing to the cause of industrialization and modernization of agriculture and rural development.

90% of customers are small and medium sized enterprises, including agricultural related businesses. The Agribank is the Vietnam’s biggest credit grantor and issue 95% of credits for farmers in the country.
Average credit size is 50.000.000 VND for short term periods and 150.000.000 VND for long term credits. The credits are mainly used for construction purpose, equipment.... The interest rates are for small credits 7% and for medium and large credit amounts 8-9%. Requirements to get a credit granted are a good proposal, financial and professional competence, asset of at least 50.000.000 to assess. Single farmer and farmer cooperatives can apply for a credit, but not farmer associations. According to Mr Doan Phuc, vice director of the Agribank in Da Nang, the demand for farmer credits can be satisfied by the Agribank. 15% of credit issued by the bank are issued for farmers.
4.10 Urban agriculture as tourist attraction

La Huong Eco tourism
La Huong is a 4 ha vegetable growing site in Cam Le district, Hoa Tho Dong Ward, and is managed by a cooperative. A large variety of vegetables is grown in La Huong including spinach, lettuce, broccoli, etc. in abidance by the VietGAP standards. The site is well equipped with electricity and an irrigation system, pumps and channels. The water for irrigation origins from the neighboring Cam Le River. The funding for this infrastructure was from the Asian Development Bank (ADB) and the city authority.


According to the ED of Cam Le district, it is planned to promote La Huong as a tourist attraction and educational center in regards of agriculture in 2015. Simultaneously an extension from 4 to 10 ha of the area is planned.
There are no detailed plans available and apparently even the representatives of the ED and the Extension Center for Agriculture, Fishery and Forestry do not know details about this project, but it is approved by the city government.
Figure 16 La Huong Vegetable growing site in Cam Le district

Probably, it is similar to the tourism activities in context of agriculture and fishery in Hoi An, where tourist can spend a day with local farmers and put hands on in order to experience the farm life of traditional Vietnamese farmers like in Hoi An (http://jacktranecotourshoian.com/#). Advantageous would be the proximity of La Huong to many tourist resorts of Da Nang.
5 Discussion

5.1 Perspectives of urban agriculture

Nowadays urban agriculture is a global issue in developing and developed world. Alongside with the supply of fresh food in the city, it is an important source of income for many city dwellers. Globally, it occupies around 6% of the world’s total cropland, which is almost two times the total area of Germany.

There are two major changes affecting urban agriculture in Da Nang:

1.) Crop change
During all my interviews with different stakeholders and site visits, the statements were in agreement of all: There is a change from growing stable crops like rice to crops, which bring a higher profit such as ornamental plants, mushrooms, vegetables and flowers. Resulting in higher income for farmers and a supply with a large variety of fresh and local products for the population. This is also perceivable, when one is comparing the gross output from agriculture in the years 2005 and 2011. The gain was 3.5 fold during this period.

2.) Access to land

From 1979 to 2009 the area occupied by agriculture decreased by 4,800 hectares in Da Nang. As in many cities, the limited access to land for farming is besides financial means the main problems for Da Nang’s urban farmers. This trend is probably continuing in the future since the population increase and expansion of urban areas are forecasted in the near future.

Urban agriculture offers the chance to use public land or other empty land, which has no other function, in a meaningful way. People who use this land for agricultural activities are facing problems, since nobody can assure the using period until this area is addressed for other purposes. Urban farmers are not willing to invest on this land and can just plan for the short term, because of the missing legal security for their investments on these areas. By losing the right to use public areas people also might became unemployment or their salary is reduced, if they have not another job or another land for cultivation.

There are no indicators that urban agriculture is taking place close or within former industry zones, but I cannot totally exclude it.

Nonetheless, in a city a variety of pollutants - found in the city’s air, water, and soil - can impair its agriculture production and its consumers. In my opinion, the solution of this danger is not suspending agriculture from the urban areas. Instead it should be the goal to reduce or even to eliminate these menaces. Frankly spoken, this is highly ambitious, but should be feasible. In the framework of this GIZ-project it is planned to bring the waste water treatment up to date, by initiating a pilot project. In this pilot project, a modern vacuum sewer system in Son Tra.
Peninsula will be installed for 110 households and should demonstrate a sustainable wastewater management. This is a small, but in my opinion, very important step for Da Nang to become an environmental-friendly city. In the long term the proper treatment of waste water contributes to make it to an important and clean water source for agriculture and other sectors. In the same manner a better solid waste management. The majority of organic solid wastes together with other solid wastes are disposed on Khanh Son landfill. Organic waste could be exploited for energy and fertilizer production.

Besides these modernization steps which indirectly or directly influences urban agriculture, a proper, precise and ongoing quality monitoring of Da Nang’s air, soils, water, wastes and the resulting by-products for reuse is necessary to ensure the quality of the agricultural products and wellbeing of the population.

Areas of the city which face a very high environmental pollution should be identified and countermeasures should be taken. These countermeasures can range from the try to improve the local conditions, restrict cultivation (limitation of crop choice, cultivation practices...) or even exclude the area from production, depending on the intensity of the hazard.

In addition to a proper and safe production, the post-harvest management of products is crucial. Poor transport, storage and handling conditions can contaminate, what has been a produced safe. Not only producers also consumer must be sensitized about food security (Orsini et al. 2013). The ability to have and enable a safe agricultural production and at the same time a sufficient and efficient waste water and waste management in Da Nang will be a major challenge for the next years in order to make it to an environment-friendly city.

The city of Da Nang supports the local population in different ways and tries to promote a sustainable and clean production of food as described above. Worth mentioning is that the local authorities endorse the circumvention of pesticide application and also want to enhance the use of organic fertilizer, which is apparently challenging for the authorities due to financial issues. But hopefully in the near future sufficient financial resources and the intention to reach this goal are present. Moreover, the authorities set a high value to the promotion of the VietGAP standards in agriculture, the performance of this certification requires many efforts and the compliance of many restrictions for the producers in order to offer a clean and valuable product for the consumers.

If urban agriculture is conducted on the rooftop, terraces and balconies of buildings, it can account positively for a building’s energy consumption and its climate control. Furthermore a garden on a building delay run-off and reduce the run-off rate and volume of rainwater. These characteristics are important for the storm water management strategies in bigger cities. The cultivation of plants on buildings and as well on empty land enlarges the green area in Da Nang and can improve the city’s climate and atmosphere positively (Liu, 2002) and help to make Da Nang to a more environmental city. Such gardens have several benefits besides and should be promoted in Da Nang.
5.2 Perspective of using by-products for urban agriculture

Recycling of by-products from the waste water and solid waste treatment is a desirable and efficient method to tackle these so called “wastes”, which, according to the current state of knowledge, should be considered as potential valuable resources for agriculture and other sectors. In Da Nang by-products are already in use, but apparently just on a low level. To enhance this ratio, preparations are required. A precise data collection should be conducted to figure out whether the local community would accept and buy such fertilizers. Additionally, it should be in the same price range as competing fertilizers on the market already available, otherwise the project will not succeed.

70% of the solid waste and 25% of the waste water in Da Nang should be recirculated in order to become an “environmental-friendly city by 2020”. To fulfil this resolution the utilization of by-products is inevitable.

**Organic waste**

Many different solutions are available and implemented in cities to do so. These models are differing in terms of:

- Costs
- Private or public responsibility
- Technical solution
- Small or large scale
- Participation rate of local population

Some city authorities combine two methods simultaneously. Like Bangkok, which on the one hand has facilities to produce fertilizer out of sewage sludge and organic waste and on the other hand, involves the local people. In detail, people have the chance to learn the methods how to prepare their own homemade compost out of their household organic wastes in workshops offered by the city administration. Additionally, organic waste is on industrial level manufactured.

However, many cities failed to introduce a functional organic fertilizer, independently whether on community level or professional level. Therefore a proper and detailed planning and preparation is essential to succeed as explained in chapter 2. Many projects failed due to a missing evaluation prior establishing such projects.

An important prerequisite to ensure a high quality fertilizer without pollutants is early source separation of solid wastes. The dilution of organic wastes with other solid wastes should be circumvented.

75% of Da Nang’s total waste amount is organic.

In my opinion, three options for using organic waste as feedstock for fertilizer production are reasonable in Da Nang:

1 **Community based**
   
   A similar approach as in Bangkok could be a solution: Trainings and workshops should be offered
to the local people. They should learn how to reuse the organic waste as resource and collect, store, process and apply it as fertilizer independently from the city authority and the extension services. Furthermore, people should be informed about the effect of organic waste as fertilizer and the importance of waste separation and avoidance. The city just provides the training. Important is that organic waste is that separated from other wastes. Main resources needed to establish this project are the organizing of trainings and information material.

This approach does not cause high costs for the city, compared to building up composting facilities. Additionally, the price of this fertilizer is not as important as for a composting facility, since people produce it on their own and no big investments are necessary. It is difficult to quantify the characteristics of such approach and more data have to be collected to get an overview.

Data should be collected about:

- The potential participation rate (not all inhabitants can and want to participate in the project)
- The reduced waste volume
- The costs and efforts of the project

2 composting facility/facilities managed by the city administration/URENCO

One centralized or several decentralized compost facilities should be constructed in the city.

Decentralized approach reduces transport costs of the organic waste, but free areas, although small, distributed across the target are necessary to build up these facilities. These areas required can be small and should be easily accessible for bringing the organic waste there. As described in chapter 2, an attempt to use organic waste for fertilizing purposes failed in Da Nang, due to high transportation costs. Nonetheless, the construction of decentralized compost facilities is a cheap method and major inputs are manpower, few infrastructure and the land for the sites.

A centralized composting facility could be an alternative option, although it requires more funding than a decentralized facility.

If biogas production is also part of the organic waste management, the leachate can also be used as fertilizer like the solid phase..

3 a combination of options 1 and 2

Sewage sludge

Sewage sludge may contain harmful compounds, and therefore land application is not the best choice to reuse it. In my opinion, the waste water management of Da Nang should be developed further and the quality of the sludge should be monitored. If the sludge quality is good and the concentration of contaminants is low, an exploitation of sludge for fertilizing can be considered.

A way to use it independently of the quality is the extraction of the nutrients and the simultaneous degradation of pollutants. But this nutrient recovery method demands a facility to extract the nutrients and is very cost intensive.
Another approach could be the utilization of the sludge as fertilizer for plants, which accumulate less contaminants, or for non-food crops, like crops for energy production, as planned for solid wastes in Chiang Mai. The operator of the landfill plans to use the waste as fertilizer for forestry, but not the agricultural production of food.

**Waste water**

Da Nang is a growing city and supply with clean water is essential for the people, economy, agriculture and tourism. According to Hanjra et al. (2012), Vietnam is likely to become dependent on waste water use and also nowadays problems with the water supply occur in the dry season, therefore sufficient waste water treatment is an important measure to cope with a putative water shortage in future and to prevent ground water resources in the long term. In the short term, farmers should be enlight about the dangers for health and environment by using untreated waste water (see 2.4.1). If not all nutrients are removed from the treated waste water, the farmers should be informed, about advantages and disadvantages of this.

5.3 **Conclusions**

**Urban agriculture**

Although the area occupied by urban agriculture is decreasing, urban agriculture has an important role in Da Nang. It contributes significantly to the local food security, offers employment or an additional income for many of Da Nang’s people. When agricultural products are locally produced in vicinity of the consumers, energy for transport and storage can be reduced. This matters especially for products with a short shelf life, like leafy vegetables. In my opinion urban agriculture is very important for the city and can, if correctly conducted, contribute to the well-being of Da Nang’s population and the quality of life there. The fact that urban farmers, when growing high value crops, can earn a high income is important for Da Nang’s economy and employment.

**By products of waste water and waste processing**

The utilization of by-products makes sense for Da Nang to use its resources efficiently and sustainably, although further studies are essential to choose a proper solution. Organic waste and treated waste water should be exploited. Currently, the application of sewage sludge does not have a good reputation for using it as fertilizer, unless it is treated using sophisticated and expensive methods. Many concerns about organic and inorganic pollutants are found in literature.
The exploitation of the organic waste for other purposes than landfilling should be a target for Da Nang. Prior starting this, a deep in study, whether and how such an exploitation could be conducted is required.
Adachi, R., Feasibility and influence of urine use in agriculture in Danang City, Vietnam.


Dinh, Q., Thi Kim Ha, N. & Ma Song, N., 2013. Rapid Appraisal on Urban Agriculture in Da Nang City, Viet Nam, GIZ.


Erlbeck, R., 2013. Integrated Resource Management in Asian Cities: The Urban Nexus,


Mohr, M., 2014. Concept for wastewater treatment on Son Tra Peninsula (Da Nang, Vietnam).


Winpenny, J., Heinz, I. & Koo-Oshima, S., 2010. The wealth of waste: The economics of wastewater use in agriculture,
