



Reshaping sustainable development trajectory due to COVID-19 pandemic

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Received: 1 June 2021 / Accepted: 12 August 2021 / Published online: 28 August 2021

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Abstract

Humanity could face the COVID-19 epidemic to crystallize a sustainable future for the water, hygiene, and food sectors. The epidemic has affected the sustainability of water, food, and health institutions in Egypt. Water consumption levels have increased in the agricultural sector to ensure food security. Regular handwashing is one of the most important measures to prevent the epidemic, and this has an impact on water consumption. The purpose of the research is to reshape sustainable development trajectory due to COVID-19 pandemic in Egypt through three interdependent phases: the first is devoted to forecast how the pandemic could be spreading in Egypt, the second is assigned to foresee implications and consequences of the pandemic on water, food, and human activities, and the third is dedicated to exploring how Egypt could utilize non-conventional water resources as a precious resource to fight the pandemic and explore sustainable recovery strategies. The results could be summarized as the diffusion of COVID-19 pandemic may be considered a group of evolutionary processes. The vision of growth to a limit may be applied; the number of cases of COVID-19 grows rapidly, but the growth will be reduced due to negative feedback signals from the environment. The paper concludes that the COVID-19 epidemic could be addressed by enhancing the water sector to better cope with future shocks. Water, food, health, and work opportunities could be provided and managed sustainably. The need to provide water to wash the hands of all citizens has been emphasized to fight the coronavirus. Non-conventional water resources could be an engine to ambitious plans to drive economic growth through megaprojects. Egypt would enable transforming this crisis into an opportunity to accelerate the pace of action towards achieving Sustainable Development Goals.

Keywords Sustainable future · Foresight · Water-hygiene-food-health nexus · Sustainable development · COVID-19 pandemic · Humanity

Introduction

COVID-19 pandemic has unleashed a health, water, and economic dangerous crisis that needs serious attention in both scope and magnitude. In March 2020, the World Health Organization declared that the contagious coronavirus disease had turned into a pandemic. It is estimated that over half of all mankind (4 billion people) have been affected by restrictions in movements and social relationships. The pandemic has triggered a global social and economic crisis. The social, trade, and economic relations and methods and forms of

work have significantly changed (Boccaletti et al. 2020). According to Worldometers, the epidemic has spread in the world and infected 68,657,356 people, 47,559,981 recovered, with 1,565,254 deaths, as of December 09, 2020. The share of Egypt has reached 119,281 confirmed cases, 103,913 recovered, with 6,813 deaths (World Health Organization). According to UN (2020), the COVID-19 pandemic will project cumulative economic losses of nearly \$8.5 trillion between 2020 and 2021.

Most countries have implemented many activities to avoid the pandemic, including the closure of entire cities, which has had devastating consequences on the economy and human living conditions. Meanwhile, it has become recognized across the world that washing hands with water and soap is the best way to prevent the coronavirus. Consequently, the water, hygiene, and food services to all citizens have been emphasized more. With the continued spread of the epidemic, it was the duty of the authorities responsible to provide all

Responsible Editor: Lotfi Aleya

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services to the demand and work in new ways and on an unprecedented scale. In most countries, it was necessary to reassess priorities and introduce new initiatives, procedures, and policies to provide the population with water, in sufficient quantity and acceptable quality, and to ensure the sustainability of water, hygiene, and food services.

COVID-19 is anticipated to significantly reduce Egyptian economic yield in most sectors. The results show a sizable negative impact on economic production and welfare in Egypt, depending on how long the pandemic will persist (Breisinger et al. 2020). The pressure to ensure access to clean water, adequate food services, and good hygiene is most acute in Egypt, where more than 100 million people live in conditions of water scarcity. In addition, many people are at increased risk of contracting COVID-19 due to their lack of basic handwashing facilities. Also, some Egyptians remain more vulnerable to the pandemic because they lack an improved source of drinking water in their places of residence, which requires them to fetch water from pipes and overcrowded public sources.

With the epidemic and the acceleration of its pace, additional risks could be posed, especially for women and girls. To face this unprecedented epidemic, the authorities responsible for the water, hygiene, and food sectors in Egypt were supposed to find appropriate solutions. The water sector's ability to adapt to health challenges and economic shocks would enable transforming this crisis into an opportunity. A more flexible future for water, hygiene, and food services to accelerate the pace of action towards achieving Goals 1, 2, and 6 of the Sustainable Development Goals could be crystallized. Sustainable agriculture, food security, water, sanitation, and end poverty could be expected.

The objective of this work is to study the effects of COVID-19 on the water, hygiene, and food sectors in Egypt. In this context, this study aims to collect data and information on the impacts of COVID-19 on the water, hygiene, and food sectors in Egypt. The response measures and initiatives have been launched or implemented by government institutions; water, hygiene, and food facilities; and other actors.

Methods

Many researchers have developed several forecasting methods to predict different features of the COVID-19 epidemic. Methods include mathematical models, mathematical statistics, infectious disease models, artificial intelligence models, machine learning, and deep learning. The logistic model is proposed to evaluate the number of possible peaks in the coronavirus occurrence. The logistic model is used to forecast the COVID-19 epidemic data in some countries such as Italy, Brazil, India, Russia, Switzerland, Austria, Turkey, the Netherlands, Indonesia, South Korea, Peru, and also the

global (Martelloni and Martelloni 2020; Consolini and Materassi 2020; Pelinovsky et al. 2020; Wang et al. 2020). The generalized logistic model is a modified version of the sigmoid logistic functions, used generally in the case of growth modeling, to produce flexible S-shaped curves.

In general, the generalized logistic model “Richards’ curve” has some parameters: d the lower asymptote; E the upper asymptote when $C=1$. Then, if $A=0$, K , carrying capacity; r , growth rate; >0 , affects maximum growth. Q is value $Y(0)$. The additional parameter α provides a measure of flexibility in the curvature of the S shape exhibited by the resulting solution curve. The growth of the epidemic outbreak could be modeled as the following: $I(t)$ is the cumulative infected cases at time t in days, K is the total cases of the outbreak, r is the growth rate of the infected cases, and a is the exponent of deviation from the standard logistic curve. Flowchart for prediction of dynamic system using Loglet Lab is shown in Fig. 1.

Prediction of COVID-19 spread curves in Egypt

The diffusion of the COVID-19 pandemic may be considered a group of evolutionary processes that cause both global and national social phenomena. The vision of growth to a limit may be applied; the number of cases of COVID-19 (CN) grows rapidly before ultimately reaching a plateau. In brief, CN will grow exponentially, but the growth will be reduced due to negative feedback signals from the environment. So, CN cannot sustain exponential growth forever, and in the long run, CN will produce an S-shaped curve. In the case of the COVID-19 pandemic, this behavior depends on interactions among many factors that trigger the so-called logistic substitution model. The PHE has developed “Loglet Lab,” a software package to fit logistic curves. “Loglet Lab” applies the logistic substitution model to both single and multiple time-series datasets. “Loglet Lab 4,” launched in 2017, is the latest version that able to apply a range of statistical tools to analyze datasets. “Loglet Lab 4” can be used to perform the diffusion of human pandemic “COVID-19” and both human cognitive and physical performance, among other phenomena.

The implications and consequences of the COVID-19 pandemic on new patterns for water, food, health, and technologies that affect life security will be considered. The complex nature of epidemic spreading requires applying logistic models to take into account the different agents and numerous possible situations. The temporal growth of the COVID-19 pandemic utilizing logistic models has been applied in Egypt. The time window of the available pandemic data is between 31 December 2019 and 13 December 2020.

The analysis was performed with many logistic different models. The coefficients are estimated including predictable infected people, carrying capacity, growth rate, and exponent indexes in the logistic model. The generalized logistic

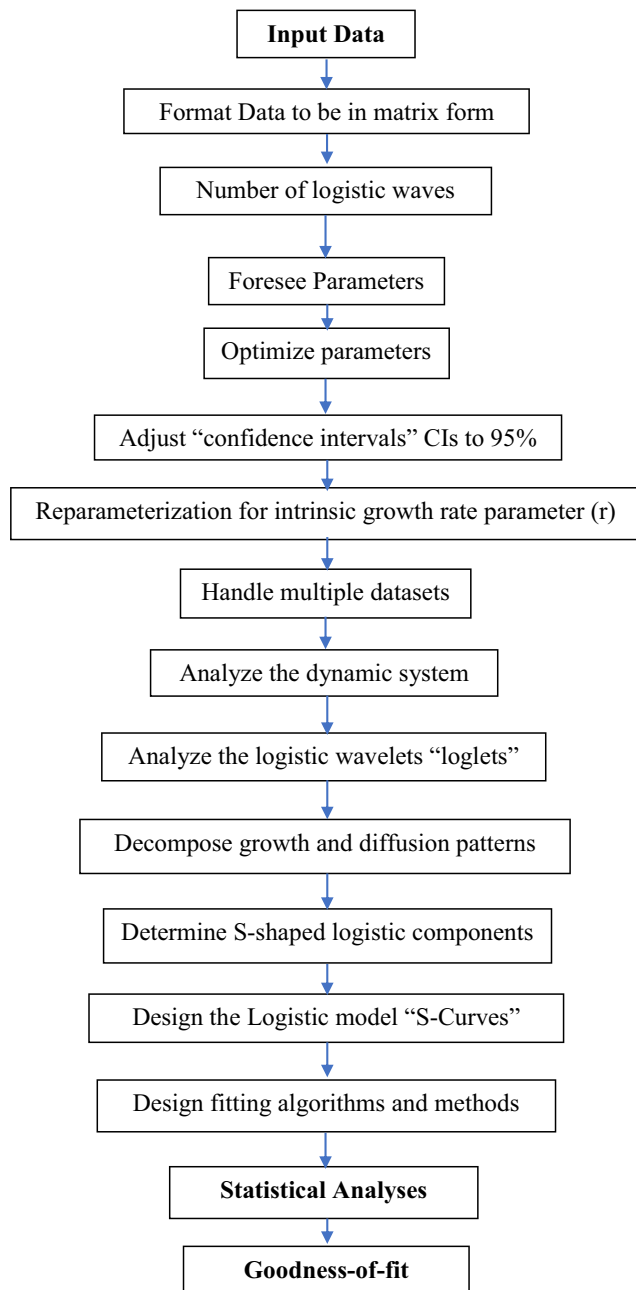


Fig. 1 Flowchart for prediction of dynamic system using Loglet Lab

equation was best described the Egyptian situation. The curves of serious infected and dead were performed until 1 April with a generalized logistic model. The testing COVID-

19 dataset has been provided by *Our World in Data* (Hasell et al. 2020).

The foresight process has been more complicated due to the uncertainty and risk associated with COVID-19. In 2020, the COVID-19 Policy Tracker has been launched by the Egyptian Ministry of Planning and Economic Development (MPED). The tracker provides an accurate up-to-date database for all policies that could be practiced in response to the COVID-19 pandemic. Different fields such as beneficiary, SDGs, implementing agency, and date could be searched. As an example, the beneficiary could be the water sector, food sector, and agricultural sector. On the other hand, the effects of the pandemic on the water, hygiene, and food sectors in Egypt are illustrated in Fig. 27. Adoption of non-conventional water resources has been presented as one of the key country’s response to mitigate the pandemic impact.

Theory and calculation

According to the World Health Organization (WHO 2020), and data from national authorities on 6 December 2020 concerning COVID-19 infections, there have been more than 1.5 million deaths and more than 65.8 million cases reported since the beginning of the pandemic. Egypt reports a resurgence in infections, and cases have increased since mid-October. Egypt is strengthening public health and social measures by reducing the working hours for supermarkets and shops and limiting the number of employees in government offices. As of 6 December 2020, COVID-19 confirmed cases and deaths and both new cases in the last 7 days and cumulative are shown in Table 1.

Loglet Lab is an online software tool with comprehensive statistical analysis capabilities built-in. The main idea of Loglet Lab is to simulate a dynamic system involving growth processes behavior by using a series of logistic wavelets “loglets.” The analysis of diffusion or growth patterns in terms of S-shaped logistic components in the easiest cases is the main function of Loglet analysis. The Loglet Lab 4.1 is the recent version of Loglet Lab that offers many features to facilitate both fitting functions selection and statistical analysis performance. Mathematical valuation of the epidemiological situation in terms of mathematical basis, models, functions, and algorithms is illustrated in Fig. 2.

Table 1 COVID-19 situation in Egypt, Eastern Mediterranean, and global

	Egypt	Eastern Mediterranean	Global
New cases in last 7 days (%)	2 831	242 563	3 970 427
Cumulative cases (%)	118 014	4 288 875	65 872 391
New deaths in last 7 days (%)	129	5 084	73 396
Cumulative deaths (%)	6 750	107 258	1 523 656

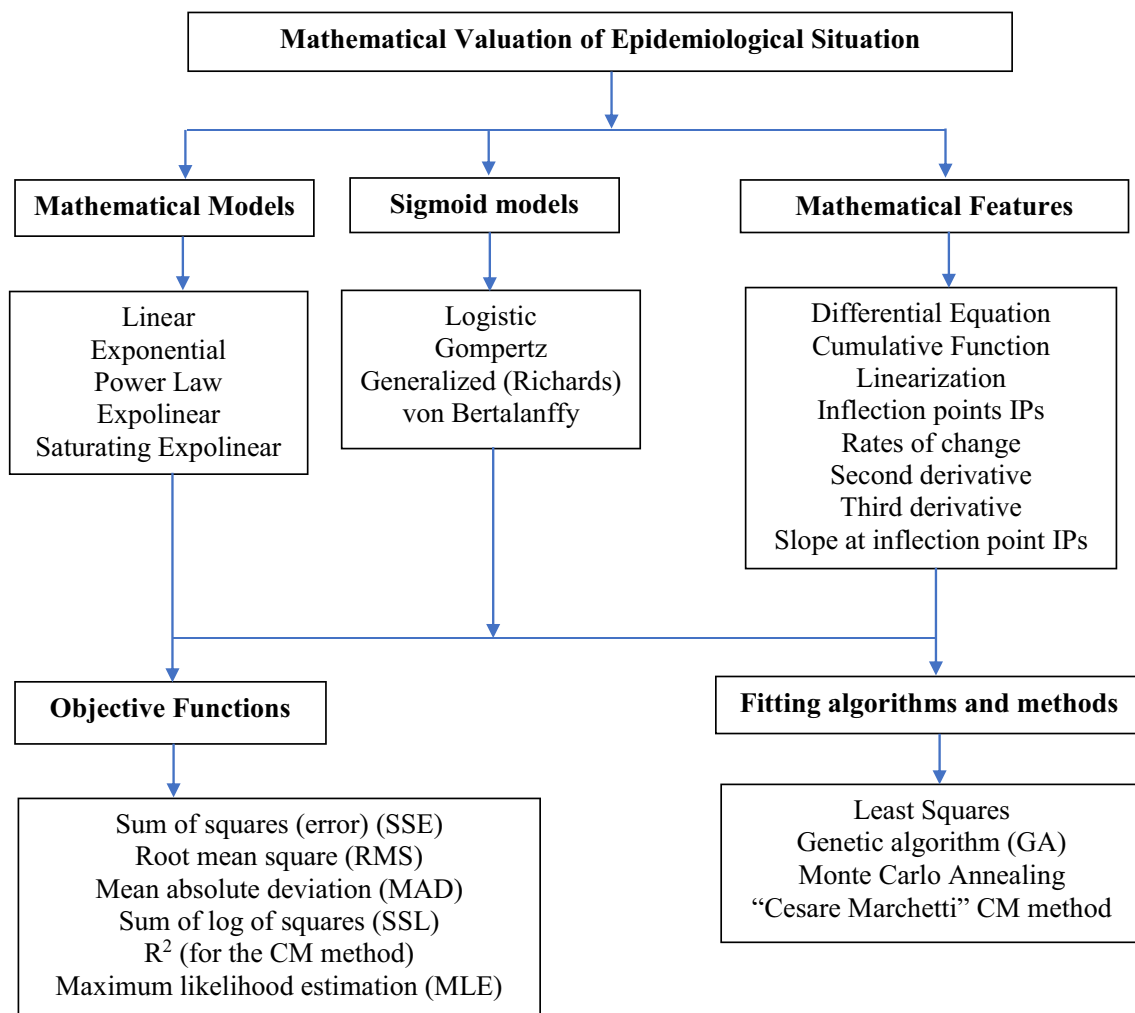


Fig. 2 Mathematical valuation of epidemiological situation

Loglet analysis is used to analyze sets of COVID-19 pandemic time-series data for foreseeing its diffusion trends. The Loglet analysis assumes the growth pattern of measured quantities (new cases, total cases, new deaths, and total deaths) and follows a sigmoid growth curve (S-shaped curve). The calculation was performed by the Loglet Lab software (Yung et al. 1999; Meyer et al. 1999; Knutsson and Andersson 2005). The dynamic characteristic of the COVID-19 outbreak epidemic process can be adequately predicted by using Loglet software (Postnikov 2020). The logistic model has been modified to predict growth trends of novel products for a growth process (Yu and Tseng 2016). Mathematical models used to manage and control invasive species have been summarized (Büyüktaktakın and Haight 2018).

In the “Methods” section, the author has highlighted how the logistic model be used to forecast the COVID-19 epidemic data in some countries in different continents such as the following:

- Asia—India, Indonesia, and South Korea
- Asia and Europe (Western Asia and Southeast Europe)—Turkey
- Europe and Asia (Eastern Europe and Northern Asia)—Russia
- Europe—Italy, Switzerland, Austria, and the Netherlands
- South America and Latin America—Brazil
- South America: Peru.

So, Egypt as an African country has no restriction to utilize such a logistic model to predict the pandemic spread. However, the researcher should adjust the parameters—mentioned in detail in the “Methods” section—so he could model the growth of the epidemic outbreak.

The prediction of parameters of the generalized logistic model for the epidemic outbreak COVID-19 spread in Egypt is shown in Appendix 2. The parameters include new cases, total cases, new deaths, total deaths, new cases per million, total cases per million, new deaths per million, and total deaths

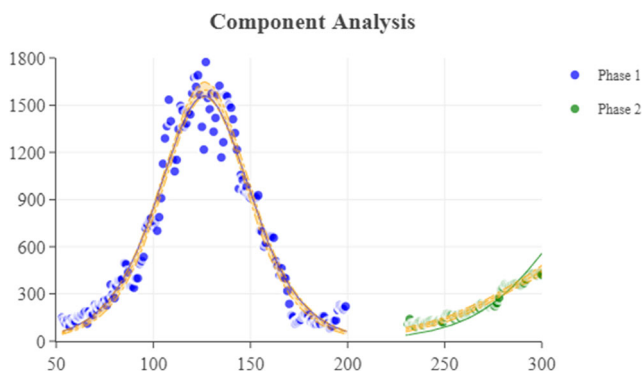


Fig. 3 New cases for 2 phases for time windows frame = 300 days

per million for 3-time windows, 300, 400, and 500 days, respectively.

Results

Prediction of COVID-19 spread curves is vital in Egypt. Figures 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 demonstrate the data obtained from *Our World in Data* and processed into Loglet Lab. The logistic curve was applied for the cumulative number of infected persons (new cases, total cases, new deaths, total deaths, new cases per million, total cases per million, new deaths per million, and total deaths per million). The plots (Figs. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26) demonstrate logistic curve fittings and predictions for three-time intervals 300, 400, and 500 days since the outbreak’s beginning. Results for new cases, total cases, new deaths, total deaths, new cases per million, total cases per million, new deaths per million, and total deaths per million for 2 phases for time windows frame are shown in Figures 3, 4, 5, 6, 7, 8, 9, 10 for time windows equal 300 days, Figures 11, 12, 13, 14, 15, 16, 17, 18 for time windows equal 400 days, and Figures 19, 20, 21, 22, 23, 24, 25, 26 for time windows equal 500 days, respectively. New cases for 2 phases time windows frame are shown in Figures 3, 11, and 19 for time windows 300 days, 400 days,

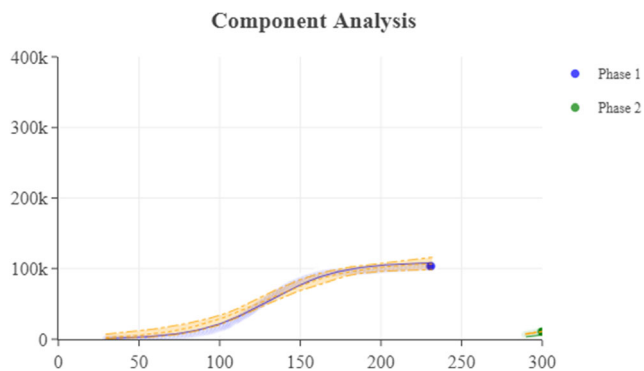


Fig. 4 Total cases for 2 phases for time windows frame = 300 days

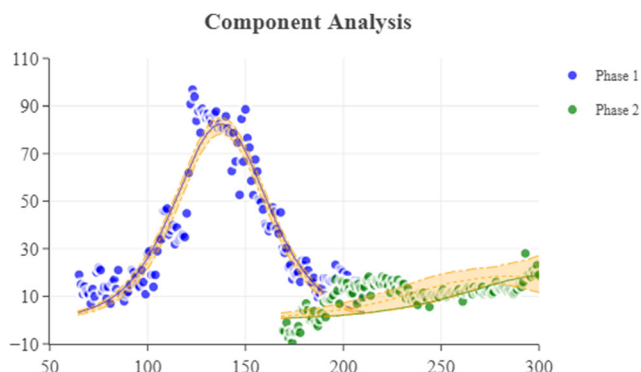


Fig. 5 New deaths for 2 phases for time windows frame = 300 days

and 500 days, respectively. Total cases are shown in Figs. 4, 12, and 20 for time windows 300 days, 400 days, and 500 days, respectively. New deaths are shown in Figs. 5, 13, and 21 for time windows 300 days, 400 days, and 500 days, respectively. Total deaths are shown in Figs. 6, 14, and 22 for time windows 300 days, 400 days, and 500 days, respectively. New cases per million are shown in Figs. 7, 15, and 23 for time windows 300 days, 400 days, and 500 days, respectively. Total cases per million are shown in Figs. 8, 16, and 24 for time windows 300 days, 400 days, and 500 days, respectively. New deaths per million are shown in Figs. 9, 17, and 25 for time windows 300 days, 400 days, and 500 days, respectively. Total deaths per million are shown in Figs. 10, 18, and 26 for time windows 300 days, 400 days, and 500 days, respectively. The solid parts of curves indicate logistic curve fittings, whereas dashed parts indicate predictions. Also, the blue color represented phase 1 whereas the green color represented phase 2.

The cumulative number of COVID-19-infected cases indicates infection trajectories for Egypt. Epidemiological modeling using Richards’ curve necessitates re-parameterizations of the generalized logistic function. The prediction of parameters is an essential task for processing of generalized logistic model. The parameters for the epidemic outbreak COVID-19 spread in Egypt are shown in Appendix 2. The parameters include K , carrying capacity [Persons]; r , growth rate [day⁻¹]; t_m , time [day]; d , the lower asymptote; $v > 0$, affects

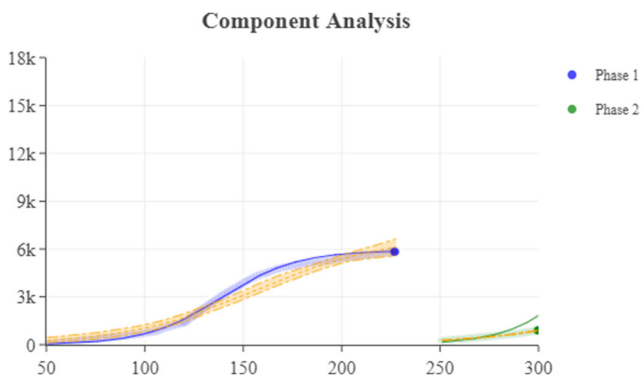


Fig. 6 Total deaths for 2 phases for time windows frame = 300 days

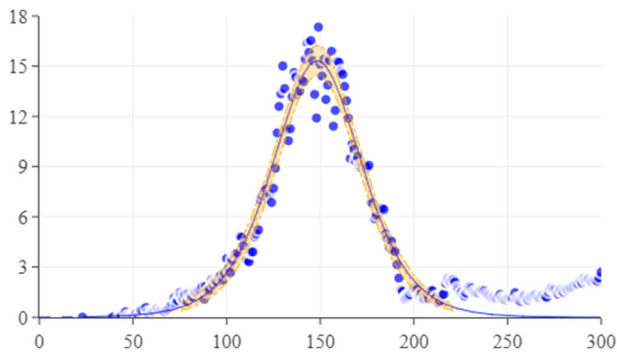


Fig. 7 New cases per million for 2 phases for time windows frame = 300 days

maximum growth; and a is the exponent of deviation from the standard logistic curve for both phase 1 and phase 2. These parameters are utilized in Figs. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26. The boundary values (minimum and maximum) and the median for each curve are presented in Appendix 2. These parameters are presented for new cases, total cases, new deaths, total deaths, new cases per million, total cases per million, new deaths per million, and total deaths per million, for 3-time windows, 300, 400, and 500 days, respectively, in Appendix 2.

Nowadays, variants of the COVID-19 pandemic have mutated into a more contagious version worldwide. Knowing that Loglet forecasting takes into account the evolution of multiple waves, new waves of the pandemic can be forecasted more easily. The main benefit of using Loglet forecasting by Richards' curve in COVID-19 epidemiological modeling is its comparatively easy expansion to the multiphase modeling of infection trajectories.

On the other hand, although the overall objective of the paper is to reshape the sustainable development trajectory due to the COVID-19 pandemic, only the first objective of the study is directly related to the logistic model using Loglet Lab software. So, it was found that to be more convenient and to not confuse the reader, these two objectives could be dealt with as dependent topics. In the other words, the other two objectives—to foresee implications and consequences of

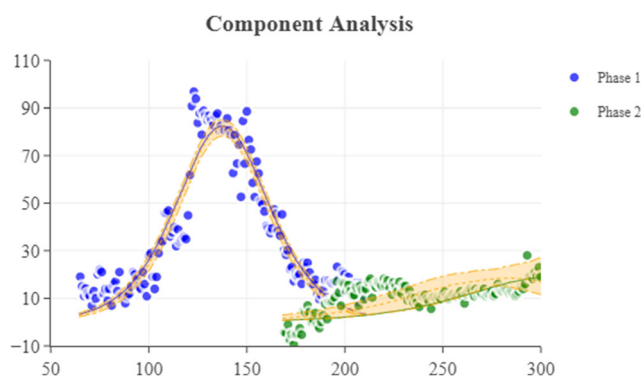


Fig. 8 Total cases per million for 2 phases for time windows frame = 300 days

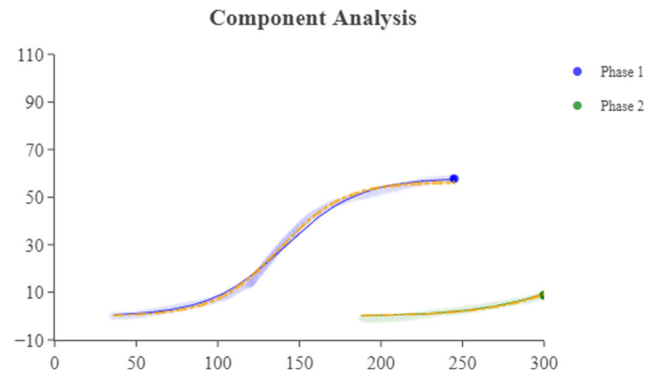


Fig. 9 New deaths per million for 2 phases for time windows frame = 300 days

the pandemic on water, food, and human activities, and to explore how Egypt could utilize non-conventional water resources as a precious resource to fight the pandemic—are not directly related to the generalized logistic model. Only, these two objectives are mandatory to complete the overall objective of the paper.

Dataset 1: time window = 300 days

Dataset 2: time window = 400 days

Dataset 3: time window = 500 days

Discussion

Egypt has been on an optimistic trajectory to achieve its Sustainable Development Goals (SDGs). The outbreak of the COVID-19 pandemic has caused a global recession. Despite the negative socioeconomic impact, the economic stabilization and reform program enhanced the economic resilience in Egypt. The Egyptian economy has been among the very few worldwide register positive growth. In 2021, Egypt has been one of 10 countries submitting its third Voluntary National Review (VNR) worldwide. The 3rd VNR has

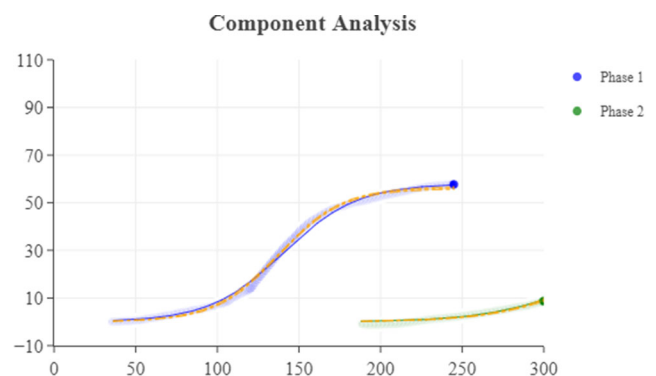


Fig. 10 Total deaths per million for 2 phases for time windows frame = 300 days

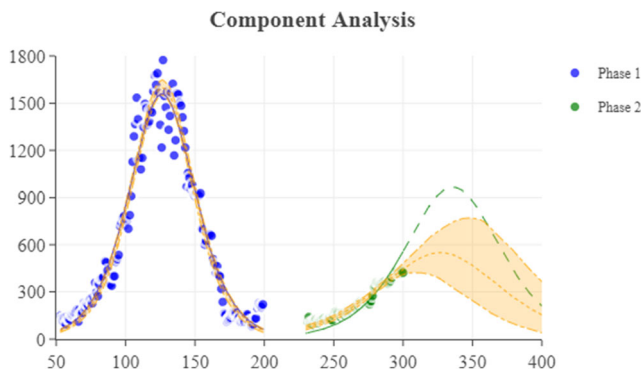


Fig. 11 New cases for 2 phases for time windows frame = 400 days

focused on how Egypt would weather the COVID-19 pandemic and other unexpected shocks by a resilient economy.

Recently, many researchers and scholars have assessed the impact of coronavirus spread-prevention actions on water consumption. A case study using the data before and after governmental actions in Brazil has been reported. The water consumption (m^3/day) has increased by 11% in the residential category. The residential category includes houses, condominiums, and apartment buildings (Kalbusch et al. 2020). Hand hygiene and personal hygiene are important public health practices to prevent the widespread of COVID-19 pandemic community transmission (Pung et al. 2020). In England, households’ water consumption before and during the COVID-19 lockdown period was assessed. A sharp increase in per household consumption (PHC) of 13% in March, 22% in April, and 29% in May 2020 across the network was recorded. During the lockdown, the mean water demand was 27% higher than the pre-lockdown. On the other hand, the clusters of household water consumers namely evening peak, late morning, early morning, and multiple peaks were increased by 25%, 29%, 11%, and 14% during lockdown PHC (l/h/d) compared with pre-lockdown PHC (l/h/d), respectively (Abu-Bakar et al. 2021). In Poland, increased water consumption was observed in apartment buildings (Dzimińska et al. 2021). In Nepal, water consumption increased during the COVID-19 lockdown (Shrestha et al. 2021). In Germany, residential water consumption increased

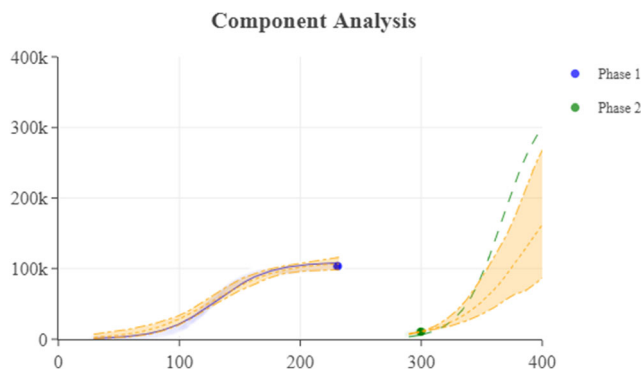


Fig. 12 Total cases for 2 phases for time windows frame = 400 days

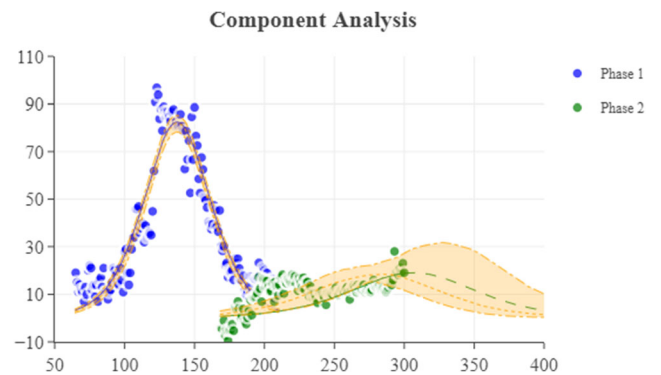


Fig. 13 New deaths for 2 phases for time windows frame = 400 days

by 14.3%, per day, during the COVID-19 pandemic (Lüdtke et al. 2021). In Emirates, residential water demand increased during the COVID-19 pandemic (Rizvi et al. 2021). In Zimbabwe, domestic water demand increased by 9% (Zvobgo and Do 2020). In Bangladesh, overuse of water during the COVID-19 pandemic due to handwashing with soap was observed (Sayeed et al. 2021).

The COVID pandemic-related impact in Egypt

The sustainable cooperation between the Egyptian Government (GoE), private sector and civil society, and international organizations yields sustainable development in Egypt. United Nations agencies (FAO, IFAD, UNIDO, and WFP) have supported Egypt to mitigate COVID-19 impact and accelerate COVID recovery. The agri-food system in Egypt including agriculture and food production contributes by 24.5% to Egypt’s GDP. COVID-19 magnifies weaknesses in Egypt’s agri-food sector and complicates the challenges of the agri-food sector. An assessment of the food system and the impact of COVID-19 in Egypt was implemented. The assessment investigated supply, demand, labor, production, and finance (UNIDO 2020).

According to MPED (2021), knowing that the first defense against the pandemic is washing hands, the GoE has facilitated access to clean water, deferred payments of both residential and commercial water bills, and allowed customers to pay for

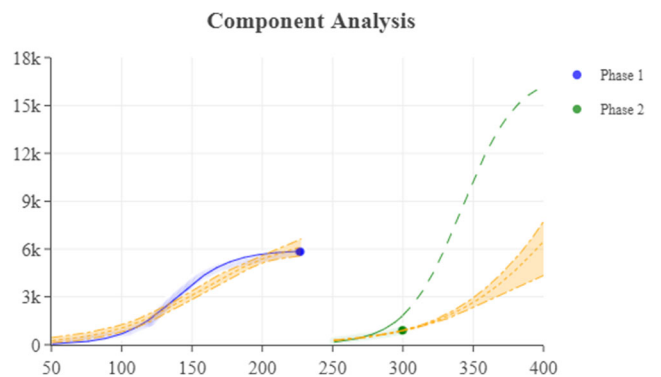


Fig. 14 Total deaths for 2 phases for time windows frame = 400 days

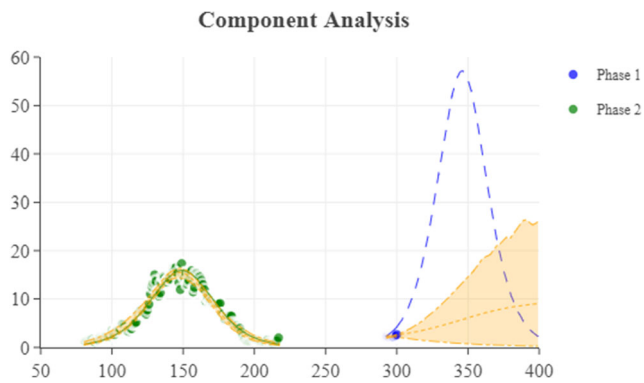


Fig. 15 New cases per million for 2 phases for time windows frame = 400 days

water and wastewater services smoothly using a smartphone application and online portal without the need for physical movement. Based on the data published in MPED (2021), the COVID pandemic-related effect in Egypt is presented in Table 2. In general, the impacts of the pandemic on nationwide Sustainable Development Goals (SDGs) indicators have been mercifully moderate. Living in households with access to basic services—clean water, sanitation, and electricity—is an essential indicator to assess extreme poverty. Keeping in mind that access to clean water has increased from 90.0 in 2015 to 97.0% in 2019, and access to sanitation from 50.0 in 2015 to 66.2% in 2019. Rates of extreme poverty are expected to have slowed down from 2019 to 2020 (with COVID) rather than a potential case without COVID. The effect of the COVID-19 pandemic on hunger-related indicators is negligible in Egypt. The hunger-related indicators have been negligibly impacted by the COVID-19 pandemic in Egypt. The key good health and wellbeing indicators are under-5 mortality rates (U5MR) and neonatal mortality rates (NMR). In 2019, Egypt has achieved the target for both indicators. U5MR and NMR have reached 19.2 and 7.5 less than 25 and 12 per 1,000 live births, respectively. In 2020, the pandemic has caused a slowdown in progress for both indicators. U5MR and NMR have dropped to 19.0 and 7.4 as opposed to 18.8 and 7.3 under a no COVID scenario, respectively.

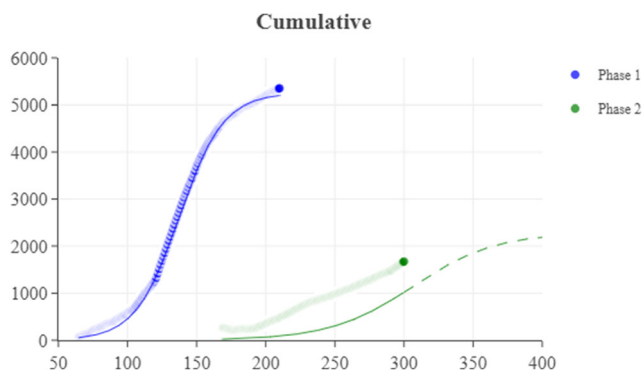


Fig. 16 Total cases per million for 2 phases for time windows frame = 400 days

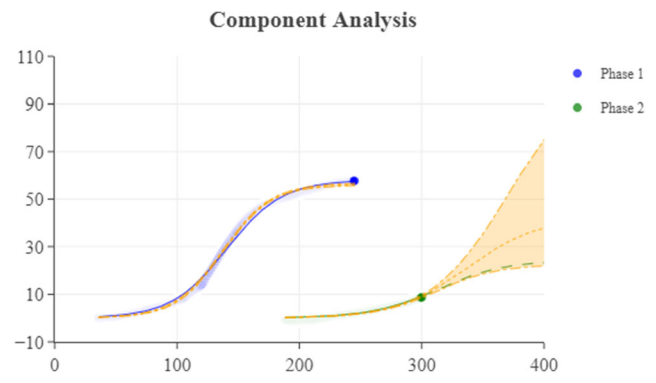


Fig. 17 New deaths per million for 2 phases for time windows frame = 400 days

The history will judge the effectiveness of the response to COVID-19 pandemic to the benefit of the human family, by the degree to which the response is organized across all sectors, not by actions of isolated government actors. With the correct actions, the COVID-19 pandemic can sustain the rebirthing of humanity to protect future generations (United Nations 2020). COVID-19 epidemic has affected the water, hygiene, and food sectors in Egypt. Many direct and indirect impacts on water, hygiene, and food sectors have occurred. Regular handwashing is considered the most significant measure to prevent coronavirus. This certainly harms water consumption. The quarantine has caused both slowdown in industrial activities and reduced commercial demand for water, which negatively affected utility revenues. Simultaneously, unemployment has left a growing number of families unable to pay their water bills. The assessments have indicated an increase in water use in the household sector and increased demand in the agricultural sector in light of food security concerns. Both water consumption and water demand levels have changed in Egypt. The economic impact has increased in the people unable to pay water bills and/or food costs, thus weakening the resources available for operations, maintenance, and repairs.

Many measures have been taken to assess the new circumstances imposed by the COVID-19 epidemic. The ministries

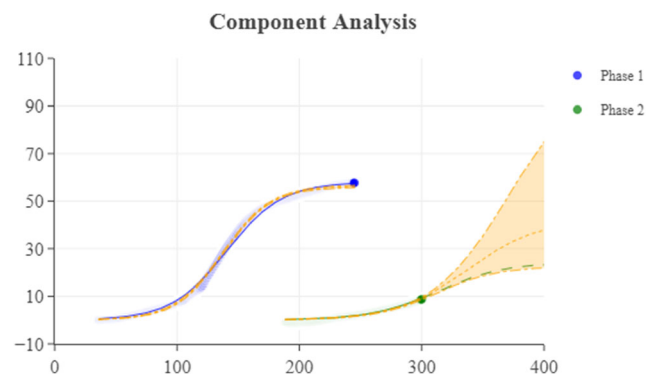


Fig. 18 Total deaths per million for 2 phases for time windows frame = 400 days

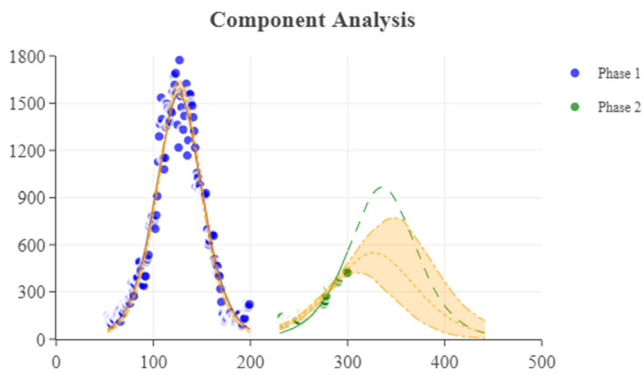


Fig. 19 New cases for 2 phases for time windows frame = 500 days

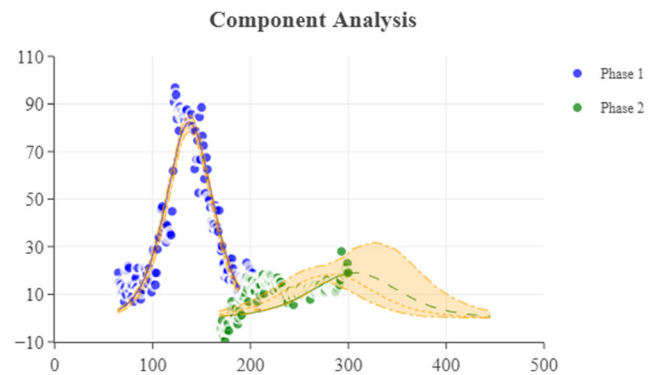


Fig. 21 New deaths for 2 phases for time windows frame = 500 days

responsible for water, hygiene, and food services; water utilities; and operators faced increased pressure to provide safely managed water, food, and hygiene services to face the constraints of movement and difficulty recovering costs. Egypt has efficiently managed to ensure the sustainability of water, hygiene, and food services. The actors in the water, hygiene, and food field (government institutions, water utilities, food organizations, etc.) have organized awareness campaigns about the importance of the water, hygiene, and food sectors to limit the spread of the epidemic and participated in its expansion. Egypt has initiated effective measures to alleviate the economic hardship and support those unable to pay by providing cash and low-cost price goods. Water suppliers have reconnected customers, with meter reading and bill collection suspended. So many water suppliers have seen their revenue stall.

The epidemic has affected the sustainability of water, hygiene, and food institutions. Egypt contains millions of refugees and poor persons, who are at greater risk because of the lack of water, hygiene, and food services in their overcrowded areas. Egypt has initiated a variety of measures to reduce the vulnerability of refugees and poor persons, and those not associated with public services to COVID-19.

Egypt has engaged in reforms and exploring new ways to operate water, hygiene, and food services and awareness to overcome the challenges that the epidemic has exacerbated. Egypt has initiated significant activities to speed up the digital

transformation of water, hygiene, and food management. A measurable change in the management of water, hygiene, and food resources will be achieved. The population could be participated to adopt the position in the future. COVID-19 detection trials in wastewater and sludge as a tool for early screening of public health are a good example. Egypt plans to monitor wastewater and sludge as a new technology for using water to monitor diseases. Egypt foresees many such digital initiatives in the future, especially in artificial intelligence. Egypt has engaged in the exchange of experiences and cooperation with other countries and international organizations during the crisis. The effects of the pandemic on the water, hygiene, and food sectors in Egypt are illustrated in Fig. 27.

The Nile Delta is formed in Egypt where the Nile River splits into two distributaries, the Rosetta Branch and the Damietta Branch that nourishes the Mediterranean Sea. The Nile Delta has a very fertile agricultural land, so it is considered the main agricultural and food production region in Egypt. Typology of climate change impacts on water resources management and agricultural systems in the Nile Delta has indicated rising sea levels and saline intrusion in the groundwater and the two distributaries of the Nile River. The key response options indicate the adaptive approaches that apply to the Nile Delta. From an agricultural perspective, simultaneous use of both surface and groundwater water is a key response option to achieve adaptability (UNESCO 2020). Supplementary irrigation (rain-fed and irrigated schemes) can

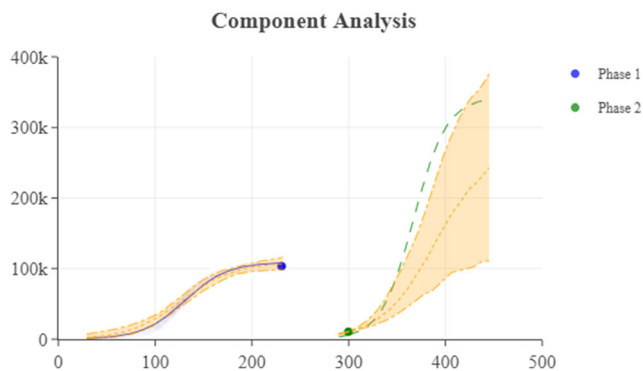


Fig. 20 Total cases for 2 phases for time windows frame = 500 days

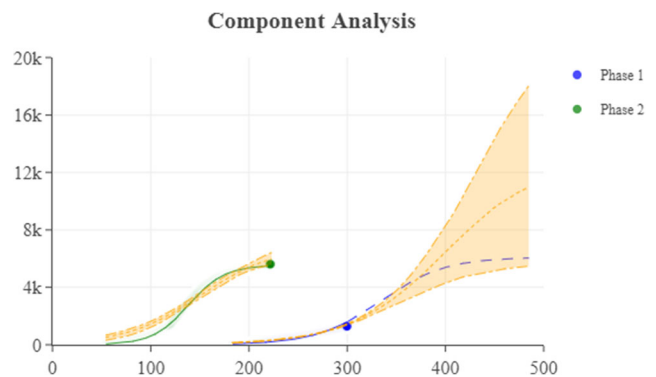


Fig. 22 Total deaths for 2 phases for time windows frame = 500 days

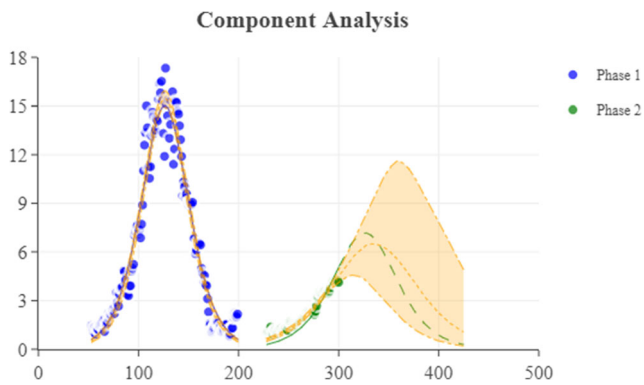


Fig. 23 New cases per million for 2 phases for time windows frame = 500 days

be utilized as a principal measure for the efficient management of water resources in the Nile Delta (ESCWA 2019). Water balance for Egypt (15/16–18/2019) in billion m^3 /year and production of refined/non-refined water (16/2017–17/2018) are clarified in Table 3.

Non-conventional water resources

Non-conventional water resources are feasible opportunities to deal with water scarcity, particularly in arid and semiarid areas. Non-conventional water resources have been defined as the total volume of water obtained through the development of new technologies. They are water productions that are harvested by desalination of sea waters or by wastewater reuse (FAO 2003). In Egypt, non-conventional water resources include but are not limited to desalination, surface groundwater (in Nile valley and Delta), reuse of greywater, reuse of wastewater, recycling of agricultural drainage water, recycling of sewage water, and atmospheric moisture harvesting. Future scenarios of Egypt's water, hygiene, and food dilemma have been applied. Non-water-based solutions as awareness and educational initiatives may be a suitable response to the water resources. Unconventional water could improve water use efficiency and strengthen other water resources quantities (Abdelkader et al. 2018).

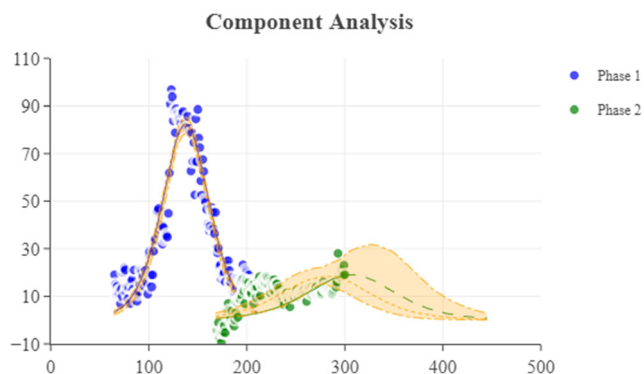


Fig. 24 Total cases per million for 2 phases for time windows frame = 500 days

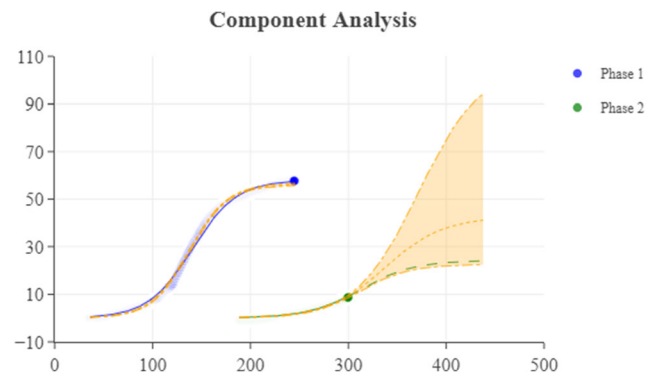


Fig. 25 New deaths per million for 2 phases for time windows frame = 500 days

Focusing on sustainable water resources planning, non-conventional water resources were studied to evaluate surface-groundwater interactions (Eshtawi et al. 2016). An optimization model that involves conventional and unconventional water has been developed to maximize the water allocation and distribution efficiency (Molinos-Senante et al. 2014). Desalination as a conventional water resource has been used to match between water availability and consumption and to supply more water resources (Mendoza-Grimón et al. 2019). Desalination projects have high social benefits. A small desalination plant has been built to irrigate both green areas and parks (Aparicio et al. 2018). Greywater resulted from the residential and commercial buildings approximately counts up to 50–80% of the household wastewater (Yoonus and Al-Ghamdi 2020). Forecasted relative humidity and temperature were used to estimate cumulative dew yields based on future climate change scenarios (Tomaszkiewicz et al. 2016).

Non-conventional resources enable sustainable use of water-stressed river basins (Pedro-Monzonís et al. 2016). Non-conventional water resources can be used for achieving sustainable food production in semiarid and arid environments (Hussain et al. 2019). Irrigation scenario for vine crops considers mixing groundwater with desalinated water, which enhances water availability and quality and increases benefits for farmers (Aparicio et al. 2019). The application of non-

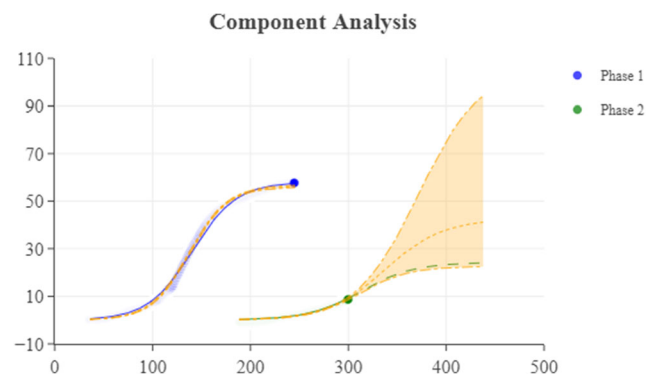


Fig. 26 Total deaths per million for 2 phases for time windows frame = 500 days

Table 2. The COVID pandemic-related impact in Egypt

		2019	2020 No COVID	2020 COVID
1	Extreme poverty (\$1.90) (% of population)	4.5	4.1	4.4
2	Access to improved sanitation (% of the population)	70.6	71.0	70.9
3	Malnourished people, % of population	4.4	4.1	4.1
4	Stunting, % of children aged 0–5	17.5	17.6	17.6
5	Under-5 mortality rate	19.2	18.8	19
6	Neonatal mortality rate	7.5	7.28	7.38
7	GDP per capita growth rate (PPP)	3.5%	2.7%	0.4%
8	Agricultural losses as a share of production	22.3	22.2	22.2

conventional water resources in irrigated agriculture impacts water-energy nexus due to energy consumed in pumping and/or treatment (Espinosa-Tasón et al. 2020). Although sustainable irrigation with saline reclaimed water as a non-conventional water resource did not affect fruit (mandarin) quality, it increased soil salinity and reduced both water productivity and crop yield (Nicolás et al. 2016). Unconventional water resources could be utilized to adapt to both drought and climate change (Morote et al. 2019).

Egypt is a country with limited water resources. Egypt's water needs are growing rapidly because of the population increase, climate change, and development activities. The Egyptian per capita water has decreased in the last 200 years from about 20,000 per year to about 600 m³ per year. The threshold of water poverty—water of an inadequate quantity or quality, to meet basic human needs—is about 1,000 m³ per capita per year. So, Egypt has fallen into the water poverty zone. The importance of groundwater in Egypt is because surface water is no longer sufficient for all national water needs throughout the year. Therefore, reliance on groundwater for needs management is imperative. Currently, groundwater is the second water resource in Egypt, contributing by 6.7 billion m³ of total available resources, with a relative importance of 8.8% of the volume of our water resources. Based on the data of the Ministry of Water Resources and Irrigation in Egypt, *water balance* is illustrated in Table 3, during the period 08/2009–15/2016. The table shows both *available water resources* and *uses of water* by volume (billion cubic meters) per year, taking into consideration that Egypt's water year begins *on the first of August* and *ends on July 31 of the next year*. Groundwater wells of the first phase of the national project are shown in Table 4.

National Project for Agricultural Development and Reclamation

Egypt has initiated the first phase of the 4 million feddan project to reduce the food gap, fight unemployment, and enhance the populated area through the creation of new urban

communities and sustainable agriculture. National Project for the Development and Reclamation of one and a half million Egyptian acres will be discussed as a case study. The one and a half million feddan project are one of the giant agricultural development projects that Egypt has started to implement. The main objective of the national project is to create sustainable communities, absorb the natural growth of the population, establish modern integrated urban communities, expand urban space, and develop agricultural, housing, and food, increasing the cultivated areas of strategic crops such as “wheat and oil,” growing investment and national production of agricultural, animal and poultry production, and industries dependent on agricultural activity, which contributes to increase the populated area and provide employment opportunities for young people and small farmers.

The project exists in 10 locations all over Egypt, West of the west Minya, Farafra, Moghra Oasis, Al Dakhla (Dakhla Oasis), West Marashda (Qena), East Siwa, West Kawn Umbo, Al Tor (Sinai), Toshka, and South East Monkhafad as shown in Fig. 28. The Egyptian Countryside Development Company (ECDC) is the source of the Physical Map of the National Project for Reclamation, Egypt, shown in Fig. 28.

The national project for the Development and Reclamation of one and a half million acres is the first land reclamation project since the state stopped land reclamation in 2005. The land area of about 500,000 feddans was allocated within the first phase of the 1.5 million feddans project through the new Egyptian Rural Development Company. The four new areas of the Egyptian Western Desert are the old Farafra, the oasis of Al-Moghra in El-Alamein area, the west of Minya region, and the Toshka area. Twenty-five percent of the land is allocated to the Egyptian youth for ownership, 75% is allocated to investors, and 10% of the areas allocated to young people and small farmers is devoted to establish linked projects with agricultural activities for these areas or to serve the agricultural activity. Training courses and capacity building programs for the beneficiaries of these lands are carried out over the course of 6 months to identify the appropriate crop structure for each region, the quality of the less water-consuming crops, and the

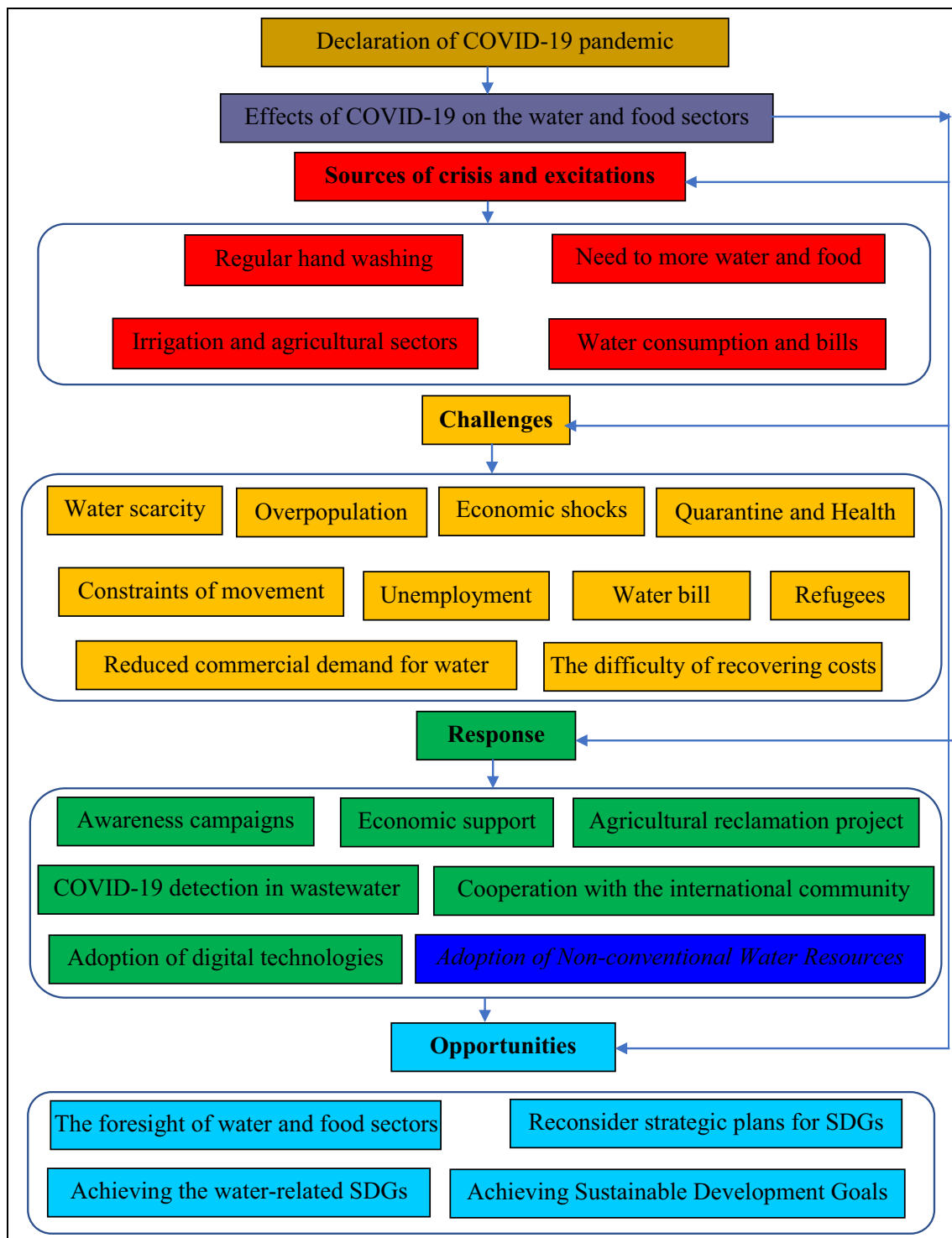


Fig. 27 The effects of the COVID-19 pandemic on water, hygiene, and food sectors

highest economic return in each region of this new reclamation project.

The rules and conditions for participating in the project from different categories (investors, small farmers, and young people), which contribute to the realization of the objectives of the project, have been formulated not only for agricultural

development but also for the establishment of new urban communities, including agricultural manufacturing, animal and poultry production, aquaculture and logistics, and industrial areas for packing and packaging products and others, and the establishment of some rations and administrative areas that serve projects.

Table 3 Water balance for Egypt

Water resources (unit: billion m ³ /year)				
Source	15/2016	16/2017	17/2018	18/2019
Nile water	55.50	55.50	55.50	55.50
Deep groundwater	2.10	2.40	2.45	2.45
Rains and floods	1.30	1.30	1.30	1.30
Desalination	0.21	0.25	0.35	0.35
Total traditional water resources	59.11	59.45	59.60	59.60
Surface groundwater (Delta)	7.39	7.05	7.15	7.00
Reuse of wastewater	13.50	13.50	13.50	13.65
Non-traditional water resources	20.89	20.55	20.65	20.65
Total water resources	80.00	80.00	80.25	80.25
Uses of water resources				
For drinking	10.65	10.65	10.70	10.70
For industry	5.40	5.40	5.40	5.40
For agricultural	61.45	61.45	61.65	61.65
Evaporation	2.50	2.50	2.50	2.50
Total uses of water resources	80.00	80.00	80.25	80.25
Water resources				
Production of refined/non-refined water (unit: MIL. M)				
Year	16/2017	16/2017	17/2018	17/2018
Item	Refined	Non-refined	Refined	Non-refined
Total Egypt	8. 867	78	8. 752	17.8

Source: CAPMAS, Egypt in Figures 2020, and Ministry of Water Resources and Irrigation

The new Egyptian Rural Development Company is the representative of the state and is responsible for the follow-up on everything related to the bidding process and the distribution of land on accepted bids and the collection of fees and premiums, as well as to overcome the obstacles that investors or small-scale farmers and young people may face. The group of individuals benefiting from land lots is bound by the terms and conditions set by the Egyptian Rural Development Company, including the recommendations of the studies approved by the Ministries of Agriculture and Irrigation in terms of the behavior and capacities of wells, crop structures, strategic crops that will be carried out in each area, and the residential areas to be leased to the beneficiaries of the project lands. Areas and prices of the first phase of the national project for the Development and Reclamation of one and a half million acres are shown in Table 5.

The pandemic has negatively impacted economic growth. By 2020, Egypt’s GDP per capita growth has dropped to 0.4% (2.1% without COVID). The agricultural losses in terms of reducing production and raising the total amount lost have been negatively impacted due to the COVID-19 pandemic. According to MPED (2021), food manufacturers’ production capacity has dropped by 30–40%, with a contraction in revenues. The Governmental Egyptian policies have been swiftly implemented to ensure both food security during global lockdowns and sustainability of the National Project for Agricultural Development and Reclamation. According to MPED (2021), the Egyptian Government (GoE) has granted agriculture sector company loans at a diminished interest rate to support their survival during the COVID pandemic. GoE has implemented several fiscal and non-fiscal policies to rescue the economic sectors (including agricultural). The goal

Table 4 Groundwater wells of the first phase of the national project

Region	Available area (acres)	Water well
West of the west of Minya	120,000	278
Old Farafra	100,000	178
Oasis of Al-Moghra in Al-Alamein Region	170,000	447
Toshka	110,000	102

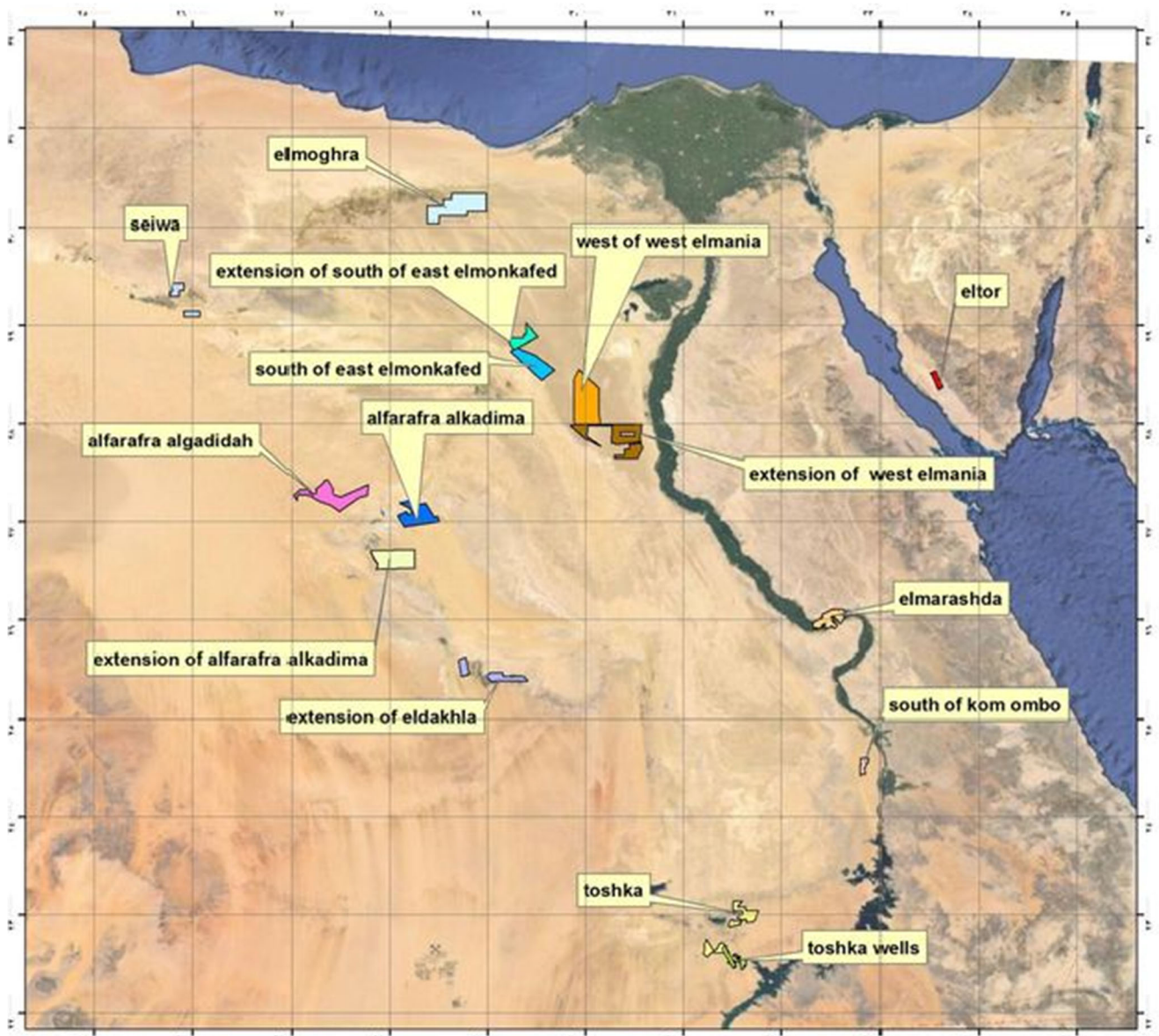


Fig. 28 Physical Map of National Project for Reclamation, Egypt (source: ECDC)

has been to retain the workforce and maintain activities, operations, and production. The focus has been to save agricultural SMEs and small agricultural business owners until stabilizing their circumstances. The fiscal policies have included waiving late fees on income tax,

VAT, customs tax, real estate tax, and other state dues. Also, loan installments have been deferred for small agricultural business owners. Examples of non-fiscal policies are exempt the food sector from both night-time curfew and movement restrictions. Also, GoE (represented by the Egyptian

Table 5 Areas and prices of the national project for the Development and Reclamation

Region	Available area (acres)	Price (thousand pounds/acres)		Notes
		Small farmers and young people	Investors	
West of the west of Minya	120,000	45	65	Including infrastructure
Old Farafra	100,000	45	65	Including infrastructure
Oasis of Al-Moghra in Al-Alamein Region	170,000	18	20	Including the well
Toshka	110,000	25	30	Without infrastructure

Agricultural Bank) has deferred loan payments for both breeders and farmers for a period of 6 months.

Conclusions

COVID-19 epidemic has direct and indirect impacts on the water and agriculture sectors in Egypt. The impact of the epidemic has generated an increase in the number of people unable to pay food and health bills. Egypt has initiated several measures to alleviate the economic hardship and support those unable to pay the water bills. The need to provide water services to washing the hands of all citizens has been emphasized more to fight coronavirus. Egypt faces this unprecedented epidemic to find appropriate solutions to crystallize a more flexible future for water, hygiene, and food sectors and improve the ability to adapt to health challenges and economic shocks. Egypt has initiated several measures to alleviate the economic hardship and support those unable to pay the water bills. The COVID-19 epidemic may be addressed by strengthening the regional cooperative framework and enhancing the capacity of the water, hygiene, and food sectors to better cope with future shocks. This health crisis can help strengthen cooperation in the field of safe and sustainable management of water, hygiene, and food sectors in the world. The focus is to enable Egypt to continue providing high-quality water,

hygiene, and food services to the population. The water, hygiene, and food sectors during this health crisis, like many sectors, discovered the possibility of working remotely as the adoption of digital technologies increased the capacity to respond to the pandemic. As governments, companies, and civil society race to curb the COVID-19 pandemic, water, hygiene, and food professionals may find an opportunity to reconsider strategic plans and improve the path towards achieving the water- and food-related Sustainable Development Goals. The main recommendations of the study are the following: continually collect experiences and expertise in the water, hygiene, and food sectors in the world during the response stages to the epidemic, as well as documenting best practices and integrating them into plans to ensure the sustainability of water, hygiene, and food services; and enable support for regional cooperation to contribute to enhancing the efficiency of the water, hygiene, and food sectors by disseminating best practices, innovations, and lessons learned for the water, hygiene, and food sectors services in Egypt; safe and sustainable management of water, hygiene, and food sectors should be emphasized due to the human perception and knowledge of the population and decision-makers in the future; and water, hygiene, and food professionals should find an opportunity to reconsider strategic plans and improve the path towards achieving the water-related Sustainable Development Goals.

Appendix 1

Table 6 Coronavirus pandemic Egypt profile

Constants (approximately)		Variables (at 2020-11-21, day 327)	
Item	Value	Item	Value
Population	102334403	Date	2020-11-21
Population density	97.999	Day	327
Median age	25.3	Total cases	112318
Aged 65 older	5.159	New cases	363
Aged 70 older	2.891	New cases smoothed	285.571
GDP per capita	10550.206	Total deaths	6521
Extreme poverty	1.3	New deaths	13
Cardiovasc death rate	525.432	New deaths smoothed	13.143
Diabetes prevalence	17.31	Total cases/million	1097.559
Female smokers	0.2	New cases/million	3.547
Male smokers	50.1	New cases smoothed/million	2.791
Handwashing facilities	89.827	Total deaths/million	63.722
Hospital beds/thousand	1.6	New deaths/million	0.127
Life expectancy	71.99	New deaths smoothed/million	0.128
Human development index	0.696		

Appendix 2

Prediction of parameters of generalized logistic model

Prediction of parameters of the generalized logistic model for the epidemic outbreak COVID-19 spread in Egypt is shown in Appendix 2. The parameters include new cases, total cases, new deaths, total deaths, new cases per million, total cases per million, new deaths per million, and total deaths per million, for 3-time windows, 300, 400, and 500 days, respectively.

Dataset 1: 300 days

New cases

2 waves

Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	99404 [94984–101501] Median: 97915	0.0627 [0.062–0.068] Median: 0.065	126 [126–127] Median: 126	1.00 [1.0–1.0] Median: 1.0
Phase 2●	88879 [43267–93676] Median: 64331	0.0435 [0.031–0.041] Median: 0.035	336 [310–344] Median: 327	1.00 [1.0–1.0] Median: 1.0

Total cases

2 waves

Current model: Richards logistic

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	108984 [99146–125175] Median: 108957	96.6 [79–174] Median: 116	131 [120–142] Median: 128	0.0455 [0.056–0.025] Median: 0.038
Phase 2●	0.000 [0.00–0.00] Median: 0.00	342823 [114861–461889] Median: 292009	74.1 [88–162] Median: 120	367 [355–433] Median: 390	0.0593 [0.050–0.027] Median: 0.037

New deaths

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

Total deaths

2 waves

Current model: derivatives

Logistic	d	K	a	tm	r
Phase 1●	0.227 [0.019–0.22] Median: 0.12	5919 [5871–8311] Median: 6857	84.6 [108–188] Median: 144	139 [142–175] Median: 157	0.0520 [0.041–0.023] Median: 0.031
Phase 2●	0.988 [0.78–0.98] Median: 0.89	17073 [6731–25014] Median: 16471	86.9 [166–191] Median: 179	342 [372–440] Median: 416	0.0506 [0.026–0.023] Median: 0.025

New cases per million

2 waves

Current model: Richards logistic

Richards derivative	K	r	tm	v
Phase 1●	2654 [645–3860] Median: 1699	0.0861 [0.016–0.044] Median: 0.025	346 [172–470] Median: 399	1.00 [1.0–1.0] Median: 1.0
Phase 2●	952 [874–998] Median: 928	0.0668 [0.058–0.072] Median: 0.067	149 [146–149] Median: 148	1.00 [1.0–1.0] Median: 1.0

Total cases per million

2 waves
Current model: Logistic

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

New deaths per million

2 waves
Current model: Richards derivative

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
Phase 2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Total deaths per million

2 waves
Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
Phase 2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Dataset 2: 400 days

New cases

2 waves
Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	99404 [94984–101501] median: 97915	0.0627 [0.062–0.068] median: 0.065	126 [126–127] median: 126	1.00 [1.0–1.0] median: 1.0
Phase 2●	88879 [43267–93676] median: 64331	0.0435 [0.031–0.041] median: 0.035	336 [310–344] median: 327	1.00 [1.0–1.0] median: 1.0

Total cases

2 waves
Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	108984 [99146–125175] Median: 108957	96.6 [79–174] Median: 116	131 [120–142] Median: 128	0.0455 [0.056–0.025] Median: 0.038
Phase 2●	0.000 [0.00–0.00] Median: 0.00	342823 [114861–461889] Median: 292009	74.1 [88–162] Median: 120	367 [355–433] Median: 390	0.0593 [0.050–0.027] Median: 0.037

New deaths

2 waves
Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

Total deaths

2 waves
Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.227 [0.019–0.22] Median: 0.12	5919 [5871–8311] Median: 6857	84.6 [108–188] Median: 144	139 [142–175] Median: 157	0.0520 [0.041–0.023] Median: 0.031
Phase 2●	0.988 [0.78–0.98] Median: 0.89	17073 [6731–25014] Median: 16471	86.9 [166–191] Median: 179	342 [372–440] Median: 416	0.0506 [0.026–0.023] Median: 0.025

New cases per million

2 waves
Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	2654 [645–3860] Median: 1699	0.0861 [0.016–0.044] Median: 0.025	346 [172–470] Median: 399	1.00 [1.0–1.0] Median: 1.0
Phase 2●	952 [874–998] Median: 928	0.0668 [0.058–0.072] Median: 0.067	149 [146–149] Median: 148	1.00 [1.0–1.0] Median: 1.0

Total cases per million

2 waves
Current model: Logistic

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

New deaths per million

2 waves
Current model: Richards derivative

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
Phase 2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Total deaths per million

2 waves
Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
Phase 2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Dataset 3: 500 days

New deaths

2 waves
Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	99404 [94984–101501] Median: 97915	0.0627 [0.062–0.068] Median: 0.065	126 [126–127] Median: 126	1.00 [1.0–1.0] Median: 1.0
Phase 2●	88879 [43267–93676] Median: 64331	0.0435 [0.031–0.041] Median: 0.035	336 [310–344] Median: 327	1.00 [1.0–1.0] Median: 1.0

Total cases

2 waves

Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	108984 [99146–125175] Median: 108957	96.6 [79–174] Median: 116	131 [120–142] Median: 128	0.0455 [0.056–0.025] Median: 0.038
Phase 2●	0.000 [0.00–0.00] Median: 0.00	342823 [114861–461889] Median: 292009	74.1 [88–162] Median: 120	367 [355–433] Median: 390	0.0593 [0.050–0.027] Median: 0.037

New deaths

2 waves

Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

Total deaths

2 waves

Current model: Logistic

Logistic	d	K	a	tm	r
Phase 1●	0.856 [0.17–1.5] Median: 0.78	6099 [5683–23996] Median: 13180	144 [187–225] Median: 209	334 [348–438] Median: 400	0.0305 [0.023–0.020] Median: 0.021
Phase 2●	0.237 [–0.48–0.86] Median: 0.16	5538 [6069–8461] Median: 6921	80.6 [134–207] Median: 168	139 [140–172] Median: 150	0.0545 [0.033–0.021] Median: 0.026

New cases per million

2 waves

Current model: Richards derivative

Richards derivative	K	r	tm	v
Phase 1●	961 [920–985] Median: 953	0.0626 [0.062–0.068] Median: 0.065	126 [125–127] Median: 126	1.00 [1.0–1.0] Median: 1.0
Phase 2●	615 [439–1383] Median: 747	0.0466 [0.031–0.041] Median: 0.035	326 [314–364] Median: 336	1.00 [1.0–1.0] Median: 1.0

Total cases per million

2 waves

Current model: Logistic

Richards derivative	K	r	tm	v
Phase 1●	5253 [4824–5340] Median: 5101	0.0628 [0.061–0.068] Median: 0.065	138 [136–139] Median: 138	1.00 [1.0–1.0] Median: 1.0
Phase 2●	2289 [1836–4054] Median: 2294	0.0332 [0.030–0.041] Median: 0.033	307 [261–326] Median: 279	1.00 [1.0–1.0] Median: 1.0

New deaths per million

2 waves

Current model: Richards derivative

Logistic	d	K	a	tm	r
Phase 1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
Phase 2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Total deaths per million

2 waves

Current model: Logistic

Logistic Phase	d	K	a	tm	r
1●	0.000 [0.00–0.00] Median: 0.00	58.0 [56–57] Median: 56	99.8 [83–89] Median: 86	141 [137–139] Median: 138	0.0440 [0.053–0.049] Median: 0.051
2●	0.000 [0.00–0.00] Median: 0.00	24.2 [23–105] Median: 43	119 [109–136] Median: 128	313 [311–370] Median: 337	0.0369 [0.040–0.032] Median: 0.034

Abbreviations and acronyms

FAO	Food and Agriculture Organization
GDP	gross domestic product
GoE	Government of Egypt
HLPF	High-Level Political Forum on Sustainable Development
IFAD	International Fund for Agricultural Development
MPED	Ministry of Planning and Economic Development
NMR	neonatal mortality rates
PPP	purchasing power parity
SDGs	Sustainable Development Goals
SMEs	small- and medium-sized enterprises
U5MR	under-5 mortality rates
UNIDO	United Nations Industrial Development Organization
VNRs	Voluntary National Reviews
WFP	World Food Programme

Author contribution Not applicable (single author).

Data Availability All data are presented. The data described in this paper are available from the Central Agency for Public Mobilization and Statistics (CAPMAS), Ministry of Water Resources and Irrigation, and Ministry of Agriculture, Land Reclamation, and International Organizations.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The author declares no competing interests.

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