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أثر شبكة الصرف الصحي المركزي على التخطيط العمراني واستعمال الأراضي في الريف المصري

Impact of Central Sanitation Network on Land Use and Urban Planning in Rural Egypt

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ملخص البحث:
تؤثر شبكة الصرف الصحي بشدة على التركيب العمراني للمدينة والقرية نظرا لمتطلباتها الفنية في التركيب والتشغيل ، هذا الأثر يشكل استعمالها للأراضي لإنشاء محطات المعالجة ، واستعمالها لشبكة الشوارع والترع لتمرير خطوطها مما يفرض شروطا ومتطلبات على تصميم هذه الشوارع وتقاطعاتها ، كلما قل توافر هذه المتطلبات قلت كفاءة الشبكة وزادت تكلفتها ، تعتبر المشكلة مضاعفة في الريف المصري نظرا لندرة أراضي البناء وغلائها مما يصعب معه توفير مساحات لمحطات المعالجة التي تستهلك عشرات الأفدنة ، بالإضافة لمشكلة البناء الأفقي وانخفاض الكثافة البنائية في الريف مما يزيد من تكلفة تمديد الخدمة، لكل ذلك يجب النظر بعين الأهمية لتطبيق وسائل الصرف اللامركزي في الريف المصري لتوفير النفقات وتقليل استعمال الأراضي وتوفير الخدمة الغائبة عن نسبة كبيرة من الأسر الريفية في مصر .

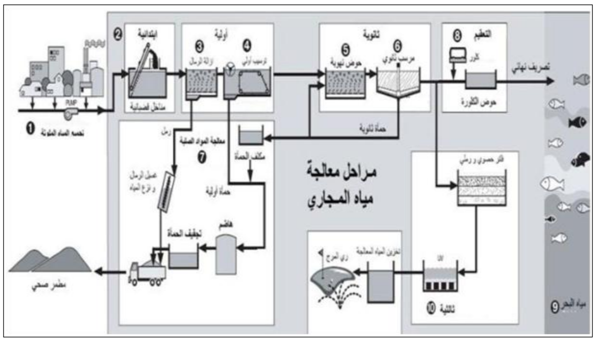
<u>مفتاح البحث</u>: شبكة الصرف الصحي – التخطيط العمراني – الصرف الصحي اللامركزي – استعمال الأراضي – الريف المصري.

ABSTRACT:
The central sanitation network is a problematic issue in rural Egypt. It requires huge investments and large vacant lands for building and installing the system. It also requires a uniform gridiron street pattern with minimum intersections to perform better. It is also preferred in case of high building capacity with high population density to ensure proper economic feasibility. All these requirements are less likely to be available in rural Egypt. Land is scarce, streets are mostly irrigular and building capacity is low because of horizontal sprawl, which highly increase the infrastructure and operation cost . Bcause of all these difficulties, most rural areas are not served with central sanitation and use decentralized primitive technologies. If improved properly, decentralized sanitation technologies can perform much better than central grid with minimum impact on land use and urban pattern.

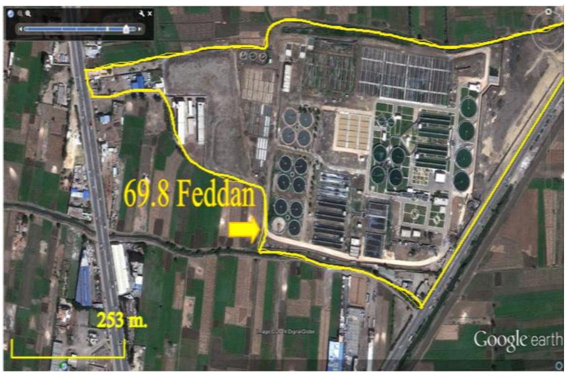
1- Introduction:

Rural Egypt suffers bad or absent central sanitation. If available, it consumes land and doesn't fit into rural street patterns. It is even unfeasible in rural areas due to horizontal sprawl and low building capacity per linear km of service.

2- **Land use of wastewater treatment plants:** Wastewater treatment has many steps and stages of process as shown in Fig (1). These steps require large areas of land for building, installing and operating the system. There is usually an <u>inverse relation</u> between land requirements and construction cost. Low cost technologies rely on exposure to sunlight for long time to perform biological treatment; consequently this requires large areas for treatment basins and longer retention time in these basins. As technology used in rural Egypt is primitive, it requires vast areas to build and install these plants. Excessive land use may not be a problem in coastal governorates and new settlements in the desert, but it is a serious problem in rural areas in the old valley where land is fertile, scarce and expensive (1). An example for land use of wastewater plants is a plant in Tanta in Al-Ghofran area. This plant is installed over 69,8 Feddan, serving 422,854 inhabitants, at a rate of 0.693 m^2/ capita (4) as seen in fig(2). Although Tanta is not rural, the same land use exist in rural treatment plants.



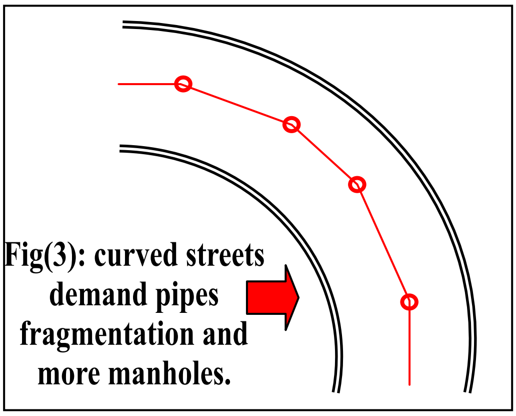
Fig(1): Wastewater treatment stages applied in Centralized system in Egypt - www.hcww.com.eg



Fig(2): Land area of 69.8 Feddan for a treatment plant in Tanta, Egypt.

3- **Urban pattern:** The cost and efficacy of wastewater network is significantly affected by the urban pattern of the serviced area. Wastewater network is in its best shape when the following is available:

A- **Straight-line streets with no or minimum curves**: As pipes are constructed straight, the best path for them is the straight path. Curves require fragmentation of network to get parallel with street curvature. The joints of these pipes are fitted with (elbows) in water pipes and (manholes) in wastewater pipes as shown in fig. (3). The increase of the number of elbows and manholes increase the cost and effort of installation, decrease the safety and efficacy of the system, and raise the threats of leaks and infiltrations.

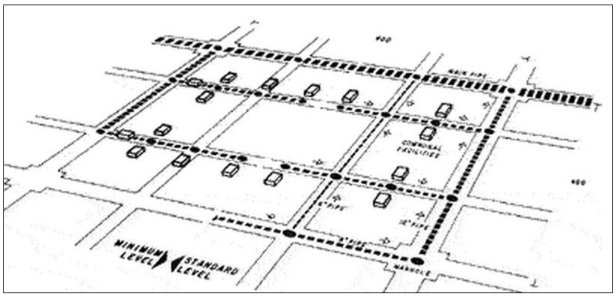


Fig(3): curved streets demand pipes fragmentation and more manholes.

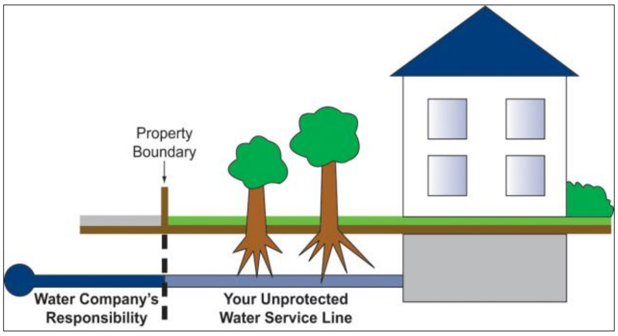
B- **Minimum street intersections:** Street intersections demand installing manholes for wastewater network as shown in fig. (4). The more intersections in the grid the more expensive it becomes to install as the cost of installing a single manhole is **1500** to **3000 LE** per unit, according to size and capacity, (2014 price) (5).

C- **Natural topography with mild slopes that serves the service's gravity**: Natural topographic slopes help accelerating the flow of waste-water towards treatment plant. Negative slopes require pumps and energy to pump wastewater against gravity, which increases the cost of both installing and operating the system.

D- **Minimum public access points:** Sewers and pipes in public space are the responsibility of the government (or the company) to fix and install. The less fixtures in public spaces the more sparing and efficient the system is. Fig. (5) shows borderline of responsibility for the water and wastewater utility.



Fig(4): Impact of intersections on sewers number http://web.mit.edu

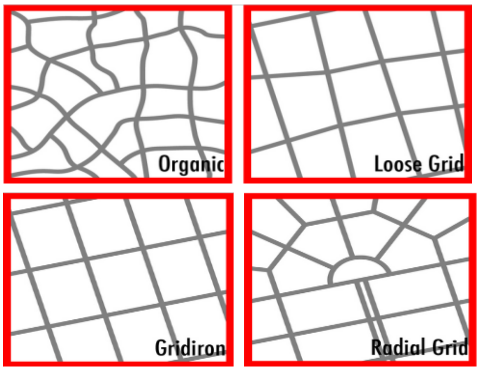


Fig(5): Borderline responsibility for water and wastewater utility-homeserve.tumblr.com

E- **Minimum street linear meters for maximum served blocks:** Population density affects the economy of wastewater installation. The urban pattern with short streets serving more blocks and people means less expenses and better quality in wastewater systems. Short path also requires less maintenance. Each linear meter costs additional 1610 to 2250 LE/m according to size and material. (2010 prices) (6).

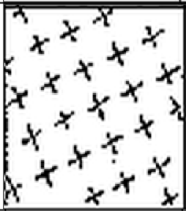
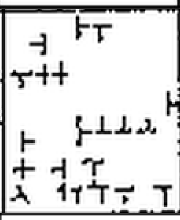
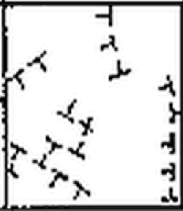
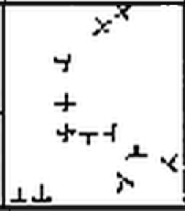
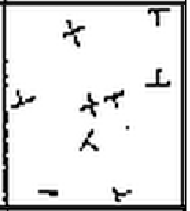
Table(1) shows a comparative analysis of different street patterns and their effect on pipes intersections, pipes length, no. of blocks served, percentage of straight pipes, no. of access points and service accesses, and no. of loops and cul-de-sacs. The best pattern for the central grid by these parameters is the (Loops and Lollipops) pattern as shown in the table.

4- **Common street patterns in rural Egypt:** Egypt has four main street patterns as seen in fig(6). But in rural Egypt, only two of them are dominant: the (Organic) pattern in old districts and informal quarters, and the (Loose Grid) pattern in modern districts, see fig(7). Other patterns like (Gridiron) and (Radial Grid) are not common in rural Egypt. These two dominant patterns have a significant impact on wastewater grid's cost and efficacy. Municipalities find more difficulty in installing and maintaining pipes in organic and informal districts. This difficulty explains the absence of this utility in many rural areas and slums where streets are not pre-planned and the urban pattern is not compatible with the grid requirements. Al-Santa city is a good example that shows the difference in wastewater pipes path in different urban types. In Al-Santa, we can notice two types of urban pattern, each having a different wastewater pipes path. Pipes are straight and reaching almost all houses in modern area while pipes are curved and bended in the old district and couldn't reach all houses due to informal and organic pattern of the area, see fig (8).

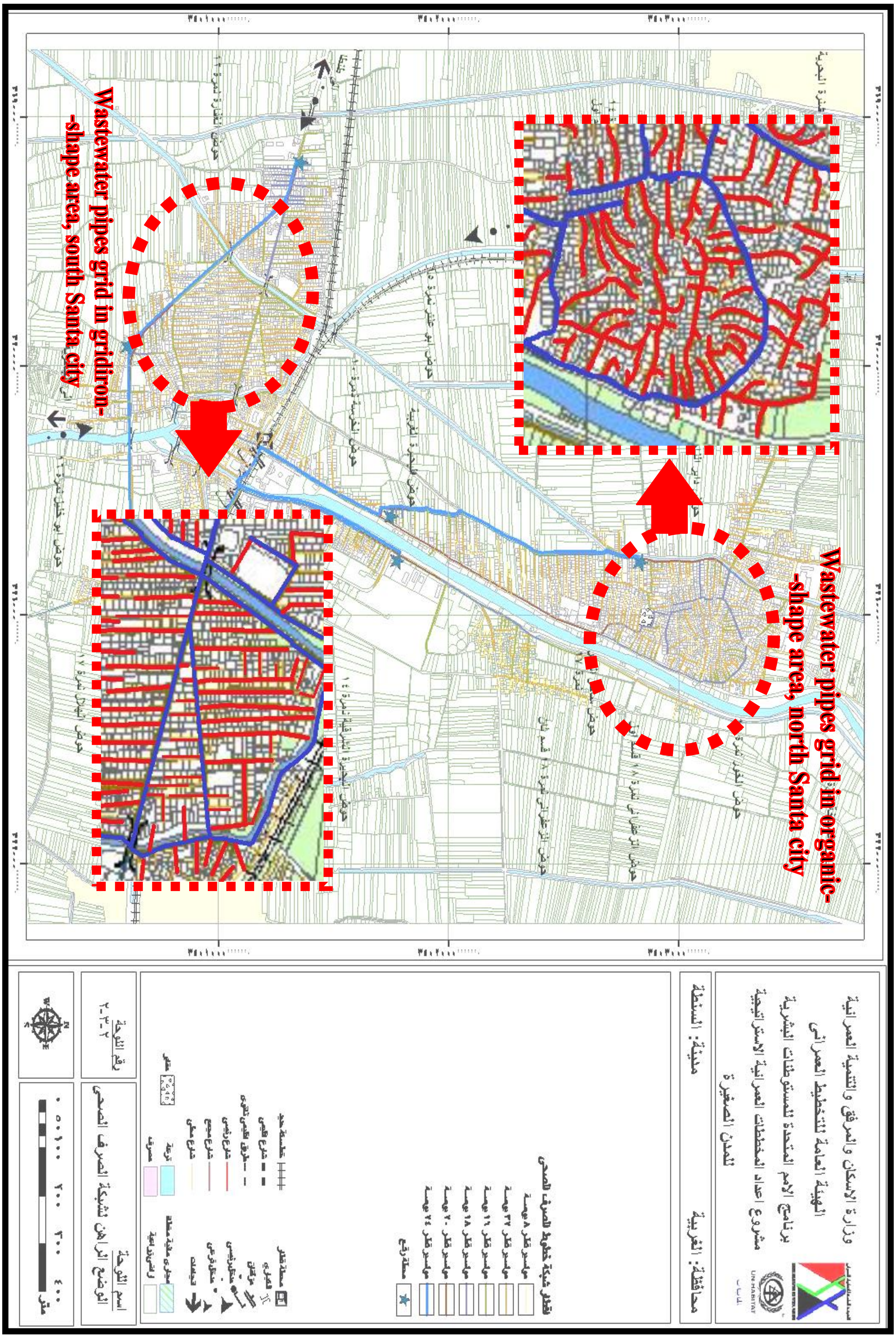


Fig(6): Common urban patterns in Egypt- http://munsonscity.wordpress.com/tag/loose-grid/

Fig(7): Two main street patterns in rural Egypt: Organic in Al-Santa and Loose grid in Basioun

Category	Gridiron	Fragmented Parallel	Warped Parallel	Loops and Lollipops	Lollipops On a Stick
Street Patterns					
Pipes Inter-sections					
No. of Inter-Sections	26	22	14	12	8
Straight line pipes %	100 %	100 %	3 %	73 %	50 %
Linear Meters of public pipes	**6339.84**	**5791.2**	**5029.2**	**4663.44**	**4754.88**
No. of Blocks	**28**	**19**	**14**	**12**	**8**
No. of Access Points (Service Access)	**19**	**10**	**7**	**6**	**4**
No. of Loops and Cul-de-Sacs	**0**	**1**	**2**	**8**	**24**

Table(1): Comparative Analysis of Neighbourhood Street Patterns impact on water and wastewater pipes grid- (www.fccdr.usf.edu/) with modification by the researcher.



Fig(8): Comparing grid lines in both organic and grideron-shape areas in Alsanta village, Gharbeya, Egypt

5- Impact of horizontal sprawl on sanitation grid's economy: Rural areas tend to expand horizontally which leads to low building capacity, see fig(9). Serving low building capacity with wastewater pipelines means more linear meters for fewer connections.

Average rural loading for wastewater is 300 to 900 connections / linear km, while average urban loading is 1200 to 4800 connections / linear km. Each linear meter of sanitation pipes expansion cost 350 LE (for public connections, 2014 prices), which means that covering rural areas with central sanitation is more expensive and less feasible, see fig (10)

Fig(9): Horizontal sprawl of rural houses, Luxor, Egypt - www.touregypt.net

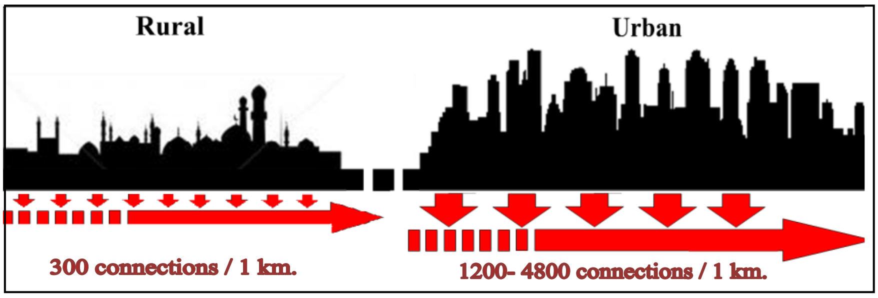


Fig (10) Rural vs. Urban infrastructure loading-Designed by the researches

6- **Impact on streets and open canals**: Central Water & Wastewater grid in Egypt usually passes under streets, railways and over canals and water bodies, see fig (11). The deterioration of the grid causes many breakings and leaks that cause serious damage for the roads and heavy pollution for water. Fixing and maintaining pipes may paralyze the traffic for many days.

In 2010, the length of the water distribution networks in Egypt was 143,000 km and the length of the wastewater collection network was 33,000 km (7), see table(2)

Sewer pipes face many threats as they expand beneath streets, the more occurrences of pipes' sliding and breaks. These breaks and sliding mainly occur because of differential ground movement, heavy vehicle traffic on roadways above the pipes, careless construction practices, roots intrusion from trees, or soil pressure.

The long path also may cause the increase of sedimentation inside the pipes. The longer the path is the more accumulation of sediments over the pipes inner walls as seen in fig (12). These sediments cause the clogging of pipes and decrease the flow capacity of the system. In rural Egypt these threats are even higher because of the deterioration of the system. All these problems result in a quick degradation of the sewer pipe materials.

A model of wastewater network in Al-Zarqaa city, Damietta, is shown below in fig(13). The main pattern problems are present in: the long path of pipes for small number of blocks, manholes in all intersections and curves, deprived areas in old quarter and rural boundaries of the city, and passing across roads and water bodies.

Holding Company for Water and Wastewater

	2007	2010
Water distribution networks	74,000 km	143,000 km
Wastewater collection networks	28,000 km	33,000 km

Table (2) : Lenghts of water and wasterwater distribution pipes in 2010- HCWW annual report 2010- www.hcww.com.eg/en/HCWW.pp

Fig 11: Pipes passing over waterways and leaking .occasionally- Kafr Hakim village, Geiza

Fig 12: sediments in pipes

7- **Conclusion & recommendations**: Central sanitation grid affects land use and urban planning in rural Egypt. Installing this grid in rural Egypt is a problematic issue. Vacant land is scarce so treatment plants can't be built properly without sacrificing precious agricultural land. Low building capacity makes the linear expansion unfeasible, and organic-patterned streets increase the no. of sewers and intersection fixtures. Decentralized sanitation can be installed on-roofs or under the houses so it consume less land. Decentralized sanitation must be considered in rural areas as a more economical alternative. With good environmental design and surveillance, decentralized sanitation can be a very good option for rural areas, suiting its organic shape, scarce lands, low income, and low building capacity. Researchers and decision makers are invited to develop and enhance decentralized sanitation technologies to be applied in these areas where central sanitation grid is not the best choice.

8- **References:**

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