

Collective analysis for Cairo's food system flows towards deriving physical planning and policy guidance.

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Abstract: Food security is one of Egypt's fundamental challenges for development and human welfare. Egypt has suffered a series of shocks that caused an evident decline in its food and nutrition security and problems as poverty and food insecurity that were usually perceived as rural issues are becoming a rising concern for urban areas as well. Cities are bound to food by their appetite. Yet, as urban dwellers, we are oblivious to what it takes for our urban food systems to function and the amount of resources needed to feed our cities. The complexity and low visibility of urban food systems have hindered addressing them in the same magnitude as other urban challenges. However, urban food systems are directly related to the city's economic development, public health and welfare of its residents. An insight into the metabolism of our urban food system; where the city is reread as an ecosystem where flows of energy and materials cross, can help us manage its complexity and contribute to its sustainable development. Taking Cairo as a case study; six vital food system flows are identified: land, water, energy, goods, capital and employment. The flows are to be analysed both quantitatively; to visualize the system's transfers and losses and spatially; to illustrate how the flows relate to the city's spatial development. The data is to be analysed in terms of: the food system resource use, environmental impacts and inefficiencies and the system's food security, in terms of the food availability and access dimensions. The paper will then reflect on how to relate Cairo's food systems to the Egyptian city-development policies and physical planning process; based on the previous analysis and the best planning practices on food systems and sustainability discussed in the literature.

Keywords: Food security, Urban Food Systems, Sustainable development, Urban Metabolism, City Flows.

Introduction

Food is considered to be a complex adaptive system; in that it is dynamic, consist of multiple interconnected elements and can change corresponding to learnt experience (Gupta, 2012). Food systems need to be addressed through a holistic approach that integrates the social, economic and environmental aspects that accompany their consumption, rather than through a traditional sectorial approach. The research aims to provide a comprehensive analysis on Cairo's food system in terms of the system's needs and resource use, challenges and inefficiencies environmental impacts, and food security through its food availability and access dimensions; towards deriving a set of policy and physical planning guidelines that attempt to minimize the system's losses and maximize its returns for its sustainable development.

Urban Food Systems

Food systems can be defined as: “i) all the activities related to the production, processing, distribution, consumption and disposal of food, ii) all the factors affecting its activities as: environment, actors, infrastructures and institutions, iii) the outcomes of these activities that contribute to food security and a range of socio-economic and environmental issues” (HLPE, 2014), as shown in Figure 1. A comprehensive approach to what constitutes an urban food system starts from defining the set of actors and activities along the food system chain that shapes the structure and dynamics of the food system; that in order to be sustained require a group of inputs in the form of flows; classified into natural resources flows represented in land, water and energy and socio-economic flows represented in goods, capital and employment. The notion behind the system’s flows was inspired by the IABR project for the city of Rotterdam and what constitute each individual flow, as shown in Figure 2, was inspired by CAPMAS annual reports on the various economic activities related to the food system. These set of activities and flows have outcomes on the environmental level contributing to land use, water quality, emissions and biodiversity levels and on the social level contributing to food security, health and nutrition. The food system also functions within larger super systems that direct the system’s behaviour represented in food policies, how the system is governed and the socio-cultural environment in which the system exist.

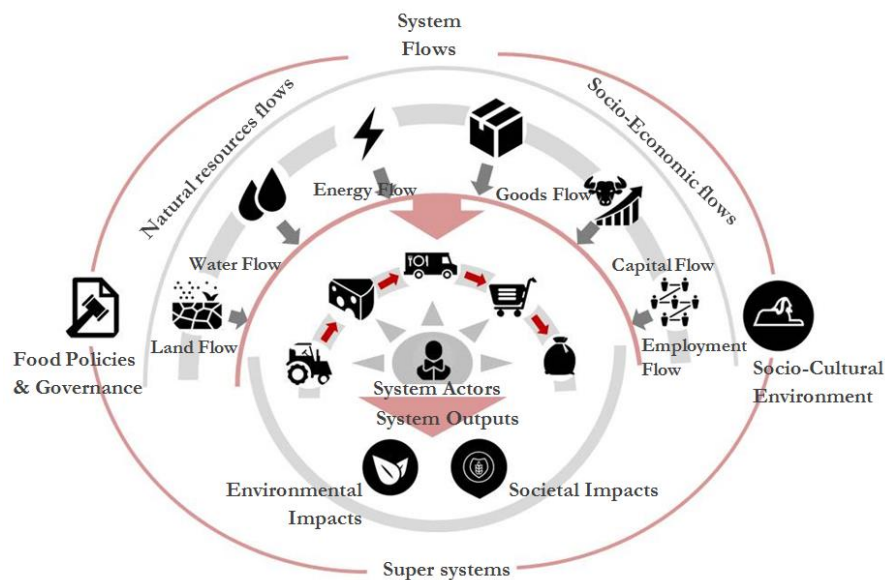


Figure 1 Urban Food System, Source: Authors.

Research Methodology

The coming section will explain the used research methodology; in terms of the applied data collection and data analysis methods.

Research setting and Study population

To help achieve a comprehensive understanding; the analysis was done on two levels; the national level represented in Egypt and the regional level represented in Cairo governorate; whose administrative boundaries are defined according to the 2016 CAPMAS Egyptian geospatial information portal. The national scale is to be used as a frame of reference to help understand the volume of contribution that Cairo’s food system shares on the national level and the variations in the performance of the different flows along the national and regional levels.

Data collection methods and Sources of information

Due to the lack of direct available data related to the food system activities; the required data were calculated from CAPMAS annual statistical reports on agricultural, industrial, commercial and environmental activities, on both Egypt and Cairo levels, with the aid of the case study's demographic and statistical data as population numbers and several design standards data books as Neufert's third edition. The research also used the 2012 Cairo's strategic plan report by the General organization of physical planning-GOPP when creating the spatial maps for Cairo's food system flows.

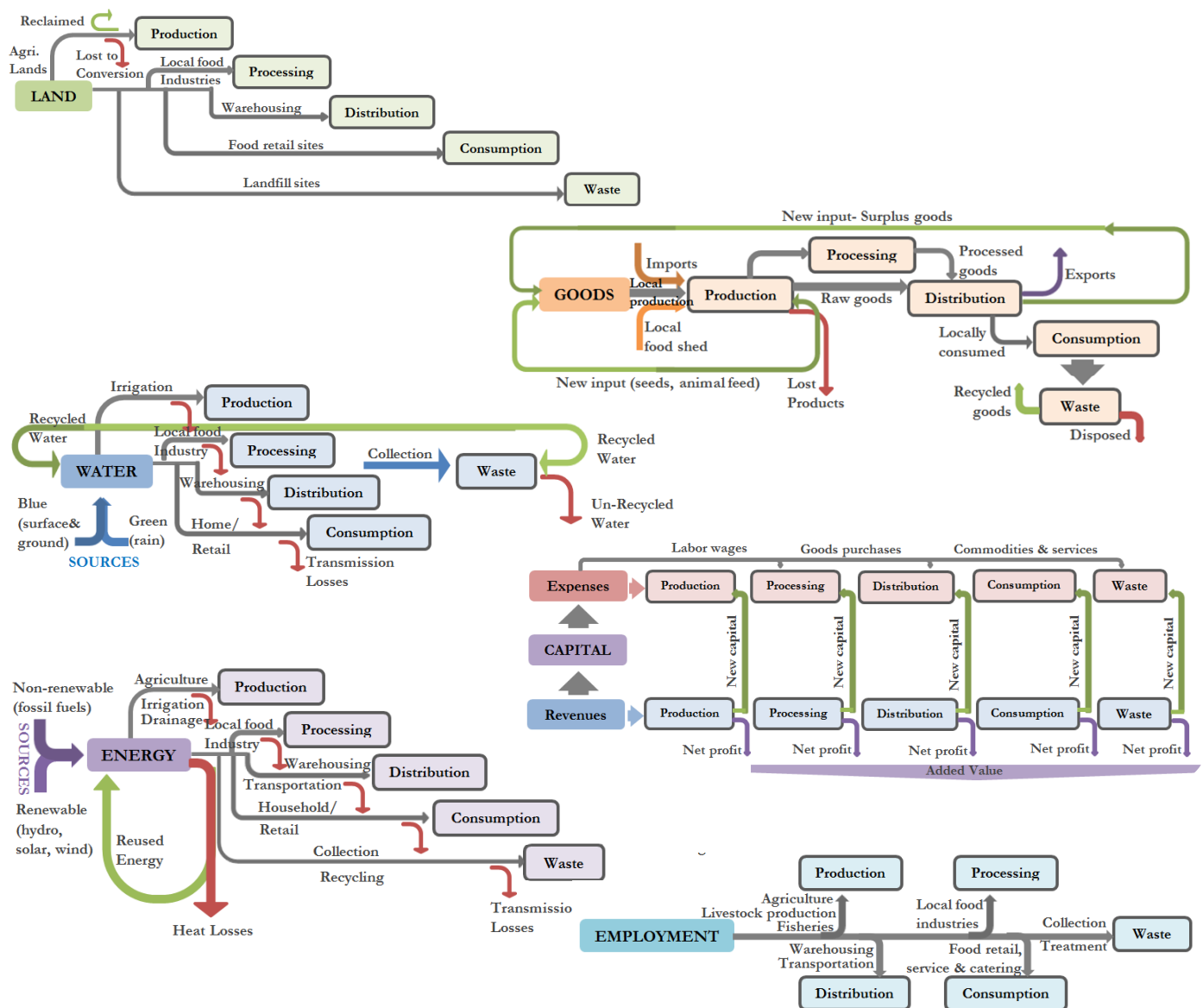


Figure 2 Urban Food System Flows, Source: Authors.

Data Analysis

Thinking in flows for sustainable urban development

Responding to urban challenges can no longer be conducted through traditional approaches; thus new paradigms of thinking are needed to understand how cities function. The applied approach rereads urbanization as an ecosystem; where flows of materials and energy cross;

working on connecting and coupling these flows to reduce losses and increase efficiency (Sijmons, 2014). Very little is known about what it takes for our urban food system to function. An insight into the metabolism of the urban food system in Cairo can help it work towards a more sustainable future; through better understanding of planning and managing its complexity (Kennedy, 2010). Six vital food system flows are identified: Natural Resources Flows; represented in land, water and energy and Socio-Economic Flows; represented in goods, capital and employment. The Flows and their consequences were examined to determine the fields of inefficiencies and look for potential synergies that can be turned into future opportunities and how they relate to the city's spatial development.

Mapping Flows

Sankey flow diagrams are graphical representations of the dynamic relationships in a system; through illustrating the structure and interaction of its constituting elements; visualizing the transfers, efficiency and nature of losses within a system (Harris, 1999). As the research will be examining flows in different units: land in feddan, goods in tonnes and capital in L.E, etc. and in order to unify these flows into quantities that could be related and compared to each other, the units will be converted to percentage format. The six defined flows will be analysed according to the five main activities that constitute an urban food system; production, processing, distribution, consumption and waste, as shown in Figure 3 and the produced Sankey diagrams will be accompanied by a spatial analysis of the study area-Cairo.

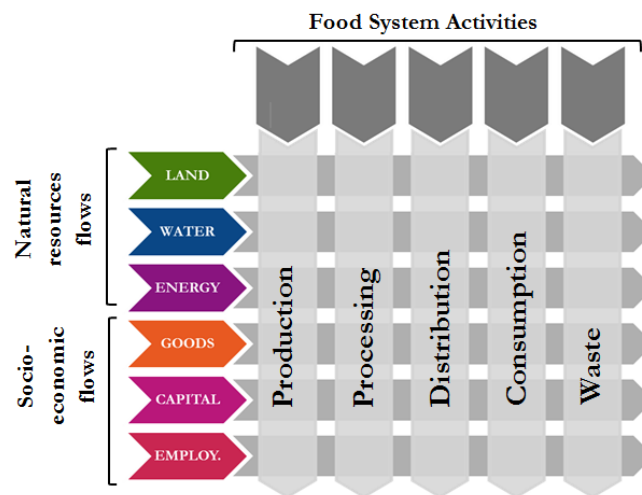


Figure 3 Methodology of the flows analysis, Source: Authors.

Results and findings

The data analysis was conducted for each individual flow, followed by a collective analysis of the six identified flows in terms of: the food system resource use, environmental impacts, challenges and inefficiencies and the system's security; to provide an insight into the current local food system situation in Cairo Governorate. The findings on the presented challenges and inefficiencies of Cairo's food system have been summarized in Table 1 and Table 2 below; applying the six identified food system flows, in relation to the five main food system activities.

Table 1 Collective analysis for Cairo's food system challenges and inefficiencies (production, processing and distribution phases), Source: Authors.

FOOD SYSTEM FLOWS	PRODUCTION PHASE
LAND	- Loss of lands to urban conversion and unplanned growth. Guidelines establishing urban and rural fringes are vaguely defined and manipulated.
	- Extremely limited arable land area available to food production in the governorate. Insufficiency of local food production and increasing dependency on food imports from neighbouring governorates and abroad.
	- Production lands constitute the highest share for the food system land needs on both the national level and Cairo's level; 99.6% and 75% respectively.
	- The Egyptian food system lacks an efficient knowledge system on the available and required agricultural resources; that can result in conflict of policies, inadequate farming decisions and food gaps.
WATER	- Cairo relies almost solely on the Nile river water; by 96%, for its food system water needs. - All water services are provided by the public sector on both Egypt and Cairo levels.
ENERGY	- Cairo relies solely on fossil fuel energy for its food system energy consumption. - Energy services are almost solely provided by the public sector; by 99.8%, with minimal involvement of the private sector.
GOODS	- Locally produced goods constitute the least share among traded goods (1.1%); where the governorate relies mostly on imported goods from neighbouring governorates (69.2%) and foreign imports (29.5%).
CAPITAL	- Farmers are financially stressed and unable to compete with other forms of development, in the face of increasing economic and social pressures as increasing land values, decreasing agricultural economic spin-off and bias against agriculture in urban areas. - Urban food activities are under constant pressure of losing their right in cities to conversion to other forms of residential and commercial development. - The production phase constitutes only 0.6% of the food system capital value; where Cairo relies more on the revenues generated from the consumption and food retail sectors rather than the production sector.
EMPLOYMENT	- On Cairo's level, the production phase accounted to only 8.4% of the total food system employment, due to the consuming nature of the governorate.
FOOD SYSTEM FLOWS	PROCESSING PHASE
LAND	- Food processing is under the threat of losing industrial lands in cities, in face of residential and commercial development.
FOOD SYSTEM FLOWS	DISTRIBUTION PHASE
LAND	- Pushing agricultural lands away from urban areas means food is travelling further distances; increasing food costs, city congestions and pollution.
WATER	- Transmission losses through the various food system activities severely affect the efficiency of its water flow. They constitute large shares of water loss; 17.96% on the national level and 28.75% on the governorate level.
ENERGY	- 59% of the energy input is lost as heat losses, in addition to 5.25% of the input lost in transmission; mounting to a total loss of 64.25% of the energy input, before reaching the various food system activities.
GOODS	- 12.3% of the total goods input are lost to spoilage and transmission losses before being processed or consumed.

Table 2 Collective analysis for Cairo's food system challenges and inefficiencies (consumption, waste and governance phases), Source: Authors.

FOOD SYSTEM FLOWS	CONSUMPTION PHASE
LAND	- Studying food outlets distribution in Cairo shows uneven distribution especially in low income areas and centralized food access in new urban communities; creating food deserts and increasing food insecurity.
WATER	- Cairo's highest share for water needs is in the consumption phase; constituting 42.9% of the total water use.
ENERGY	- Cairo's highest share for energy needs is in the consumption phase; constituting 27.7% of the total energy use.
CAPITAL	- The highest share for the food system expenses is recorded in the consumption phase on both the national and governorate levels; 53.5% and 76.2% respectively. - The consuming nature of the governorate and dependency on food imports causes loss of economic opportunities for the local community, increases food expenses and decreases the food system revenues; decreasing its total added value below the average national levels; (National: 75%, Cairo: 18.6%).
	- The Egyptian food market suffers from price distortions among different geographical regions and between rural and urban areas and price volatility due to the dependence on international imports and the Egyptian pound devaluation against the USD. - Several governmental institutions are involved in consumer protection which can create overlaps and conflicts. Consumers and businesses lack of awareness with the consumer protection mandate.
	- The Egyptian food subsidy program suffers from low quantity and quality stocks, is expensive to operate; requiring third of the Egyptian budget and is poorly targeted.
EMPLOYMENT	- The highest employment share is recorded in the consumption phase (64%); as Cairo relies almost solely on food retail rather than food production sector.
FOOD SYSTEM FLOWS	WASTE PHASE
LAND	- Waste landfills belong solely to the public sector, however unofficial random disposal sites can often be found around the city. - The land sites are designated for mainly dumping activities; where composting and recycling activities rarely take place within the governorate.
WATER	- Only 4% of the water input is recycled and turns back to the system as new input. Thus, the majority of the used water in the food system (96%) is either lost in transmission or disposed of.
GOODS	- Only 6% of the goods input are recycled and return back to the system for reusing.
EMPLOYMENT	The least employment share on both the national and governorate's level was recorded in the waste phase; 1% and 3.6% respectively.
GOVERNANCE & DEVELOPMENT PLANS	
- Comprehensive development plans that directly or indirectly address food systems in cities have not yet been devised for Egyptian cities.	

Recommendations and policy advice

After briefing on the research findings and results, this part will reflect on the research recommendations and policy advice for Cairo's food system; based on the previous analysis and principles and best planning practices on food systems and sustainability discussed in the literature, as shown in Table 3, Table 4, Table 5 and Table 6.

Table 3 Recommended physical planning and policy guidelines for Cairo's food system (production phase), Source: Authors.

FOOD SYSTEM FLOWS	PRODUCTION PHASE
LAND	<ul style="list-style-type: none"> - Distributing the governorate into a series of transitioning zones from rural to urban; with an established set of planning guidelines for each zone with regards to building densities and percentage of natural to built environment; to help preserve rural areas and obtain a balanced relation between urban and rural environments. Inspired by the Transect theory, (Andrés, 2003).
	<ul style="list-style-type: none"> - Diversifying urban food production models in city development plans; in both horizontal urban expansion settings, as in suburbs; using peri-urban agriculture models as: farming units, yards gardens, rights of way and vertical urban expansion settings, as in compact urban areas; using space intensive models as: roof tops and vertical farming techniques; accommodating to the available space. Inspired by le corbusier's radiant city, Wright's broadacre city and Havana's urban agriculture experience (Corbusier, 1987), (Wright F. L., 1958), (Murphy, 2005).
	<ul style="list-style-type: none"> - Establishing a National urban agriculture program in cities to promote education, training and national conscious towards urban agriculture systems and provide research and technical assistance to urban agricultural units; providing services as: extension agents and cooperative agriculture assemblies (Gonzalez, 2000).
	<ul style="list-style-type: none"> - Establishing a robust food knowledge system that provides an accurate data base on agricultural resources as: land parcels, land quality, production rates, etc. and assists farmers in managing their farms according to national priorities. - Providing policies that facilitates the applying of urban farmers for land and the practice of urban farming on either state enterprises as: city owned parks and rights-of-way and reclaiming underused urban spaces as car parks and brownfield sites for growing food, or self-provisioning enterprises on private properties as private residential parcels and backyards.
WATER	<ul style="list-style-type: none"> - Integrate more resource efficient water usage techniques as agricultural & waste water treatment and water desalination activities. Storing rain water in times of surplus; to be used in dry seasons in productive and recreational landscapes.
ENERGY	<ul style="list-style-type: none"> - Introduce new measures to integrate renewable energy sources as solar and geothermal energy sources, into the power grid; to help achieve a more sustainable and resource efficient energy system.
CAPITAL	<ul style="list-style-type: none"> - Implementing urban agriculture models especially in underserved communities, for its potential to provide empowerment, in terms of providing job opportunities, income and accessible local food, with shorter supply chains (Unger, 2006).
EMPLOYMENT	<ul style="list-style-type: none"> - Allocating further employment opportunities in the local food production sector in both state and private enterprises to decrease the governorate's food dependence and food expenses. - Ensuring further integration of the private sector in service provision activities to reach balanced shared responsibilities among both sectors.

Table 4 Recommended physical planning and policy guidelines for Cairo's food system (processing and distribution phases), Source: Authors.

FOOD SYSTEM FLOWS	PROCESSING PHASE
LAND	- Circular food industries: establishing comprehensive circular food industries; through integrating seedling industries with farming, food production, processing and food packaging in a closed cycle, with other supplementing industries as plant-based pharmaceuticals; where the output of one industry is the input of another; for maximized resource use efficiency and minimal food waste. Inspired by circular economy business models (OECD, 2002).
	- Conscious land zoning policies that acknowledge food industries as local non-polluting industries; essential to the development and welfare of the community and whose proximity to urban areas is cost efficient and environmental friendly (Jones, 2005).
WATER	- Service provision: allocating food industries in proximity to required services and infrastructure: as water, energy, transportation and infrastructure for better exchange and provisioning conditions.
ENERGY	
CAPITAL	- Policies that integrate food processing industries in the local economy through a diverse array of large, medium and small sized enterprise and verified in their provided services from processing, preparing, packaging and trading food.
FOOD SYSTEM FLOWS	DISTRIBUTION PHASE
LAND	- Land zoning policies that provide sufficient storage and warehousing spaces and markets for local food distribution activities within the city, efficiently connected to the required transportation and infrastructure.
	The integration between food production and distribution activities to shorten and strengthen supply chains; through alternative food distribution models as farmers markets, farm to table models and community supported agriculture programs; that directly connect local producers to consumers. These models are cost efficient for both producers and consumers provide more local economic opportunities and are environmental friendly (Jones, 2005).
ENERGY	- Integrating urban food production models to reduce energy use due to their small scale production that reduces machinery needs and decreased transportation due to proximity of production sites. - Applying shorter supply chains as farmers markets and farm to institution models for reduced transportation & energy consumption (Unger, 2006).
GOODS	- Diversified food transport network: boosting the quality of goods flow; through developing a diversified and well integrated transport network for goods distribution; comprised of motorized (delivery vans, cargo lockers and pickup points) and water transport.
	- Cargo hubs: reducing freight traffic that passes through the city's urban centers to avoid congestions and delays and directing it away to inner and regional ring roads, along which the city's cargo hubs are strategically allocated; benefiting from the goods flow to generate added value. Inspired by IABR Rotterdam project (IABR, 2014).
CAPITAL	- Implementing local and urban food production models with shorter supply chains that decreases food expenses and are cost efficient for both producers; who obtain increased direct revenues and consumers who obtain decreased food costs (Unger, 2006).

Table 5 Recommended physical planning and policy guidelines for Cairo's food system (consumption phase), Source: Authors.

FOOD SYSTEM FLOWS	CONSUMPTION PHASE
LAND	<p>- Mapping food system's coverage: To ensure adequate food access; mapping food outlets and their service zone coverage should be applied as a prerequisite to spatial planning. Food outlets mapping can be examined in relation to population densities, poverty distribution and public transit routes distribution within the city (Cassidy, 2008).</p>
	<p>- Neighborhood design: including the allocation and distribution of food outlets as a design consideration in neighborhood design; allocating 400m walking distance for high access areas and 800m walking distance for low access areas and ensuring better distribution through corner shops and small variety stores in a mixed use setting, rather than agglomerated shopping complexes, segregated from residential areas (Unger, 2006).</p>
	<p>- Land zoning policies that utilizes the economic, social and cultural potential of food retail in revitalizing neighborhoods in both large commercial centers and small neighborhood streets (UNEP, 2016).</p>
WATER	<p>- Consumer awareness activities that attempts to influence consumption patterns to more sustainable choices; in terms of dietary habits, resource use and food waste, as a lever towards change to a more sustainable and resource efficient food system.</p>
ENERGY	
GOODS	<p>- Transport planning: including the distribution of food system outlets as a factor in cities transport planning; taking into consideration how consumers are to reach them either by walking, using public transit or private vehicles within the assigned coverage distances.</p> <p>- Developing a transport loop that connects citizens to the city's boulevards and public markets for an enhanced shared space and mixed urban environment (IABR, 2014).</p>
CAPITAL	<p>- Egyptian food market:</p> <ol style="list-style-type: none"> i) Further monitoring to tackle price dispersion and hikes with better integration between the different institutions involved in consumer protection under a unified plan (IDSC, 2013). ii) Executing advocacy activities for both consumers and businesses; to clearly set out the rights and responsibilities towards consumer protection (IDSC, 2012).
	<p>- Egyptian food subsidy program:</p> <ol style="list-style-type: none"> i) Updating the food subsidy program database and restructuring its operating guidelines to efficiently target vulnerable households. ii) Ensure efficient distribution of consumer complexes and provision stores, especially in underserved neighborhoods. iii) Increasing dependence on local food commodities rather than imported commodities to obtain stable and sustained supply and decrease the program's expenses (IDSC, 2013).

Table 6 Recommended physical planning and policy guidelines for Cairo's food system (waste and governance phases), Source: Authors.

FOOD SYSTEM FLOWS	WASTE PHASE
LAND	<ul style="list-style-type: none"> - Extracting raw materials from waste and food flows through integrating waste recycling and reuse activities in food production, industries and consumption; to successfully close the food system loop and reduce its losses (IABR, 2014).
	<ul style="list-style-type: none"> - Provide taxes reduction and reduced service provision expenses for industries and businesses that implement recycling and reuse activities. Implementing strict laws on industries and businesses that perform random and hazardous disposals in river and inner city sites (CIWMB, 2006).
	<ul style="list-style-type: none"> - Policies that aim at reducing food waste and resource use along the food system inputs, through a number of prevention strategies: ensuring efficiency in the production and consumption phases and increasing public awareness on food waste, sustainable disposal and recycling activities. (UNEP, 2016).
WATER	<ul style="list-style-type: none"> - Further Integration of agriculture and waste water treatment techniques in the food system water use.
ENERGY	<ul style="list-style-type: none"> - Channeling energy waste; through shifting from individual heat production in households and businesses to developing a stable heating network grid of heat hubs that couples between generated and residual heat and control cascading to various demands in the city; reducing energy consumption and CO2 emissions. The generated heat energy can be reused in various industrial and heating activities across the city (IABR, 2014).
GOODS	<ul style="list-style-type: none"> - Edible food recovery: cutting down the food system's waste through the integration between food system activities; by connecting food outlets as restaurants and grocery stores with food banks and charitable feeding organizations; to sustainably regulate food surpluses and support individuals that cannot meet their basic food needs (Cassidy, 2008).
	<ul style="list-style-type: none"> - Segregated waste collection: facilitating its implementation by designing a segregated sewage system that transport the collected organic waste to protein collectives; that can be used later on in urban farming (IABR, 2014).
CAPITAL	<ul style="list-style-type: none"> - Allocating further capital resources to the food waste sector to ensure a more sustainable and resource efficient food system.
EMPLOYMENT	<ul style="list-style-type: none"> - Allocating further employment opportunities in the food waste sector in collection, composting, recycling and reuse activities.
GOVERNANCE & DEVELOPMENT PLANS	
	<ul style="list-style-type: none"> - Addressing food systems comprehensively in the governorate's development strategies; through one of the following modes, (UNEP, 2016): <ul style="list-style-type: none"> i) Food policy council: comprised of representatives of the food system segments within the community as: farmers, retailers, NGOs, as well as governmental officials; working together towards establishing a more just and ecologically sustainable food system. They exist outside government structure and have an advisory function through research, advocacy and community education with a food system focus. ii) Department of food: dedicated to local food issues and setting public and private programs to enhance the community's food security. iii) City planning agency: part of the government planning agency that acts as a starting point towards integrating urban food systems with other urban systems and benefit from the existing databases on various community indicators to analyze and formulate policies and programs related to the local food system.

Conclusion

In terms of the food system needs; the production phase constitutes the highest share of resources use on the national level, however, on Cairo's level, the consumption phase constitutes the highest share of resources use; asserting the consuming rather than productive nature of the governorate. Thus, the need to implement design strategies that aspire to reduce resource use for the same economic input use as circular food industries, diversified food transport networks and alternative distribution models with shorter and strengthen supply chains. In terms of the system's losses and inefficiencies; around third of the system's water input, more than half of its energy input and 12.3% of its goods input are lost before usage and only 4% of the total water input and 6% of the goods input are recycled to be reused in the system as new input. Thus, the need for devising design strategies that address the systems' inefficiencies and maximize its returns as improved infrastructure and services provision, resource recovery and raising awareness to more resource efficient consumption patterns. Cairo's local food production is insufficient to fulfil its demands and the governorate relies mostly on food imports from the neighbouring governorates and foreign countries. This can be traced back to the extremely limited arable land area in the governorate, loss of lands to urban conversion and unplanned growth; where farmers are financially stressed and unable to compete with other forms of development. Thus, urban conscious land use and zoning policies that protect agricultural resources and integrate food system activities successfully in urban settings are strongly needed; as transitioning zones, integrating food production in city development plans mapping food system's coverage for better food access and including the allocation and distribution of food outlets as a factor in cities transport planning and a design consideration in neighbourhood design. Working towards the integration and balanced share of responsibilities along its different actors is crucial for the success of the system, along with an efficient food knowledge system that allows integration and coordination among the food system elements, to avoid conflict in policies and ensure adequate decision making. Food systems have not yet been addressed in Egyptian urban development plans and it is needed to devise a mode of governance dedicated to local food issues to formulate policies and programs with further consideration to the food system on the urban agenda.

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