AHMES
Archaeological Heritage
& Multidisciplinary
Egyptological Studies 3

Series Editor
Giuseppina Capriotti Vittozzi

The series AHMES was created within the Institute for Ancient Mediterranean Studies (ISMA) of National Research Council of Italy (CNR) and reflects the interdisciplinary openness of the research line "Egypt, ancient Mediterranean crossroads: historical and archaeological research between tradition and innovative technologies". Main aim of the series is to give light to research projects that put into dialogue Egyptology and natural sciences, expressing the multidisciplinary vocation of CNR and from this drawing light.

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...continuiamo con tenacia, rigore, passione e curiosità immutati a cercare 'luce e beneficio' della scienza, nella certezza che la ricerca è tra i pilastri fondativi della nostra società e tra le garanzie più robuste di sviluppo, democrazia e pace.

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Archaeological Heritage & Multidisciplinary Egyptological Studies 3

ARCHAEOLOGY AND ENVIRONMENT

Understanding the Past to Design the Future: A Multidisciplinary Approach Proceedings of the International Workshop "Italian Days in Aswan", 16th-18th November 2013

edited by Giuseppina Capriotti Vittozzi and Francesco Porcelli

Consiglio Nazionale delle Ricerche

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The Aswan Conference was the result of a collaboration involving the CNR Institute of Ancient Mediterranean Studies (CNR-ISMA), the Scientific Office at the Embassy of Italy in Egypt, the Nubia Museum and the Nubia Fund (Egyptian Ministry of Antiquities), UNESCO – Cairo Office and Aswan University. The theme of the Conference can be summarized in three words: Science meets Archaeology. Geologists, physicists, meteorologists, biologists, experts in ICT, remote sensing and in the analysis of satellite data, met with archaeologists, museologists and conservators to discuss, initially, how climatic and cataclysmic events affected the evolution of ancient civilizations in the course of history. Inevitably, it became an occasion to discuss how scientists, archaeologists and more generally operators of cultural heritage can work together.

Frontcover illustration:
Aswan, Elephantine Island
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With contributions by
H. Abd Al-Rahmana, A. Angelini, M.K. Badir Beshay, M. Baldi,
G. Capriotti Vittozzi, E.M. Ebrahim , H. Elhaes, M.Z. Elshandidy,
P. Falcioni, A. Faraman, R.J. Flower, L. Genovese, M. Hamdan,
F. A. Hassan, M. Ibrahim, K. Lemmens, B. Marcolongo,
M. Nilsson, H. Porfyriou,M. Sala, C. Stewart, J. Ward

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Area della Ricerca Roma 1
Via Salaria km 29.300
00015 Monterotondo Stazione (RM)
Italy

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BIBLIOGRAPHY

Bandarin Van Oers 2012 — F. Bandarin – R. Van Oers, *The Historic Urban Landscape. Managing Heritage in an Urban Century*, West Sussex 2012.

Collins Crasemann Collins 1986 — G. R. Collins – C. Crasemann Collins, *Camillo Sitte: The Birth of Modern City Planning*, New York 1986.

Cullen 1961 — G. Cullen, *Townscape*, London 1961.

Giovannoni 1913a — G. Giovannoni, *Vecchie città ed edilizia nuova,* in *Nuova Antologia* 48, 1° giugno 1913, pp. 449-472.

Giovannoni 1913b — G. Giovannoni, *Il diradamento edilizio dei vecchi centri. Il quartiere della Rinascenza in Roma*, in *Nuova Antologia* 48, 1° luglio 1913, pp. 53-76.

Giovannoni 1931 — G. Giovannoni, *Vecchie città ed edilizia nuova*, Torino 1931.

Porfyriou 2002 — H. Porfyriou (ed.), *Studi comparativi: 1. Metodi e strutture catalografiche europee nell'ambito dei beni architettonici e culturali; 2. La legislazione relativa ai settori di salvaguardia in Europa*, Padova 2002.

Porfyriou 2010 — H. Porfyriou, *Spazio urbano come luogo. Camillo Sitte e il ruolo della visione nella Modernità*, in M. Di Monte – M. Rotili (eds.), *Spazio fisico- Spazio vissuto* (Sensibilia 3), Milano 2010, pp. 261-278.

Porfyriou 2014 — H. Porfyriou, *Camillo Sitte. Optically Constructed Space and Artistic City Building*, in J. Cepl – K. Wagner (eds.), *Images of the Body in Architecture. Anthropology and Built Space*, Berlin 2014, pp. 166-188.

Porfyriou Genovese 2012a — H. Porfyriou – L. Genovese, *Interventi integrati per la valorizzazione del paesaggio archeologico di Sovana*, in *Arkos. Scienza e restauro* 28, 2012, pp. 79-85.

Porfyriou Genovese 2012b — H. Porfyriou – L. Genovese (eds.), *Water shapes. Strategie di valorizzazione del patrimonio culturale legato all'acqua*, Roma 2012.

Porfyriou Genovese 2013 — H. porfyriou, *Review of Bandarin and Van Oers 2012*, in *Planning Perspectives* 28/2, 2013, pp. 323-325.

Zucconi 1997 — G. Zucconi (ed.), *Gustavo Giovannoni. Dal capitello alla città*. Milano 1997.

Anthropogenic Impact on Water Disasters The Long-Term History Between Rome And Its Territory

Laura Genovese

ICVBC - CNR, Roma

12

Abstract

The city of Rome and its landscape still show an extraordinary stratification of traces of the past. As a river city, its birth and development have been conditioned at all times by the natural and geographical characteristics, in particular by the presence of the Tiber River.

A multitude of data coming from historical and archaeological records allowed to highlight how to the conflictual relationship between Rome and the Tiber have contributed also human activities.

Actually, from the very funding of the city the landscape have been extensively and deeply manipulated and domesticated in order to establish an artificial balance between the settlement and the territory, and to address if not prevent, weather fancies and natural disasters linked to the Tiber.

The aim of the research have been to understand if, even in ancient times, human activity influenced territory resilience in facing stresses related to climatic variations, contributing at various levels to speed up or slow down, but also increase or contain its effects.

1. Introduction

Recently, the particularly unfavourable climate situation has increased the common attention to climate changes and natural disasters related to them. The frequency of natural disasters linked to excess or shortage of water, having direct and indirect impacts on the environment and on almost every human activity has aroused a particular concern. Indeed, these phenomena have highlighted the fragility of a system that requires new long-term strategies for better react to natural stresses and reconcile human needs (e.g. settlements, production, etc.) with a sustainable management of the environment.

Public and private bodies, at a national and international level scale, are now evaluating possibilities to make places more resilient[1], with respect to climate changes, starting from the consideration of contemporary problems.

Moreover, the scientific research in the last decades have demonstrated the long-term history of climatic oscillations, weather disorders and natural disasters, with which man has had to deal constantly, highlighting not only the tight interdependence between men and environment, but the deep influence of climate on almost every human activity.

In this context, the study of the past came to the foreground, considered as a relevant step towards the better understanding of the present scenario, useful for the evaluation of what to expect in the future and how to face it[2].

Slowly, a multidisciplinary approach to the topic has been spread, and a valuable contribution has come from studies in the Human Sciences. Progressively precious evidence has been produced through interlinking historic sources (such as archival documents, iconography, cartography, etc.) and scientific data derived from archaeological excavations. These results have gradually allowed a more complex and deep understanding of the past which is essential in order to grasp the transformations generated at various levels (e.g. in political, economic, social and even cultural frameworks) by phenomena related to climate changes[3].

However, still more data need to be evaluated and many issues are waiting to be dealt, as the environmental resilience. Although the tight interdependence between men and environment has been already proved, it still has to be understood if and in what proportion, even in ancient times, human activities have influenced territory resilience in facing stresses related to climatic oscillations, contributing at various levels to speed up or slow down, but also increase or contain its effects.

1 Resilience is the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity: Walker *et al.* 2006.
2 Cusset 2003; Acot 2004; Mauch – Pfister 2009, xi-382; Guidoboni – Navarra – Boschi 2010.
3 Allinne 2008; Hermon 2009; Matheus *et al.* 2010; Schenk – Janku – Mauelshagen 2011; Galtarossa – Genovese 2014.

The issue is very complex and almost two principal aspect need to be taken into consideration. On one hand, it has been established that weather solicitations can become disasters if the environmental conditions are not able to provide appropriate responses, but on the other, man has systematically transformed the *habitat*, changing its characteristics and its internal balance. Thus, man might have a share of responsibility in environmental response to climate stresses.

In this perspective, the history of the ancient river civilizations, like the Egyptians or the Romans, offers much food for thought. In fact, the undoubted influence of both natural and geographical characteristics on the birth and flowering of these civilizations, has paid in change an extensive and deep manipulation, domestication and exploitation of the environment, aiming at establishing an artificial balance between settlements and territory, and to address, if not prevent, weather fancies and natural disasters[4].

In this regard, the case of Rome and its historic landscape appears to be very significant, still showing an extraordinary stratification of traces of the ancient Roman civilization. Besides, the evaluation of this issue has become particularly urgent in the last two recent years, within the context of a project of Rome's municipality aiming at adapting and transforming some city's aspects in order to make it more resilient[5]. However, without taking into consideration the archaeological discoveries and the geo-hydrological aspects, characterising the eternal city's history, this project is bound to fail.

Fig. 1 - ***The modern Tiber River basin (after Bersani – Bencivenga 200, fig. 1)***

2. The Natural Context: Between Land and Water

The birth and development of Rome have been conditioned at all times by the natural and geographical characteristics of the site. The consideration of the shape of the mountains and the hydrological regime is crucial for a better understanding of the process of the urban growth and its impact on the landscape[6]. In particular, as a river city, the relationship between Rome and its main river, the Tiber, has been essential.

Tiber originates on the slopes of Fumaiolo Mount, on the side facing the Tuscany, and covers a distance of about 405 km from the source to the mouth, for an average annual flow at the mouth of almost 240 m^3 / s, that makes it the first river of the Apennines Mountains for length and flow. The Tiber is the second longest Italian river basin (17,375 km^2) and it is rich in tributaries and sub-tributaries. Only in the Lazio region, particularly from the Sabina area to the Agro Romano, the basin also includes the system of Nera and Aniene tributaries; the last one intercepts the Tiber only in Rome (fig. 1).

4 Luciani 1985; Le Gall 2005; Guidoboni – Navarra – Boschi 2010, 50-53.

5 Rome has been selected to become a resilient city thanks to funds coming from the Rockefeller Center; http://www.100resilientcities.org/pages/about-the-challenge#/-_/; http://www.100resilientcities.org/cities/entry/romes-resilience-challenge#/-_/

6 De Rita – Funiciello – Parotto 1988; Boni – Bono – Capelli 1988; Funiciello 1995; Bersani – Bencivenga 2001, 3-5; Leveau 2008, 140-141.

Given the characteristic shape and the surface extension of its basin, the rainfall distribution and the regimentation of the different sub-basins, such as those of the Paglia and the Aniene Rivers, compared to those of the higher basin or the Nera River, the Tiber is characterized by changes in flow regime.

From the combined evaluation of archaeological and historical evidence, and geological analysis compared with the current hydrography has emerged that the river has always had a torrential nature with strong seasonal variations and irregularities.

It has been evaluated that, like many Mediterranean rivers, Tiber has always been characterized by long dry summers and sudden autumn overflows, which caused frequent floods, sometimes catastrophic (fig. 2)[7].

Thanks to this alluvial character, the shores and plains along its course had to be almost inhospitable and unsuitable to permanent settlement.

Various underground circulations of water, at variable depth, also characterize the complex hydrology of Rome. That is why the area where the city stands straddles two major hydrogeological structures, the group of Vulsini-Monti Cimini-Sabatini and the system of the Albano Hills, both consisting of volcanic soils, almost permeable, and surrounded by low permeability soils that determine a well-defined limit of permeability.

In proximity of Rome, the very geo-lithological constitution of soil and subsoil determines the presence of abundant groundwater that easily re-emerge as springs after copious and prolonged rains (fig. 3)[8].

Year	Number	Source
414 BC	1	Titus Livius 4.49.2
363 BC	2	Titus Livius 7.3.2
241 BC	3	Orosius, *Historiarum Adversum Paganos* 4.11.6; St. Augustinus, *De Civitate Dei* 3.18
215 BC	4	Titus Livius 24.9.6
203 BC	5	Titus Livius 30.26.5
202 BC	6	Titus Livius 30.38.10-11
193 BC	7	Titus Livius 35.9.2-3
192 BC	8	Titus Livius 35.21.5-6
189 BC	9	Titus Livius 38.28.4
57 BC		M.Annaeus Lucanus, *Phorsalia* 8.824
54 BC	10	Dio Cassius 39.61; Cicero, *ad Quintum* 3.5
44 BC	11	Horat., Carmen, I, 2, 13-20
27 BC	12	Dio Cassius 53.20
23 BC	13	Dio Cassius 53.33
22 BC	14	Dio Cassius 54.1
13 BC	15	Dio Cassius 54.25
5 AC	1	Dio Cassius 55.22; Cassiodorus, *Chronicon* 604
12 AC	2	Dio Cassius 56.27
15 AC	3	Dio Cassius 57.14; Tacitus, *Annales* 1.76
36 AC	4	Dio Cassius 58.26
69 AC	5	Tacitus, *Hist.* 1.86; Svetonius, *Oth.* 8
Regno di Nerva (96-98 AC)	6	Pseudo-Aurelius Victor, *Epitome* 13
Regno di Traiano (98-117)	7	Plinius, *Epistulae*, 8.17; Pseudo-Aurelius Victor, *Epitome* 13
Regno di Adriano (117-138)	8	*Historia Augusta, Adriani* 20
147 AC	9	*Historia Augusta, Ant.* 9; *Fasti Ostiensi*, *NSc* 1939, p. 361 = I. It. XIII, I, p. 207
Regno di Marco Aurelio (161-180)	10	*Historia Augusta, Aureli* 8
217 AC	11	Dio Cassius 78.25
253 AC	12	Aurelius Victor, *De Caesoribus* 32
371 AC	13	Ammianus Marcellinus 24.6
379 AC	14	Bedae, *Chronicon* 589
398 AC	15	Claudius Claudianus, *De Bello Gildonico* 41-43

Fig. 2 - ***List of the floods of the river Tiber in Ancient Roman time (414 BC - 389 AD)***

Fig. 3 - ***Hydrological map of the area of Rome with location of springs (after Lombardi – Corazza 2008 , fig. 13)***

7 Given the serious consequences and the emotional impact on the population, Tiber's floods have been widely documented by the sources, so that a complete chronological list since the 5th century BC can be obtained: Bersani – Bencivenga 2001, 6-8; Muzzioli 2009, 392-393; Aldrete 2007, 10; Le Gall 2005, 35-37; Mocchegiani Carpano 1986, 147-148.

8 Ventriglia 1971; Luciani 1985; Funiciello 1995; Corazza – Lombardi 1995; Lanciani 1975; Annoscia 2007, 40-44.

According to recent years studies, the morphological structure of the city's central areas, although much altered over the centuries, through accomplices and earthworks cuts already begun in early Roman time, would have been characterized on the right bank of the Tiber from the predominance of the ridge of Monte Mario Vatican-*Janiculum*, which stretched towards the south. The eastern side of this ridge shows a series of short and deep transverse incisions that drain rainwater and small springs.

On the left bank of the river, morphology was more complex: the hills, with lower elevations compared to the opposite ridge, were affected by a dense network of river incisions related to the presence of the Seven Hills of Rome. The Quirinal, Esquiline and the Viminale Hills were separated by deep incisions caused by small streams that flowed into the valley of the *Spinons* River, which caused the presence of a swamped area between the Capitol and the Palatine Hills (*Lacus Curtius* and *Velabrum Minus*).

The Esquiline and Celio Hills were scanned from the valley corresponding to the current via Labicana, which was crossed by a stream whose confluence with the important waterway (*Nodicus Flumen*), coming from the *Decenniae* Marshes and passing through the *Camene* valley, determined a wide marshy area (*Velabrum*) corresponding to the plain of the *Circus Maximus*.

Besides, the hills sited on the left bank of the Tiber had as natural limits the Aniene to the north, the ditch of *Aqua Bullicante* to the east, *Almo Flumen* (current Marrana at Caffarella valley) to the south, and the Tiber to the west[9] .

3. Rome from the Foundation to the Imperial Age

Since the most remote antiquity, the presence of the Aniene upstream and of the extensive wetlands, downstream, made Rome's site an obligatory crossing point of the Tiber. In correspondence of the Tiber Island, the river was easily crossed for many months of the year, given its torrential regime. Already in the second half of the second millennium BC, the ford became the area of communications and trades between Etruscan coming from the north, people coming from *Magna Graecia*, in the south, and Italics living in the central inland area of the Lazio Region[10].

Gradually, the site attracted more settlements, raising on the top of the hills all around, for obvious defence reasons both military and natural, which means from the floods of the Tiber river.

The settlement typology at high altitude was preserved even with the ritual foundation of a fortified city, in the mid-8th century. The settlement arose on the Palatine Hill and the Acropolis stood on the top of the Velia, while on the Esquiline Hill there was the *necropolis*[11].

Under Tarquini's kingdom (ca. 753-509 BC)[12], the city gradually incorporated the dual marshy plain of *Forum Romanum* and *Velabrum*, in communication with the Tiber and poorly defended by its floods.

In order to make liveable areas on which the city was developing, it appealed to drain the swampy lowlands through the construction of sewers[13]. These were conducts placed at suitable depth on the ground, and running along the line of the gutter of the valleys, standing between the hills and leading directly into the river. With this technique, areas between the Palatine and the Capitoline Hills, and between the Quirinal, Esquiline and Viminale, were

9 Mocchegiani Carpano 1985, 164-165; Ammerman 1990; Id. 1992; Funiciello 1995.
10 Acanfora 1976, 99-146; Colonna 1988, 411-528; Torelli 1980, 1-17; Pallottino 1993.
11 Ball Platner 1929; Marazzi – Mocchegiani Carpano 1978, 467-472; Coarelli 1984; Pallottino 1993, 174-195; Carandini 2000; Id. 2004.
12 Pasquali 1936; Cristofani 1990; Quilici 1990.
13 Rosicarelli 1985; Mocchegiani Carpano 1985, 165-178; Adam 1988, 284-288; Tölle-Kastenbein 1993, 205-217; Hopkins 2007.

progressively reclaimed.

Tarquinius Superbus, in the last period of his kingdom, did also the *Cloaca Maxima* to drain the areas of the *Forum Romanum*, the *Circus Maximus*, and the *Suburra*. Due to the *Cloaca Maxima* was also drained the *Velabrum*'s marshy plain, close to *Foro Boario*[14]. However, sewers flowed directly into the Tiber, so that at each river flood, they were incapable to work, also regurgitating waters and extensively flooding into lower parts of the city.

In the Republican period and in the Imperial one, sewers from the pre-eminently hydraulic works turned into a hydraulic hygienic network, to dispose surface waters and waste ones, and to gutter waters coming from the countryside through a large number of magnificent aqueducts[15].

The reclamation of the most depressed areas and the construction of sewers can be considered the first attempt to control surface waters and, therefore, to defend the city of Rome from Tiber's floods (fig. 4).

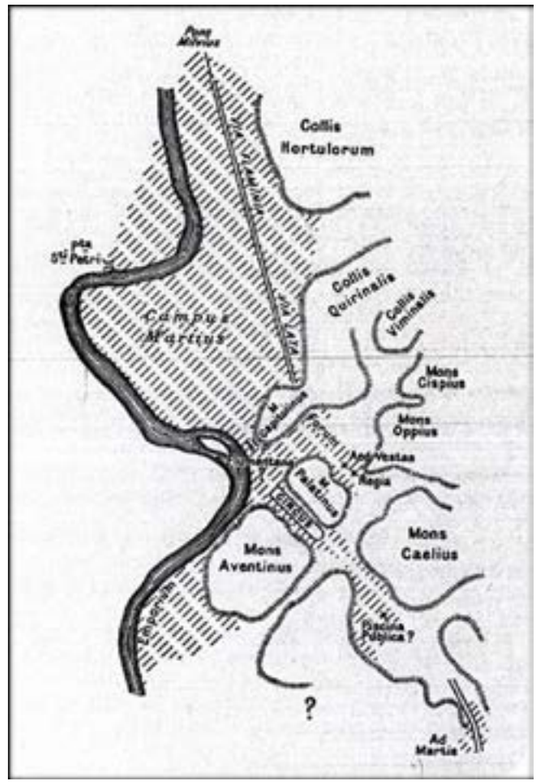

Fig. 4 - ***Areas of Rome exposed to Tiber's floods in Antiquity (after Le Gall 2005)***

The situation radically changed during the Empire, when there was a growing development of the city in the *Campus Martius* and beyond the *Via Lata* (now Via del Corso) where, in the 2nd century AD, entire neighbourhoods of houses were built[16]. In this unbridled development, Rome improved its surface also in the *Campus Martius*, and in two other low-lying areas near the river, the *Transtiberim* area and the one at the Aventine Hill base.

Because of the new organization of the city, during the Imperial Era, floods had to assume an impact deeper than until the end of the Republic Period, when public buildings occupied areas at lower levels[17]. Moreover, floods had to be even more severe in modern times as the ground level was minor than today. Indeed, although even the bed of the river was located at an inferior level, at about one meter below the present one, in some areas of the city the ground was at a much lower levels[18].

14 Ball Platner 1929, 126-127; Coarelli 1983; 1988; Mocchegiani Carpano 1985, 171-173; Ammerman 1990; Richardson 1992; Carandini 1992; Segarra Lagunes 2004, 85.
15 Bersani – Bencivenga 2001, 9-11; Ball Platner 1929, 20; Adam 1988; Hodge 1992; Tölle-Kastenbein 1993.
16 Cesar emperor pointed in the *Campus Martius* as the new development zone of the city. After him, Augustus (31 BC -14 AD) encouraged the development of this area through the erection of his family mausoleum and other monumental buildings. Robinson 1992, 17-22; Coarelli 1997; Le Gall 2005, 130-132.
17 Coarelli 1984.
18 At Pantheon, the primitive Agrippa's building had the floor at approximately 2.5m below the current one, while temples that stood in the area of Torre Argentina were more than 3m below the present level of the soil. Le Gall 2005, 20; Massard-Guilbaund – Platt – Schott 2002; Matheus *et al.* 2010.

4. Man and Environment in a Complex Relationship

As a river city, the birth and development of Rome have been conditioned at all times by the presence of the Tiber River. However, a multitude of data coming from historical and archaeological sources have progressively highlighted how also human activities have contributed to the conflictual relationship between the city and the river.

In this perspective, it is important to note that from the very funding of the city the landscape has been manipulated in order to keep it liveable and suitable for a settlement. The geographical and hydrological characteristics of the site made it appropriate only to the establishment of a small town, but the urban growth, with infrastructures and roads, necessitated an intensive and sustained actions of processing of the natural landscape, thus the regularization of both the Tiber and its basin was one of the major problems to face with.

On this regard, starting from the Imperial Era, a project of diversion of the Tiber River that had never been realised, could be inscribed in a larger climate of modernization of urban structures started by Cesar emperor (45 BC)[19]. Thus, Augustus can be considered as the first to address concretely the problem of floods defense, making widen and fixing the Tiber bed. After him, Tiberius (14-37 AD) established the roles of *curators alvei Tiberis et riparum*, with the task of keeping clear the riverbed. However, these provisions did not interrupt the flooding incidence even when the interventions were extended to a wider geographical area[20].

In fact, following the severe flooding in 15 AD, Tiberius decided to solve the problem of floods and delegated Ateius Capito and Lucius Arruntius to evaluate a strategy. They proposed to reduce the Tiber's water flow through depriving it of two of its tributaries, the Chiana and the Nera. The first would have to be diverted towards the Arno River, and the second dispersed in the countryside of Terni, after being deprived of the waters of Velino Lake.

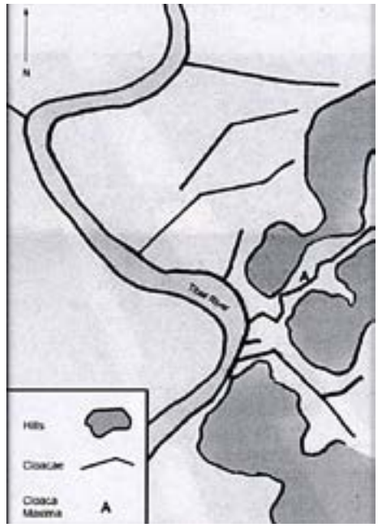

Fig. 5 - *The cloacae of Rome under the Empire (image processing after Moccheggiani Carpano 1985, fig. 3)*

This hydrographic revolution was averted thanks to the protests from local residents who feared, rightly, to see their campaigns turned into swamps or, in the case of the Florentines, who feared most severe flooding by the Arno.

Few years later, in 52 AD, Claudius emperor ordered the construction of an artificial channel at the mouth of the Tiber, now known as Fiumicino. This would have had the dual purpose of connecting Rome to the new seaport of Ostia and of facilitating the venting of water to the sea, aiming at reducing the floods pressure in the urban area (fig. 5).

After him Trajan emperor seems to have designed and built a septic drain side of the flood waters that had to cross the Prati di Castello, but they do not retain traces[21].

Although other emperors faced with the defence of the city against floods[22], epigraphic and literary sources are prodigal of information related to water disasters occurred in the later centuries, thus returning evidence of the inadequacy of many of these interventions (fig. 2).

Unfortunately, it is not yet possible to determine the

19 Segarra Lagunes 2004, 117; Leveau 2008, 142.
20 On the imperial projects of both Augustus and Tiberius, Robinson 1992, 86-89; Segarra Lagunes 2004, 70-71, 307-308; Leveau 2008, 139.
21 On the imperial projects of both Claudius and Trajan, Robinson 1992, 89; Le Gall 1986, 113-116; Id. 2005, 134-136; Bersani – Bencivenga 2001, 26-27; Aldrete 2007, 181; Leveau 2008, 137.
22 Segarra Lagunes 2004, 71-72, 308; Bersani – Bencivenga 2001; Guidoboni – Navarra – Boschi 2010, 55.

proportion of the impact of these transformations, in particular on the resilience of the environment, mostly because we do not know with certainty the characteristics of the river and the land at this stage[23]. Furthermore, there are many other data that still wait to be considered, as large-scale phenomena of deforestation and intensive and extensive soil cultivation, which accompanied the development of Rome, causing an increased soil erosion, river flow and hydrological disorders, as in other Mediterranean areas.

Moreover, the relationship between these transformations and climate still have to be proved, in order to understand, for example, if floodings were accentuated by the particular climate of the time or if, vice versa, human action, affecting the progress of the surface waters, had an impact on the microclimate[24].

Nevertheless, studies of recent years have highlighted the continuity of floods and revealed an increase in Tiber's level, at least during periods of flood, which required a continuous effort to adapt urban infrastructure[25].

This presentation aimed at delineating concisely the matter, basing on the state of the art in recent years. However, the issue is very complex and surely a most extensive and multidisciplinary analysis, conducted with the aid of new technologies, satellite and processing, could provide new opportunities for a better understanding of the historical dynamics.

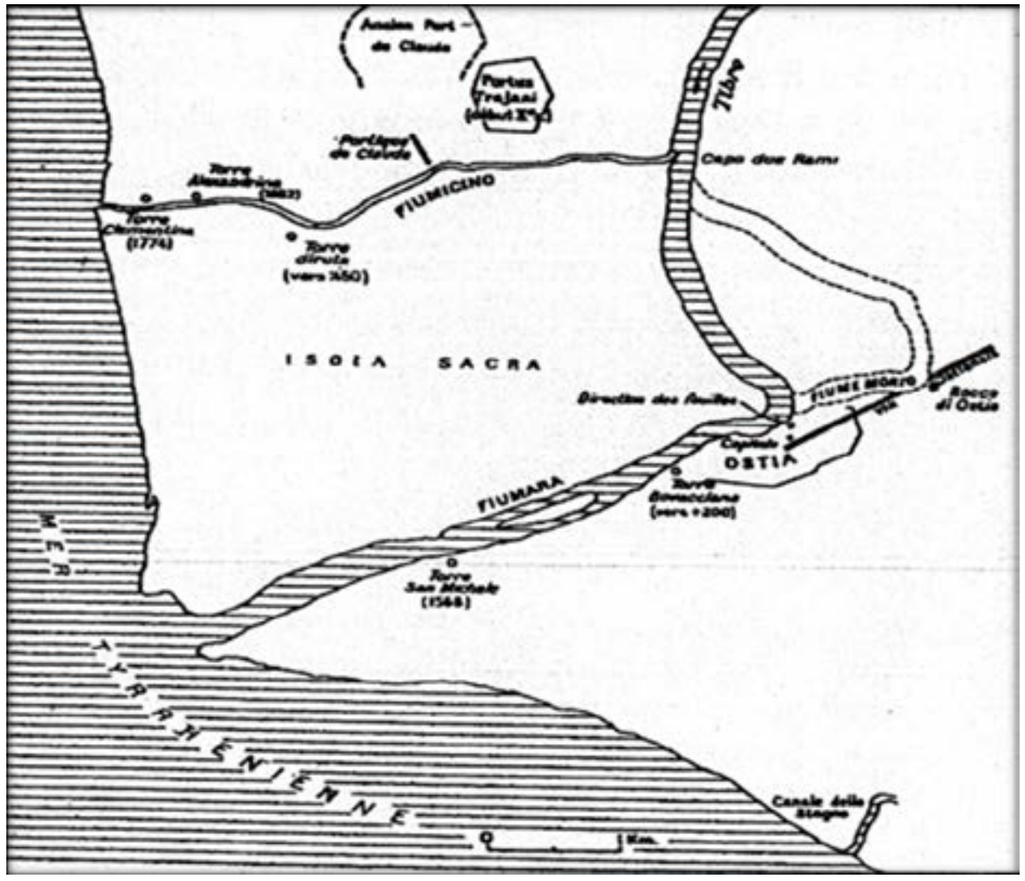

Fig. 6 - *The delta of Tiber River (after Le Gall 2005, fig. 11)*

23 Le Gall 2005, 25-33.
24 Allinne 2008, 139; Leveau 2008, 139, 144-145; Guidoboni – Navarra – Boschi 2010, 53-54.
25 Di Martino – Belati 1980; D'Onofrio 1980; Bersani – Bencivenga 2001; Le Gall 2005; Segarra Lagunes 2004.

BIBLIOGRAPHY

Acanfora 1976 — M.O. Acanfora (ed.), *Civiltà del Lazio primitivo*. Catalogo della mostra (Roma - Palazzo delle Esposizioni), Roma 1976.

Acot 2004 — P. Acot, *Storia del Clima. Dal big bang alle catastrofi climatiche*, Roma 2004.

Adam 1988 — J.P. Adam, *L'arte di costruire presso i romani. Materiali e tecniche*, Milano 1988.

Aldrete 2007 — G.S. Aldrete, *Floods of the Tiber in Ancient Rome*, Baltimore 2007.

Allinne 2008 — C. Allinne, *L'évolution du climat à l'époque romaine en Méditerranée occidentale: a perçu historiographique et nouvelles approches*, in E. Hermon (ed.), *Vers une gestion intégrée de l'eau dans l'Empire romain. Actes du Colloque International Université Laval*, octobre 2006 (Atlante tematico di topografia antica, Supplemento 16), Rome 2008, pp. 89-97.

Ammerman 1990 — A.J. Ammerman, *Morfologia della valle fra Palatino e Velia*, in *Bollettino di Archeologia* 14-16, 1992, pp. 107-111.

Ammerman 1992 — A.J. Ammerman, *On the Origins of the Forum Romanum*, in *American Journal of Archaeology* 94, 1990, pp. 627-645.

Annoscia 2007 — G.M. Annoscia, *Fonti e strutture per la conoscenza del sistema idrico di Roma nel Medioevo*, Roma 2007.

Ball Platner 1929 — S. Ball Platner, *A Topographical Dictionary of Ancient Rome*, London 1929.

Bersani Bencivenga 2001 — P. Bersani – M. Bencivenga, *Le piene del Tevere a Roma dal V secolo a.C. all'anno 2000*, Roma 2001.

Boni Bono Capelli 1988 — C.F. Boni – P. Bono – G. Capelli, *Carta Idrogeologica del territorio della Regione Lazio, scala 1:250.000, Regione Lazio*, Roma 1988.

Carandini 1992 — A. Carandini *Le mura del Palatino, nuova fonte sulla Roma di età regia*, in *Bollettino di Archeologia* 16-18, 1992, pp. 1-18.

Carandini 2000 — A. Carandini, *Roma: Romolo, Remo e la fondazione della città*, Roma 2000.

Carandini 2004 — A. Carandini, *Palatino, Velia e Sacra via: paesaggi urbani attraverso il tempo*, Roma 2004.

Coarelli 1983 — F. Coarelli, *Il Foro Romano. I. Periodo arcaico*, Roma 1983.

Coarelli 1984 — F. Coarelli, *Guida archeologica di Roma*, Verona 1984.

Coarelli 1988 — F. Coarelli, *Il Foro Boario*, Roma 1988.

Coarelli 1997 — F. Coarelli, *Il Campo Marzio. Dalle origini alla fine della Repubblica*, Roma 1997.

Colonna 1988 — G. Colonna, *I Latini e gli altri popoli del Lazio*, in G. Pugliese Carratelli (ed.), *Italia. Omnium terrarum alumna*, Milano 1988, pp. 411-528.

Corazza Lombardi 1995 — A. Corazza – L. Lombardi, *Idrogeologia dell'area del centro di Roma*, in R. Funiciello (ed.), *La Geologia di Roma, il Centro Storico. Memoria, Carta Geologica d'Italia*, Volume 1, Roma 1995, pp. 178-211.

Cristofani 1990 — M. Cristofani (ed.), *La Grande Roma dei Tarquini*. Catalogo della mostra (Roma, 12 giugno - 30 settembre 1990), Roma 1990.

Cusset 2003 — C. Cusset (ed.), *La Météorologie dans l'Antiquité: entre Science et Croyance*. Actes du Colloque International Interdisciplinaire de Toulouse, 2-4 mai 2002 (Mémoires/Centre Jean Palerne 25), Saint-Étienne 2003.

De Rita Funiciello Parotto 1988 — D. De Rita – R. Funiciello – M. Parotto (eds.), *Carta geologica del complesso vulcanico dei Colli Albani*, Roma 1988.

Di Martino M. Belati 1980 — V. Di Martino – M. Belati, *Qui arrivo il Tevere: le inondazioni del Tevere nelle testimonianze e nei ricordi storici*, Roma 1980.

D'Onofrio 1980 — C. D'Onofrio, *Il Tevere e Roma*, Roma 1980.

Funiciello 1995 — R. Funiciello (ed.), *La Geologia di Roma, il Centro Storico. Memoria, Carta Geologica d'Italia*, Vol. 1, Roma 1995.

Galtarossa Genovese 2014 — M. Galtarossa – L. Genovese (eds.), *La città liquida la città assetata. Storia di un rapporto di lunga durata*, Roma 2014.

Guidoboni Navarra Boschi 2010 — E. Guidoboni – A. Navarra – E. Boschi (eds.), *Nella spirale del clima. Culture e società mediterranee di fronte ai mutamenti climatici*, Bologna 2010.

Hermon 2009 — E. Hermon (ed.), *Société et climats dans l'Empire romain. Pour une perspective historique et systémique de la gestion des ressources en eau dans l'Empire romain*, Naples 2009.

Hodge 1992 — A.T. Hodge, *Roman Aqueducts & Water Supply*, London 1992.

Hopkins 2007 — J.N.N. Hopkins, *The Cloaca Maxima and the Monumental Manipulation of Water in Archaic Rome*, in *Waters of Rome Journal* 4, 2007, pp. 1-15.

Lanciani 1975 — R. Lanciani, *Le acque e gli acquedotti*, Roma 1975.

Le Gall 1986 — J. Le Gall, *Il Tevere e Roma*, in *Tevere un'antica via per il mediterraneo*, Catalogo della mostra (Roma - S. Michele a Ripa, 21 aprile - 29 giugno 1986), Roma 1986, pp. 113-116.

Le Gall 2005 — J. Le Gall, *Il Tevere, fiume di Roma nell'antichità*, Roma 2005.

Ph. Leveau 2008 — Ph. Leveau, *Les inondations du Tibre à Rome: politiques publiques et variations climatiques à l'époque romaine*, in E. Hermon (ed.), *Vers une gestion intégrée de l'eau dans l'Empire romain*. Actes du Colloque International Université Laval, octobre 2006 (Atlante tematico di topografia antica, Supplemento 16), Rome 2008, pp. 137-146.

Lombardi Corazza 2008 — L. Lombardi – A. Corazza, *L'acqua e la città in epoca antica*, in R. Funiciello – A. Praturlon – G. Giordano (eds.), *Memorie descrittive della Carta Geologica d'Italia*, Vol. 80, Firenze 2008, pp. 189-219.

Luciani 1985 — R. Luciani, *Roma sotterranea. Catalogo della mostra. Comune di Roma - Assessorato alla Cultura*, Roma 1985.

Marazzi Mocchegiani Carpano 1978 — M. Marazzi – C. Mocchegiani Carpano, *La geomorfologia del colle Palatino in relazione agli insediamenti protostorici e alle trasformazioni di epoca repubblicana e imperiale*, in *Un decennio di ricerche archeologiche* (Quaderni de «La Ricerca Scientifica» C.N.R., 100), Roma 1978, pp. 467-472.