



**Adama Science and Technology University (ASTU)**

**School of SMCME**

**Department of MSVE**



# **Research Project Final Report**

**Title of the Research Project:**

*Adaptation and technology transfer of Self-Watering Pots, in Adama City, as urban agriculture.*

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## Abstract

Meeting food demand in quantity and quality is a big issue, due to the ever-increasing population and environmental change. Indigenous farming (subsistence farming) is not in the position to meet food demands, both in rural and urban areas. Urbanization is expanding food requirements highly increased, so, the introduction of “Urban Agriculture”, in a simple way for the urban population is essential. Urban agriculture supports farm production as additional food sources, at household level increasing nutrition/balanced food/ decreasing malnutrition, creating jobs and increasing income, locally. Adaptation of vegetables is easy, inexpensive, needs small space and also a hobby. In order to minimize gardening spaces, frequency of watering, time and water consumption, the technology of **self-watering pots** is being introduced. A watering system is through the principle of capillarity and adhesion phenomenon, which is natural. The soil on which the plants are grown sucks water up from the source to the roots of a plant, as required, naturally. As the processes, only about one-tenth of the portion of soil being used is exposed to the water body, through the sieves like fabricated sheet metal, (fig. 1 and 2). The construction watering system designed in such a way that it services different pots at a time. Two categories of planting systems proposed for the experiment; pots and ground. In experimental design, carrot, tomatoes, and pepper were planted in self-watering pots and at the same time, similar vegetables were replicated on the ground, to be treated separately under similar conditions. Qualitatively (using a bar graph and from observation) the advantages of pot application over the ground very obvious. Through standard analysis, using ANOVA variant analysis, the significance is not contrastable (tab. 6 and 7), considering the standard significance level, 0.05, especially on areas and water consumption respectively. It can be anticipated that a long term data collection and analysis required underlining the significance using ANOVA. In general, it can be concluded that watering pots have more advantages than those on the ground in terms of water consumption, time, and space and weeds control.

## Keywords

Urban agriculture, Food security, Poverty, Nutrition, Self-watering pots, Capillarity, Adhesion.

## **Acknowledgments**

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## **1. Introduction**

### **1.1. Background**

Ethiopia is still one of those countries in the world that face the highest rates of child malnutrition. Today meeting the food demand in quantity and quality is a big issue, due to the increase of population and environmental change. Indigenous farming (subsistence farming) is not in the position to meet food demands, both in rural and urban areas. Urbanization is expanding food requirements highly increased, so, the introduction of “Urban Agriculture”, in a simple way for the urban population is essential. Moreover, highly selective and restricted food consumption habit practicing in Ethiopia aggravates the problem more and more. Many survey reports indicated that there are a variety of foods items that are not being fully exploited in fighting against hunger in many parts of Ethiopia. In addition to the dietary benefits, vegetable at home garden production and development also offers

employment opportunities, particularly for both urban and rural women, to provide more income than staple crops per unit of land. These food items grow quickly, so they providing a fast response to emergent needs for year-round food supply. The production costs of such items are cheap, availability at the door-step, adaptability to household needs and support rural and urban economics in limited space, in a sustainable way. In general, it is strongly believed that vegetable food plants should be considered as a serious issue when developing strategies to fight rural and urban food security in Ethiopia. Therefore, year-round production and consumption of these crops are the most sustainable way of reducing and controlling poverty and micronutrient deficiencies in urban and rural poor communities and can be additional income when seriously adapted to the community.

### **1.2. Statements of the problems**

Urbanization and food requirement is directly proportional. As urbanization fast grows food demands also increase.

Additional food or income is inevitably required to compensate food shortage at the household level. The exercise of

“Urban Agriculture”, in a simple way for the urban population is one of the best options. In addition, the available food in quantity and quality is poor in urban areas. The knowledge and culture of using such

technology are still at a low level or totally not started. That is why the introduction of Self-Watering Pot is essential as the technology is simple and easy to adopt, which is not yet practiced in our region

### 1.3. Objectives

General:

- Design, fabrication, and adaptation of **Self-watering pots**, to grow different vegetables; as part of food security.

Specific:

- Design and manufacture different **self-watering pots** to grow different vegetables

- Develop different parameters and collect data in adaptation processes of different vegetables
- Set the adaptability parameters and identify suitable vegetables to the areas
- Select the best variants to be used by the community and produce the manual to be used in adaptation

### !4. Significance

The gained results from the conducted research project indicate the viability of the application of the technology of Self-Watering pot in and around Adama city is enormous and justifies the developments of Urban agriculture. It includes:

- Solution provision to solve the shortage of food, partially at a household level easily;
- Skill, adaptability and technology transfer in small scale;
- Support balance nutrition/diet at the household level

## 1. Literature Review

### 2.1. General approaches

One distinction that is often made in the literature refers to the extent to which urban households that engage in agriculture have some degree of market orientation or are purely producing agricultural goods for their own consumption. Similarly, the current population of Ethiopia is expected to rise within a short period of time and those living in the cities are continuously increasing faster. It is apparent that people are suffering from a lack of vitamins and essential minerals, mostly children. Every year, on average, about five million people have problems securing enough food for them and need assistance, due to drought. It is obvious that in Ethiopia there is no shortage of food as long as the rural population has not been affected by drought. It is, however paradoxical, that still all the time (draught or not), they are suffering from low dietary values of similar food staff. To overcome such shortages of food and increase its value at a household level, small scale gardening has vast potential. Vegetables, which can be easily adopted at a household level, are an inexpensive and accessible source of essential nutrients for the urban and rural

population in Ethiopia where the people experience malnutrition due to heavy dependence on cereals such as teff, which need more land, labor and needs more resources input and has limited dietary source. In order to minimize gardening spaces and water consumption, the technology of using self-watering pots is to be mainly considered, which helps to grow healthier vegetables easily. Any container (used cans, plastic, paintings, oil, food staff and etc) can be used for these purposes. Used water can be recycled (used) for the purposes of watering the vegetables through a self-watering pot. Therefore, this research project is to be conducted controlling all inputs, i.e. soil, compost (organic fertilizer), water (including used), sun-lights, cultivating processes, duration, amount and applications of seeds, nursery, seedling transplanting, processes and etc. To sustain urban agriculture the technology of seed saving and commercializing the products can be introduced aligned with food supply and environmental protection. It has to be highlighted that Agricultural activity will continue to be a strong contributor to urban households .

## 2.2. Theoretical background

The history of *Self-Watering Pots* starts from natural phenomena, **capillarity and adhesion** processes, (1 and 8). The rise of **water** in a thin tube inserted in **water** is caused by forces of attraction between the molecules of **water** and the glass walls and among the molecules of **water** themselves. Adhesion of water to the walls of a vessel will cause an upward force on the liquid at the edges and result in a meniscus which turns upward. **Capillary action** occurs when the adhesion to the walls is stronger than the cohesive forces between the liquid molecules, (7). It is the movement of a liquid through or along with another material against an opposing force, such as gravity. ... Examples of **capillary action** in water include water moving up a straw or glass tube, moving through a paper or cloth towel, moving through a plant, and tears moving through tear ducts, (4, and 6).

The phenomenon of **capillarity** also occurs in the **soil**, in the same way,

that **water** moves upwards through a tube against the force of gravity; **water** moves upwards through **soil** pores or the spaces between **soil** particles. As a result, the smaller the **soil** pores, the higher the **capillary** rise, (2 and 3). Capillary-driven liquid flow is the main transport mechanism in the soil system of which the water rises from a lower elevation to higher elevation. Such capillary rise phenomena lead to serve the plant roots, based on the requirements of water. Therefore plants take advantage of water's stickiness to organic tissues and soil, so the **capillary action** and the movement of the water occurs through the **plant**, when the adhesion is stronger than the cohesion, as actually water molecules are naturally attracted to each other, (8). The level in the loam may rise and drop but usually stabilizes very close to the water level in the tube containing clayey **soil**. Clayey soil has the highest capillarity, followed by loamy and sandy soil, (5 and 9).

### 3. Methodology

#### 3.1. Experimental Site

The experimental site situated in Adama city, which is about 100 km from Addis Ababa, east, specifically, right in Adama Science and Technology University campus. The experimental site equipped with all Promotion of easily manageable small-scale household cultivation to secure, partially, healthy food is one of the best options. It is, therefore, essential to direct small resources and indigenous knowledge to introduce manageable gardens at an urban household level, where space and water are limited. Moreover, growing plants need frequent follow-up so time-consuming practices. To minimize such extra activities, save resources and time, **self-watering pots** are introduced mainly to grow healthier vegetables easily, at a household level. Any container (cans, plastic, PBC etc) can be used for the purposes. **Self-watering pots** have magic processes and different from ordinary pots to grow plants. Plants in **ordinary pots** that are exposed to hot sunny weather

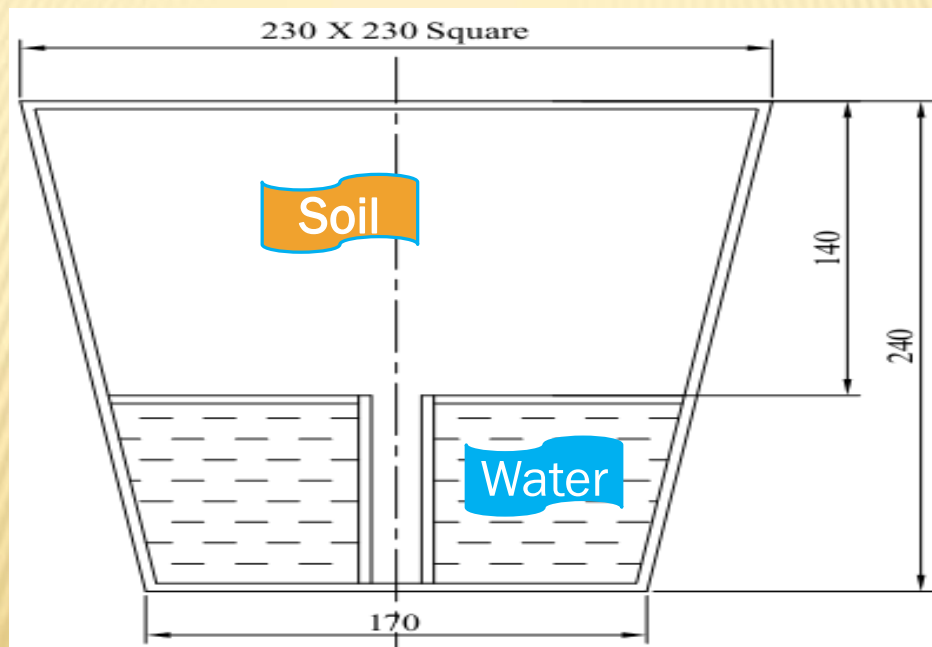
necessary materials, such as water containers, different pots with different sizes, shelter and facilities to take and record experimental data.

#### 3.2. Design and fabrication

without regular access to water can quickly dry out and become unhealthy. **Self-watering pots** are an affordable solution that provides a slow release of water to the plants as they need it. Frequent follow-up, watering day today and space is, therefore, drastically lowered.

All the designs for different pots and mechanical works like drilling, grinding, soldering and bending, installations, fittings of water pipes, etc were done mostly at Adama Science and Technology University, (ASTU).

As the construction materials, locally made, different plastic pots (for flowers and decorations) PBC tube, sheet metal, (fig), that could be fitted to require sizes and dimensions were used.



**Fig. 1. Square and tapered pot adapted to self watering**

In the modification, construction, assembly, and fitting accessory to conduct the research, the procedure being used include some steps. The following main steps are based on the stating hypothesis, the functionality of the natural phenomenon for this particular way of growing plants, which is to be proved.

**First step: surveying;**

**Identify and facilitate accessible research areas:** the research site has to be identified in the ASTU campus. All necessary

infrastructures, like fencing, collection and preparation of soil, suitable for plants (seedbed preparation) shall have been made.

**Second step:**

**Design, procurement of materials, fabrication (fig1-5):**

designing and design parameters of the self-watering planters have to be fixed. Based on the design parameters, the items required shall be procured. Manufacturing and fabrication have to be then done,

based on the parameters provided. All necessary preconditions shall be prepared to prepare seedbed inside the self-watering planter, to

make them ready to plant. In planting different vegetable seeds (in-group) have to be considered



**Fig. 2. Round and Square and tapered pot adapted to self watering pots**



**Fig. 3. Square and tapered pot adapted to self watering pots**



**Fig. 4. Round and tapered pot adapted to self watering pots**

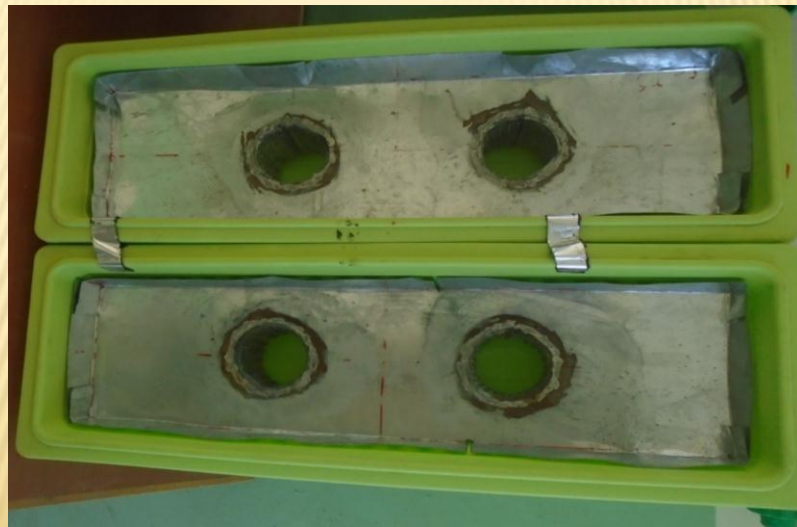


Fig. 5. Four sided and tapered pot adapted to self watering pots

### Third step:

**Experimental Design & data collection:** designing the experiment to gather data, using appropriate data collection procedures to set in each group of self-watering pots. The experimental design facilitates to conduct an experiment, in real field situations, by building a coordinated program to share the results among each other and to build a database.

### Fourth step:

**Data analysis and Recommendation:** Data collected have to organized, systematically and analyses scientifically, so clear enough to give the real picture of the whole processes, being done during research activities and verify the best adaptable types (sorts) of vegetables to that particular area.

### 3.3.Data collection and analysis

#### 3.3.1. Data collection

There are two categories of vegetables on the testing site, i.e. in pots (fig. above) and ground, in a replicated manner. Soils for growing vegetables are similar and no extra investigation to verify its type, while it is beyond the scope of this experiment. Selected vegetables for these experiments were:

- Tomato
- Carrot
- Pepper

#### Parameters

- The capillarity and adhesion processes through the soil for self-watering (Self-watering pots):
  - Design, and measurements.

- Design and measurements
- Observation
- Water consumption in references to vegetables grown on the ground parallel to those in self-watering pots:
  - Observation and measurement
- Frequency of watering (interval and duration in both pots and on the ground):
  - Based on the temperature and water needs for plants.
- Spaces for growing similar vegetables (both pot and ground)
  - Observation,

**Table 1. Average data related to the area, mm<sup>2</sup>, through measurement,**

Plants	Pots	Ground
Tomato	350	300
Carrot	200	250
pepper	250	250

**Table 2. Data on Suitability/comfortability through exercise and observation**

Plants	Pots	ground
Tomato	Better	Not at all
Carrot	Much better	
pepper	Effective	

**Table 3. Data collection on watering frequency through observation.**

Plants	Average watering frequency in		Ratio
	Pots	ground	Ground Versus Pots
Tomato	Every 2 weeks	Every 4 days	4 times as much
Carrot	2.5 weeks	Every 3 days	7 times as much
pepper	2.5 weeks	Every 3 days	7 times as much

**Table 4. The average amount of water required and Temperature.**

Plants	Pots (average), liter/2 weeks	Ground (average), liter/4 days	Daily temperature (average), °c
Tomato	4	1	25
Carrot	1.5	1.5	
pepper	1.5	1.5	

**Table 5. Data collection on weeding through observation**

Plants	Weed control	
	Pots	ground
Tomato	Too little	Too much
Carrot		
pepper		

### 3.4.2.Data analysis

Data is collected and analyzed using two categories to compare and contrast growing vegetables, i.e. in pots and on the ground. Based on the parameters stated above, quantitatively Table 1 and Table 4 are used. Qualitative approaches (Table 2, Table 3 and Table 5) are mainly based on observations. For statistical data analysis, graphs,

specifically bar-graphs and ANOVA Two-way analysis of variance are used, tables, 6 and 7. as it is indicated above, Tables 1-5), namely:

- Table 1. Data related to the area,
- Table 2. Data on the Suitability,
- Table 3. Data on watering frequency,

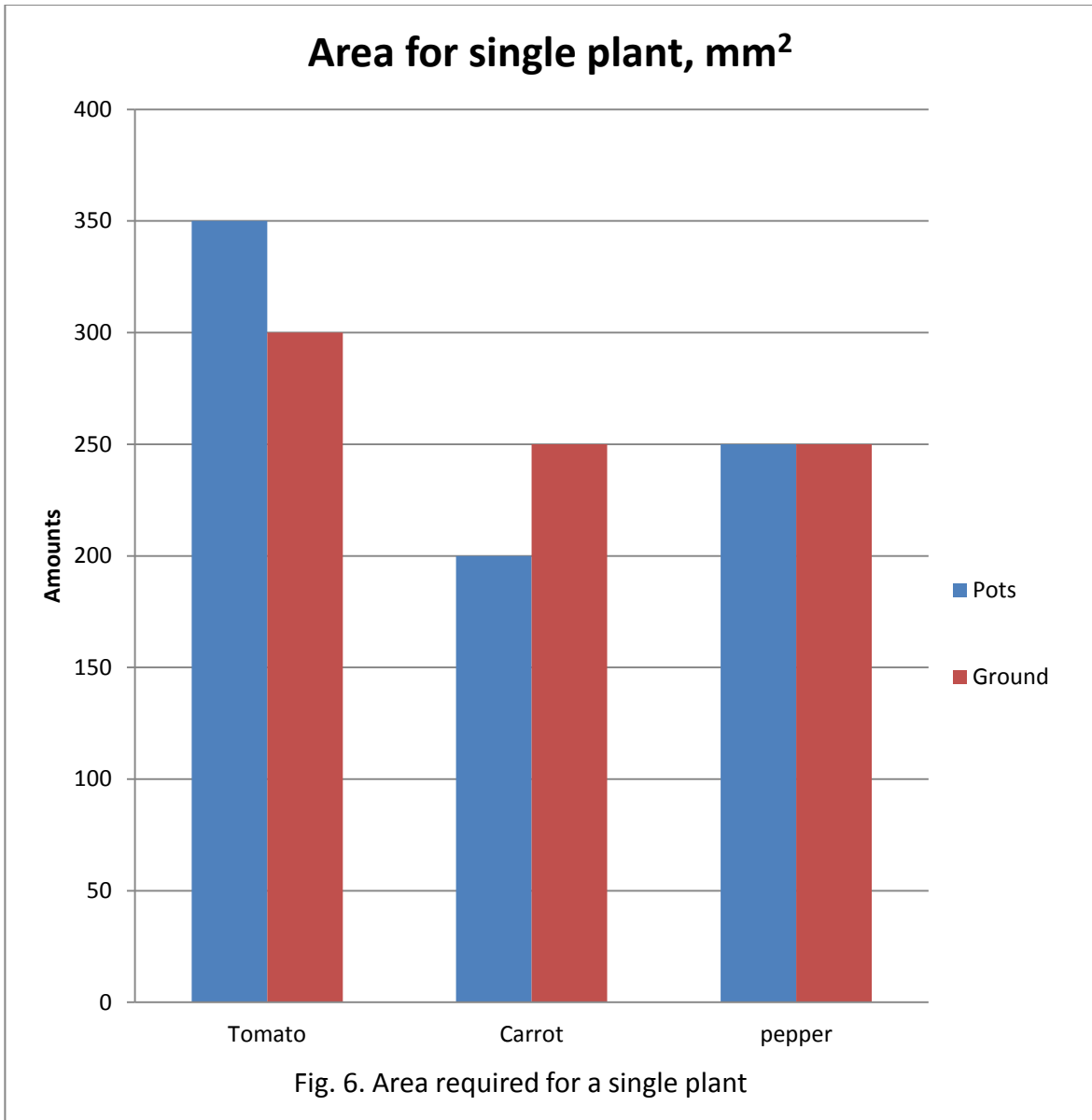
- Table 4. Data on water consumption and related temperature,
- Table 5. Data on weeding, each tabulation, and graphical support, the analysis indicates the comparison of the selected items, such as:
  - Amount of water
  - Weeds control

These are the main focus areas explored and to be considered to meet the requirement and sustain the implementation of the research results. In the analysis both graphical and ANOVA, variance analysis is used correspondingly, especially for the numerical data (quantitative data) collected. The rests are analyzed through narration, while the data are collected through observations.

In the case of the area covered by a single plant, table 1 (above), figures 6 and ANOVA table 6, below, there are

- Space
- Comfortability
- Frequency of watering

no such significant differences between pot and ground plant. **However, it has to be kept in mind that plants in a pot can be accommodated anywhere, one top of another on the shelves and etc.** According to both graphical, figure 6, and ANOVA table 6, the effect of pots and ground on area required not contrastive. So, as clearly indicated, especially in both graphical and two-ways ANOVA analysis, the variation among the plant in terms of the area required is insignificant, considering, the standard the significance level,  $\alpha=0.05$ .



**Table 6 ANOVA 1-Area for a single plant**

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Rows	10833.33	2	5416.667	4.333333	0.1875	19
Columns	1.82E-12	1	1.82E-12	1.46E-15	1	18.51282
Error	2500	2	1250			
Total	13333.33	5				

In suitability cases, table 2, above indicates that the pot plants are very easy to move from place to place because they have everything they required on their own. That makes the users more comfortable to look after the pot plants without much attention.

Today water consumption is very critical. As it is shown in table 3, above, the consumption of water was drastically reduced in pot plants. The average watering frequency is four times lower as compared to ground plants. It is directly related to time, in which the users water their plant every 2 weeks, while for pot plants every 4 days.

Table 4, above and ANOVA table analysis, corporate with figure 7 below indicates the water consumption related to local temperature. The water consumption in liters for ground plats is about four times as much as that of pot plants that can be observed from the graphical representation, below. However, still, the significance is not contrasted using ANOVA for the analysis. The reason behind it still remains on the lack of replications for some long time to come up with distinction and conclusion, regarding water consumption.

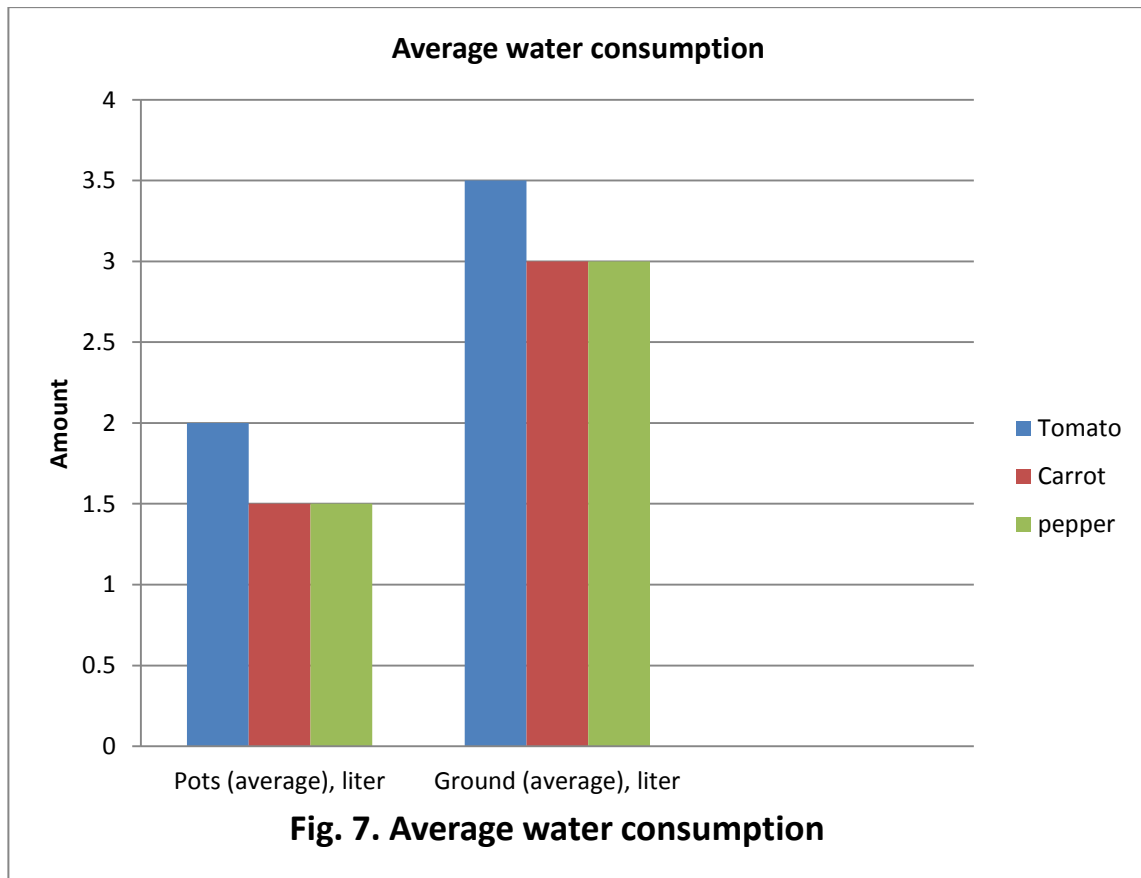
Lastly, the effects of weeds are not to be neglected. Most of the time weeds

**Table 7. ANOVA 2-Variation of water consumption per week**

are growing on the surface of the soil on their own, without seeding them. They need only moisture on the surface. In the case of plants grown on the ground the surface of the soil allows wet, so for the weeds is a very favorable condition to grow, while it is directly irrigated from the top, on the surface.

The reverse is the case in pot plants, there is no direct irrigation, instead, ;

indirectly. Through capillarity, water is only sucked up to the dried areas to balance nature, through the phenomenon of capillarity and adhesion processes. Therefore, the surface remains dry, which limits weeds to grow. Water consumption is done in both graphical and two-ways ANOVA analysis, as indicated below



<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
0.0	2.0	0.0	0.0	1.0	19.0
2.1	1.0	2.1	2.7	0.2	18.5
1.5	2.0	0.8			
3.6	5.0				

#### 4. Result and Discussion

The results were based on quantitative and qualitative data, collected as shown in tables 1-6 and figures 6 and 7, above. The results were restricted to space requirement, suitability for the users, water requirement and weed control.

Referring to tables (1 & 6) and figure 6, above the space required for each plant approximately specified. It is important because this technology is supposed to be applied in urban areas where the areas are restricted. As it is clearly indicated, there are no significant differences between pots and ground in terms of area requirements. Pot plant growing is still remained advantageous, while it can be accommodated anywhere and put pots over another using simple mechanisms or installation. It can be used even on the corridor upstairs in living rooms or houses. Regarding suitability, table 2, above is related to mobility. For post-plant possibilities are there to move from place to place and install, as required, based on weather conditions. Important is the watering frequency,

which is related to water consumption, labor and time. As is shown in table 3, above, the frequency of watering pot plants is 4 times less than that of ground. The amount of water is of course, measured every time for pot and ground plant, parallel to the watering frequency. Table 4 and figure 7, in which the water consumption very high. The loss of water in the pot through evaporation is minimized while in the case of the ground the evaporation of **water** from **soil** takes place almost entirely at the surface.

As clearly observed from the above data tables and figures, the functionality of pots on the principles of the natural law of capillarity and adhesions is possible. The capillarity and adhesion phenomenon entirely depends on types of soil, which is not considered for this research project. However, the theory suggests that soil grain pore size significantly contributes to a maximum capillary rise.

## 5. Conclusions and Recommendations

### 5.1. Conclusions

After the selection of the site, the shelter was constructed and areas for the pot organized. Designed and fabricated pots were installed according to their mechanisms. Pots were planted with selected vegetables, (tomato, carrot and pepper). Similarly, the same vegetable items were planted on the ground, right under the same shelter. The number of vegetables and their items was directly planted after nursery periods. After 7 days the plants in cases (pots and ground), started growing and data taking started. Based on the analysis of data collected, the following conclusions can be drawn:

- The approaches were based on the possibility of watering plants without human interference, naturally, on 3 selected vegetables. The natural phenomenon, Capillarity and adhesion have well worked, as it is already

### 5.2. Recommendation

Since the data to be collected highly governed by the natural phenomenon and the fluctuation of parameters varies with seasons. A long term database is recommended to quantify the results scientifically. Users' participatory dissemination is also required through the

assumed. Further replications and redesign might be required after application on the household level.

- This method of growing the plant at the household level is economically feasible and technically not complicated. To conclude the results as most a long time data collection res required. That is way in ANOVA analysis the contrast between pots and ground in terms of water consumption due to insignificant.
- The materials construction pots are not expensive, locally found and easily applicable at the household level, so the probability of sustainability is very strong.
- The analysis of soil, related to capillarity might be required to optimize the processes of capillarity and adhesion

extension of this research project to sustain among the end-users. Soil types and their parameters, in terms of plants and water consumptions, have to be considered to complete the overall situation of the application of pot plating.

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## Appendices

### A. Figure 8. Size of some selected pots external dimensions



Fig.1. Square papered pots (Pictures)

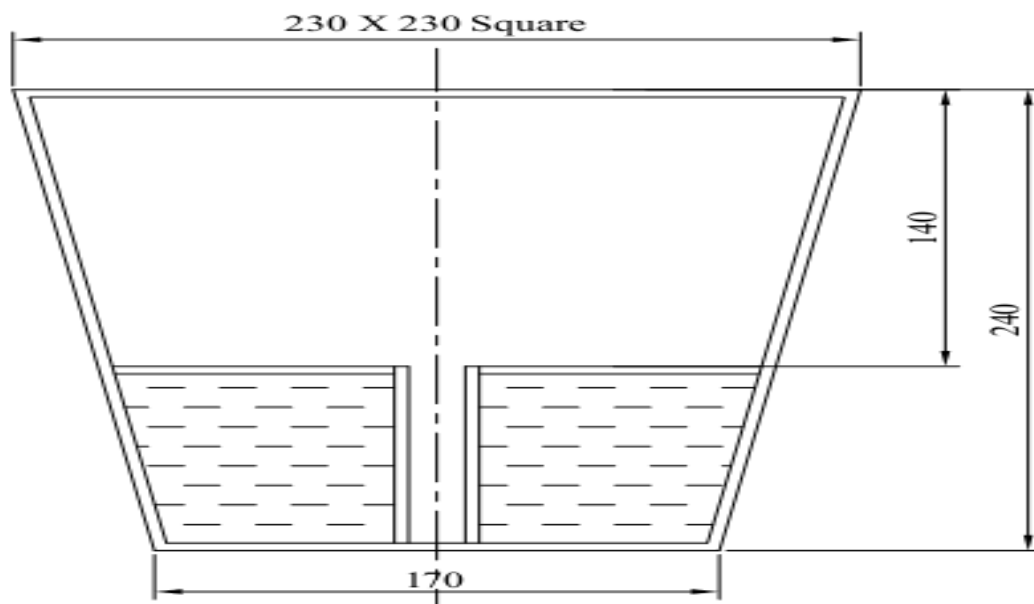


Fig.2. Square papered pots (Dimensions)



Fig.3. Round- papered pots (Picture)

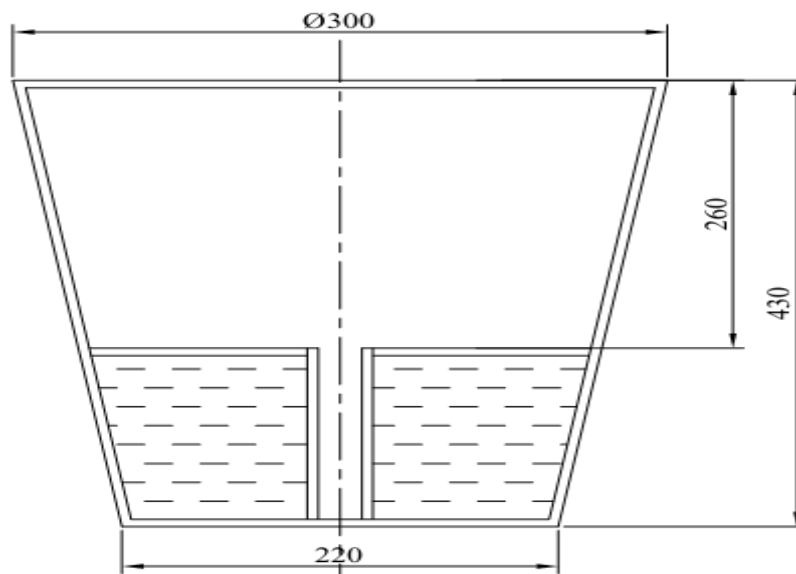


Fig.4. Round- papered pots (Picture)

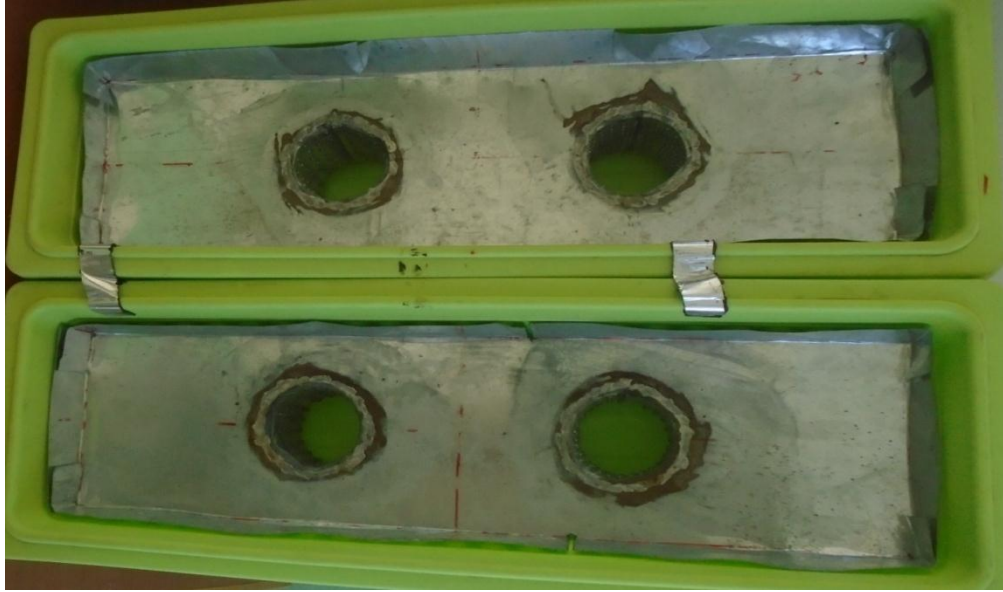


Fig.5. Round- papered pots (Picture)

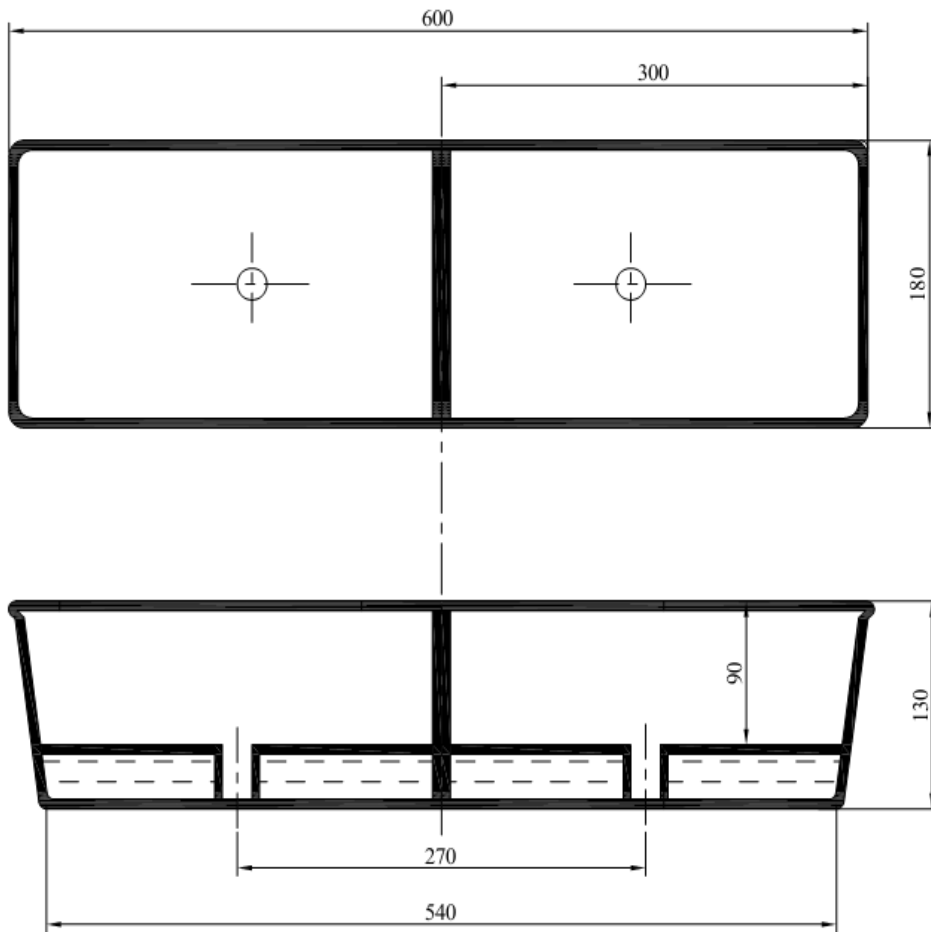


Fig.6. Round- papered pots (Dimension)

## B. Budget requirements of the research project

<b>Financial (Budget) Requirements of the Research Project</b>		
<b>Items</b>	<b>Unit cost</b>	<b>Amount in Birr</b>
Personal:		
Local travel:		
Vehicle		
• Taxi	30.00* 4 persons*15 days	1800.00
• Fuel or auto rent	200.00*4 persons*10 days	2000.00
Field subsistence:		
Per diem for Researchers	206.00*4 persons &10days	8240.00
Services:		
Labor	50.00*3 persons*30 days	4500.00
Guard (attendant)	500.00 *1*10 months	5000.00
Photocopy	Lump-sum	2000.00
Printing, a compilation of the results & manual preparation	Lump-sum	3000.00
Fetching water	Lump-sum	4000.00
Equipment & materials from:		
Construction of shelter, including material and labor.( detail is attached)	Lump sum	40,000.00
Manufacturing and fabrication of self-watering planters, including materials & labor	500.00* 100 pieces	50,000.00
Water reservoir, including portable smaller container	Lump-sum	5,500.00
Consumable:		
Stationery materials	Lump sum	1000.00
WR- CD	50.00*20	1000.00
Flash dicks	100.00*4	400.00
Variety of seeds	100.00*20 variety	2000.00
<b>TOTAL AMOUNT</b>		<b>130,440.00</b>