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Moenjodaro

UNESCO Emergency Mission Following Disastrous Rainfall in 2022



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1st Mission Report

December 2022

Moenjodaro

UNESCO Emergency Mission Following Disastrous Rainfall in 2022

1st Mission Report 21 - 29 October 2022

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December 2022

In August 2022, the Moenjodaro World Heritage Site received disastrous rainfall up to 779.5 mm that seriously affected the archaeological remains. The intensity of heavy rainfall caused severe structural damages, including collapse of walls, developing cavities and holes in structures due to loss of mud and bricks, erosion of slopes and mud *pushta*, weakened the foundations of walls and structures at Moenjodaro Site. Heavy rain also affected the drainage system and the main drain. The main drain around the Main Stupa area choked with silt and other wastes causing accumulation of water into the ruins up to the level of two feet inflicting further damages to the structure.

The site, already fragilized, is in a vulnerable condition and needs urgent intervention with damage assessment and stabilization work to protect these from further decay and future disasters. In the context of limited technical and financial capacity of the staff of the Directorate of Archaeology and Antiquities, Sindh, to handle such a huge disaster and major conservation and restoration work it is required to involve and seek guidance of international experts and technical support from UNESCO. Hence World Heritage Centre strongly encouraged the State Party to apply for International Assistance and mobilized the World Heritage Fund. Directorate of Archaeology and Antiquities, Sindh worked closely with UNESCO Islamabad office to prepare international request for immediate technical and financial support for immediate and long-term conservation of the site under the guidance of international experts and UNESCO.

The engagement of an international conservation expert is intended to ensure that the damage caused to Moenjodaro site by monsoon rainfall is stabilized, and to enhance the emergency response and preparedness capacity of the Directorate of Archaeology and Antiquities and the Government of Sindh, to prevent and mitigate the impact of future natural disasters. This will be achieved through the following specific objectives:

1. A thorough damage assessment of the World Heritage Site, to establish findings and long-term recommendation.
2. Defining adapted measures and launching the stabilization, including immediate repair of damaged sections; training on emergency conservation best practices for site management staff.
3. Capacity building training for relevant staff to address emergency response and preparedness against future natural disasters.
4. Detailed strategy for long-term conservation of both sites, emergency response and preparedness against future natural disasters.
5. Identification of the potential of new knowledge that might result from some damage to be balanced with possible emergency needs including immediate repair and stabilization of affected sections of Moenjodaro as well as trainings and equipment required;

Cover picture: overall view of the Citadel (SD) area of Moenjodaro archaeological site

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1. Summary and overall conclusions and recommendations

The emergency international expert mission following the August 2022 heavy rains at Mohenjodaro World Heritage Site was organized from 21 till 28th October by UNESCO and the Directorate of Archaeology of the Government of Sindh. After a preparation phase and studying of the preliminary reports prepared by Mohenjodaro conservation office, the mission at the site comprised technical inspections of all site areas and technical meetings. The content of this summary was discussed during the final synthesis meeting at the end of the mission on 28 October 2022, between the mission expert and the Sindh government.

Thanks to the good organization of the mission by the conservation team at Mohenjodaro, all areas of the site have been visited and examined which allowed to take stock of the level of destruction and first measures already implemented. A visit to the protective dykes and spurs was also organized, and additional reports and documents available in the office library were taken into account. The conservation laboratory was also visited with presentation of all testing procedures.

The heavy rains that have occurred by the end of August 2022 have been challenging for the archaeological remains. Actually, the recorded level of rains represented twice the quantity ever measured for a full year (400 mm in 1994). In spite of all efforts made by the conservation team during the 10 days of rains (pumping of water in some of the rooms, verification of drainage canals, covering of the stupa with tarpaulin, etc.), there has been numerous destructions and there is hardly any structure which has not been affected in a way or another.

As a general appreciation, it is clear that the conservation works that had been undertaken for several decades were very useful. Still many built structures are in an acceptable state of conservation. The site remains impressive, more specifically as the conservation team has immediately engaged in cleaning works making already possible for visitors to access the main areas (SD & DK, VS in progress¹). **The site has been seriously affected however with a great variety of levels of destruction, including variations from area to area.**

Major findings of this first mission:

1) State of the property and the causes of decay

The first need was to observe and share an understanding of what had happened at the site (circumstances and processes of decay). This led to establish that:

. The great majority of the structural degradation are the result of an insufficient capacity of the walls capping to absorb water (as aimed at²) combined with the formation of large flows of water against wall basis and, at some places, water stagnation, that weakened the basis of walls while there have also been infiltrations from the top of the walls with a majority of the destruction resulting of combined processes involving leaning of walls (base) and further infiltration between the wall and rooms floors (top and floors levels).

. The main degradation circumstances and processes have been identified. Those will be described and analyzed further for inclusion in final expert's mission report³. Overall, there have been three main causes of decay (superficial drainage, salts crystallization and hydration inside mortar and bricks, and pre-existing weaknesses in the walls structures), nothing really new, but with an increased level of threats (higher rainfall than experienced earlier) to the site, resulting in more decays;

. The specifications contained in the 1997 conservation manual are pertinent. They have had some level of efficiency, while probably had not fully been implemented as recommended.

¹ Areas have been named after the name of the archaeologist who excavated them (initials)

² See Conservation Manual – Treatment descriptions p.13

³ To be issued in February-March 2023 after 2nd mission in January 2023

This manual should therefore be considered as still effective though will need to be revised to cope with the impact of evolving trends of the climate (Intensity and frequency of heavy rain falls);

. Thus some of the contents in the conservation guide need to be revised according to new potential threats (climate change with potential repetition of higher instant rainfalls). That mainly concerns the following conservation practices : drainage system and flooring method, bonding between old and new materials, quality of mortar and bricks at wall basis) that will be followed by proposals for the development of complementary research / experiments to be implemented for developing complementary solutions to those existing (or upgrading the properties of the building materials);

. As a result of the heavy rains and formation of gullies on some archaeological mounds, some structures have been revealed. Some structures appear to have specific interest (e.g. east side of the citadel) as a new archaeological corpus and it would also be important to analyze structures that may require preventive measures (avoiding degradations in case of new heavy rains).

2) Human resources

. The existing conservation team, in spite of its high motivation, faces difficulties to undertake all necessary maintenance and preventative works as proposed in the conservation manual. That will need to be discussed further with exploring potential for additional recruitments of workers with a variety of skills (masons, one carpenter, foremen, laborers) at Mohenjodaro (increase of regular budget);

. The team was impacted by the damaged state of the property but has remarkably addressed the situation during and after the rains. It has kept good moral and appears to be highly motivated for tackling the situation;

. Taking into account the extent of what is still to be done at all the areas of the site after the recent heavy rains (cleaning of debris, stacking of bricks, earth movements for drainage system), this team urgently needs to be seriously reinforced, at least for a good period of time⁴.

Proposed preliminary plan of action:

In the light of the extent of the conservation works to be implemented after the destructions resulting from the heavy rains and that such an important conservation project will require several years (probably 3 years), it is proposed to take this situation as an opportunity to invest in an in-depth reflection for better preparation of Mohenjodaro site (and its conservation team) against the potential future impacts of climate change. Such a project would include research and experimentation on a variety of aspects: selection of materials, improvement of mortar / bricks resistance; increased salt control/ mitigation; major changes in drainage system and should end with a revision of the current conservation manual (25 years old) and also the Master plan (approved 50 years ago).

It should be noted that what would then become a large project would require specific funding, probably around 1.5 million USD⁵. Such a project will need time to be developed and its description cannot be prepared before getting the results of the detailed condition survey (mapping and quoting) that has been elaborated and launched during the UNESCO mission in October 2022. It also requires time for national and international experts to reflect on its extent and how each key issue identified should be addressed. Of course, time will also be needed to identify and secure the necessary funding sources.

⁴ A first period of 4 months has been proposed. An evaluation will be done during next mission for further extension.

⁵ The breakdown is presented in appendix 5, though this evaluation will be revised after the second mission to be undertaken in January 2023

Having this in mind, it is still very important to address immediate conservation needs with the goal of minimizing the exposure of the site structures before the arrival of next monsoon (starting from July 2023). It is thus necessary to urgently reinforce capacities of Mohenjodaro conservation team, during, at least, a first four month period to:

- . Make sure that the conservators / architects at Mohenjodaro can spend most of their time on the preparation and finalizing of the agreed maps and plans indicating state of conservation + bill of quantities for each area, and collecting of information (surveys, archaeological reports) for the most sensitive areas and preparing first technical proposals for undertaking the repairs with the guidance of international expert (actual works to be launched during its second mission);
- . Make proper communication system (including Internet coverage on site) available among experts (national and international) for smooth remote communication and data inputs, since there is no stable Internet facility on site. As a backup the local team can do the remote meetings in Larkana.
- . Make sure that the existing field team fully concentrate on the most urgent technical work using techniques already proven and mastered: underpinning, simultaneous repair of retaining walls and room drainage, creating water outlet systems where they are needed, starting from the citadel area, then DK, HR and VS.
- . Make an extra budget available (regular budget has been already allotted to take immediate measures during rains);
- . Make funds available for recruitment of 28 workers allowing the deployment of 4 independent teams that will be in charge of the works that do not need high skills like cleaning of debris, transporting and properly stacking bricks to be re-used, large movements of soil and debris (e.g. drainage of temple main room in HR area), removal of paths slabs, etc.;
- . Deploy (or redeploy) two additional assistant conservators for assisting in the condition surveys (elaboration of plans per theme⁶) and the supervision of works at the site;
- . Confirm the task of the national expert to undertake a specific study on “Ancient drainage systems” as they appear in archaeological reports so that the year-old solutions can be given priority when taking conservation decisions;

To that end, it is recommended to urgently allot an amount of 70 000 USD to the Moenjodaro conservation team as described in the table below, with some items (deployment of assistant conservators for example) potentially being covered “in kind”, in order to complete the implementation of the emergency interventions (stabilization of structures at risk) and a first set of drainage improvements (priority to rooms that do not possess any water outlet system) while also ensuring that the whole regular yearly maintenance schedule be addressed at all areas of the site (7).

	Designation	Q	Unit	Cost / Unit	Total
1	Team of workers (7 persons per team; 4 teams during 4 months)	16	Month	1700	27200
2	Assistant conservators (one for surveys, one for works supervision)	8	Month	900	7200
3	Building materials (earth, burnt bricks)		Bulk amount		16000
4	Tools and small equipment (wheelbarrows, pickaxes, shovels, ...)		Bulk amount		10000
5	Computers (Labtop) with softwares	2	Pieces	2000	4000
6	Satellite internet box	1	Piece	2500	2500
7	Satellite connection	4	Months	100	400
8	Logistic support	4	Months	500	2000
				Grand total	69300

⁶ See appendix 3

The second international mission of the UNESCO expert is planned for January 2023, while regular Zoom meetings and email exchanges will be organized twice a month until then to follow-up on progress of both detailed condition survey and works at site.

The second mission of the expert will make use of all the data that will have been collected and processed during the next two months, including data on working time on-site, training needs, etc., as well as from the specific study to be assigned to the national expert on "Ancient drainage systems". As applied during the first mission, work will be undertaken taking into account suggestions made by Moenjodaro team and local experts on the basis of shared understanding of various aspects of the situation.

The second mission also will aim at finalizing and launching (with possibly a series of demonstration works when adaptations to the existing specifications will be agreed upon) the detailed plan for the in-situ works to be undertaken, by elaborating the plans on desired states of conservation for each type of assets: drainage, walls, paths, salt management, building materials performances verification, etc. However, if main stakeholders would be convinced by the relevance of launching a full revision of the conservation and management plan of the site, part of the time allocated to the international expert could be devoted to assist in the preparation of a project document to be presented to potential donors.

2. Activities carried out during first mission

2.1. Mission programme

After discussion with UNESCO representatives, both in Pakistan and UNESCO Headquarters in Paris, as well as with Sindh Government, it was agreed that the mission would be organised from 21 till 29 October 2022. The mission was prepared with primarily reading all documents made available by UNESCO Islamabad. It allowed to undertake the following:

Friday 21	Departure from Grenoble Travel to Karachi through Istanbul
Saturday 22	Arrival in Karachi Meeting with: . Dr. Abdul Fatah Shaikh, Director, Archaeology and antiquities, Sindh . Prof. Altaf Aseem, Archaeologist, Member of Mohenjodaro Technical consultative committee, National expert Travel to Moenjodaro by road Dinner / meeting with the Site manager, Dr. Syed Shakir Ali Shah
Sunday 23	Inspection of SD area, including discussions at site on specific situations and on-going works Elaboration of a program for the site visits of the week
Monday 24	<i>Morning</i> Inspection of DK Area Visit of laboratory and discussion on results of former lab activities <i>Afternoon:</i> Discussion on work plan to be established in view of defining a long term plan for the improvement of superficial drainage system
Tuesday 25	<i>Morning</i> Inspection of HR Area Demonstration of rammed techniques for floors treatment (and gullies) <i>Afternoon:</i> Discussion on issues related to the presence of salts (origin, effects, ways of mitigation)
Wednesday 26	<i>Morning</i> Visit of circular drain, dyke and spurs / Indus river Visit of Moneer and SV Areas <i>Afternoon:</i> Discussion on work plan to be established in view of defining a short term plan for mitigating structural risks (walls)
Thursday 27	<i>Morning</i> Conclusive meeting with Mohenjodaro team with discussions on tasks, responsibilities & plans for the future <i>Afternoon:</i> Trip back to Karachi

Friday 28

Preparation of summary report

Final debriefing meeting with:

- . Dr. Nasim ul Ghani Sahito, Secretary to Gvt. Of Sindh, CTAAD
- . Manzoor Ahmed Kanasro, Director General, AA&C Department, Sindh
- . Dr. Fateh Shaikh, Director, Archaeology and antiquities, Sindh
- . Prof. Altaf Aseem, Archaeologist, Member of Mohenjodaro Technical consultative committee, National expert

Departure back to France

2.2. Methodology

Considering the specific and complex situation of Mohenjodaro, its world heritage status, its size (300 ha), its longstanding history of conservation efforts, and the extensive impacts of the recent heavy rains there is a need to adopt a very cautious attitude with a strong first focus on getting a maximum understanding of what occurred last August, how and possibly identifying the reasons, circumstances and processes of the variety of deterioration cases observed taking into account what had occurred and the measures taken since the site excavations.

The proposed stance was to give priority to consider the adversity that has occurred last August as opportunities, in order to increase knowledge about the site (from an archaeological point of view) and to deepen the understanding of the circumstances and processes of decay that have occurred so as ensure a maximum portion of knowledge before any conclusion and possible suggestions and recommendations be made.

The reflection is therefore nourished by studying:

- . Documents provided by UNESCO (reports and basic documents);
- . Reports on the situation at Mohenjodaro prepared by the Director for Antiquities and Archaeology, of the Culture, Tourism & Antiquities Dpt., Gov. of Sindh and by Director of the site (Archaeological museum).
- . Reports and documents provided by the team in charge, with a special attention given to the "Manual for the conservation and maintenance of Mohenjodaro, prepared in 1997 (CLT/CH/97/185 (UNDP FIT) and the Master Plan prepared in 1972.

Besides, the mission was organised in alternating sites inspections and formal meetings with the team in charge of the conservation of the site. The site visits were conducted with the site supervisors, masons and labourers. Numerous exchanges and discussions contributed to the understanding of what was observed, starting from a variety of hypothesis that were evaluated taking into account the diversity of point of views, former experiences and observations, for some of the participants have been working more than 10 years for the site.

2.3. Preparation of the report

The present report was prepared along with the implementation of the mission, and elaborated taking into account the discussions held at the site and further, during the concluding meetings organised both at the site (conservation team leaders) and in Karachi.

The final version of this report was submitted officially after revision by UNESCO – WHC and UNESCO Islamabad office.

3. Basic information on the property (WHC web site)

Outstanding Universal Value: brief synthesis

The Archaeological Ruins at Moenjodaro are the best preserved urban settlement in South Asia dating back to the beginning of the 3rd millennium BC, and exercised a considerable influence on the subsequent development of urbanization. The archaeological ruins are located on the right bank of the Indus River, 510 km north-east from Karachi, and 28 km from Larkana city, Larkana District in Pakistan's Sindh Province. The property represents the metropolis of Indus civilization, which flourished between 2,500-1,500 BC in the Indus valley and is one of the world's three great ancient civilizations.

The discovery of Moenjodaro in 1922 revealed evidence of the customs, art, religion and administrative abilities of its inhabitants. The well planned city mostly built with baked bricks and having public baths; a college of priests; an elaborate drainage system; wells, soak pits for disposal of sewage, and a large granary, bears testimony that it was a metropolis of great importance, enjoying a well-organized civic, economic, social and cultural system.

Moenjodaro comprises two sectors: a citadel area in the west where the Buddhist stupa was constructed with unbaked brick over the ruins of Moenjodaro in the 2nd century AD, and to the east, the lower city ruins spread out along the banks of the Indus. Here buildings are laid out along streets intersecting each other at right angles, in a highly orderly form of city planning that also incorporated systems of sanitation and drainage.

Criterion (ii): *The Archaeological Ruins at Moenjodaro comprise the most ancient planned city on the Indian subcontinent, and exerted great influence on the subsequent urbanization of human settlement in the Indian peninsular.*

Criterion (iii): *As the most ancient and best preserved urban ruin in the Indus Valley dating back to the 3rd millennium BC, Moenjodaro bears exceptional testimony to the Indus civilization.*

Integrity

The Archaeological Ruins at Moenjodaro comprise burnt brick structures covering 240 ha, of which only about one third has been excavated since 1922. All attributes of the property are within the boundaries established for proper preservation and protection. All significant attributes are still present and properly maintained. However the foundations of the property are threatened by saline action due to a rise of the water table of the Indus River. This was the subject of a UNESCO international campaign in the 1970s, which partially mitigated the attack on the mud brick buildings.

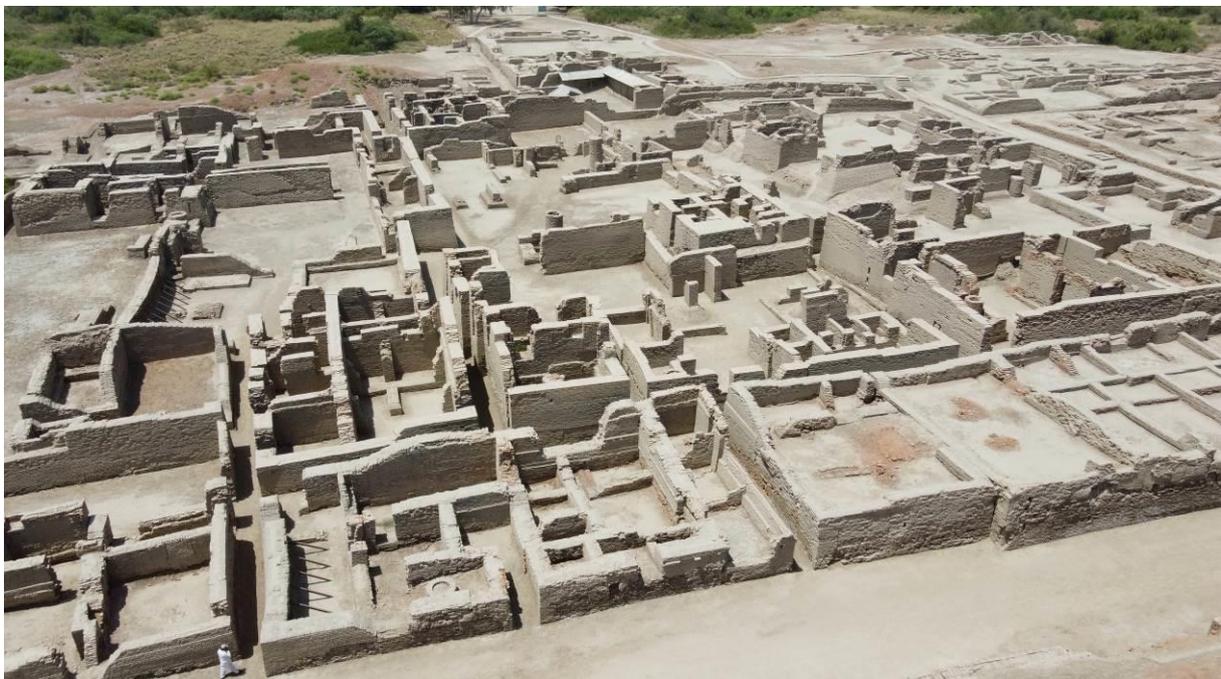
Authenticity

The Archaeological Ruins at Moenjodaro comprise the first great urban center of the Indus civilization built 5000 years ago with burnt brick structures. The property continues to express its Outstanding Universal Value through its planning, form and design, materials and location. The setting of the property is vulnerable to the impact of development in its vicinity.

Protection and management requirements

The Archaeological Ruins at Moenjodaro are being protected by National and Regional laws including the Antiquities Act 1975 from the threats of damage, pillage and pilferage and of new developments in and around the boundaries of the property. There is a management system to administer the property, protect and conserve the attributes that carry Outstanding Universal Value, and address the threats to and vulnerabilities of the property as outlined above. A comprehensive Master Plan has been prepared by the Department of Archaeology and Museums, Government of Pakistan to identify the actual extent of the archaeological area of Moenjodaro. However during the process of approval of the Master Plan, the archaeological area of Moenjodaro has been transferred from the Federal Department of Archaeology to the Culture Department, Government of Sindh. Under the Constitution Act 2010 (18th Amendment), the Culture Department, Government of Sindh is now responsible for the proper up-keep and maintenance of the property.

In order to tackle the potential weaknesses as mentioned in the statements of authenticity and integrity there is a site office supported by a scientific laboratory to deal with the issues of conservation and other problems in a scientific way with traditional methods. The problems of salt action, thermal stress and rain are dealt with through a holistic approach involving application of mud slurry, mud capping, re-pointing and other consolidation works such as under-pinning in order to retain the authenticity and integrity of the property. Besides the above threats there is the danger of flood which was mitigated to some extent by constructing embankments and spurs. However, a breach of the dam upstream would cause catastrophic damage. The Department is therefore undertaking regular monitoring of the dam and is seeking secure funding from the Government, NGOs and other donor countries in order to strengthen it.



Moenjodaro, drone picture of DKG area, April 2021© MCO - Arch. N. A. Sangha

4. Findings of the mission: overall assessment

On the 2nd of September 2022, a brief report was sent by Ihsan Ali Abbasi, Curator and Naveed Ahmed Sangah, Architect to the Director, DAMS, Antiquities and Archaeology, Culture, Tourism & Antiquities, Govt. of Sindh in Karachi which included the following words:

“We received torrential rains particularly at Archaeological Ruins of Mohenjodaro. In August we received record heights level rain i.e 779.5 mm started from, 16/08/2022 to 26/08/2022, and in July 2022 211 mm, which play havoc role for the exposed structures of this site, unfortunately we witnessed the mass destruction at the site.”

Actually, the level of rainfalls quoted for these last days of August 2022 (not taking into account the July figures) represents twice what has ever been recorded for a full year in Mohenjodaro. The situation has not been unprecedented. Most of the past reports include references to heavy rains, but rather short in duration. The “Conservation Manual” prepared in 1997 clearly refers to such rains and provides indications for mitigating measures, including clear guidelines / specifications for the superficial drainage as well as for wall capping.

However, what appeared to have been sufficient in terms of monsoon preparedness until this year was unfortunately only partially efficient under such exceptional rainfall. Very concerned by the situation, the Antiquities staffs were mobilized to do their best to protect what could be, even if their own houses were being flooded by that time. It is an effort important to acknowledge. That included setting of tarpaulin on the top of the stupa, pumping water (even at night) in flooded rooms, repair of drainage canals, etc.



Pictures by Arch. N. A. Sangha: Left, installing tarpaulin on top of the stupa; Right, the Great bath when flooded

Work at the site never stopped and the team worked hard to ensure that the site could be visited by the public with full security, starting with the most visited area: the citadel. The team’s hard work in protecting the site was emphasized during the September 8, 2022 visit of the UN Secretary General Antonio Guterres accompanied by Foreign Minister Bilawal Bhutto Zardari, Sindh Chief Minister Murad Ali Shah, Sindh Provincial Minister for Culture and Education Syed Sardar Ali Shah, and UNESCO Director Youssef Filali-Meknassi.

At this occasion the UNSG had declared⁷ *“It is not a matter of generosity, but a matter of justice,”* and reiterated the United Nations’ commitment, strong support and solidarity with the flood-affected populace of Pakistan: *“The UN absolutely supported the Pakistani nation and*

⁷ Express tribune : <https://tribune.com.pk/story/2375944/unsg-visits-mohenjo-daro-assures-support-for-conservation>

requested the well-resourced nations to support the country massively, so that it could face the future challenges of climatic changes and save its nation”.



FM Bilawal briefed Guterres on the damages conceded by Mohenjo Daro due to historic rains and floods. PHOTOS: EXPRES

The goal set by UNSG is clear and the UNESCO mission therefore was not only to assess current damages, but also identify the potential variety of levels of destruction at the various areas that the site comprises (7), to increase resilience in preserving the site.

It is needed first to observe and understand what had happened at the site, including circumstances and processes of decay. These observations allowed to learn as much as possible to make pertinent suggestions not only for stabilization and further restoration but also to launch a reflective process on how the site and its conservation team could be better prepared to the possible return of such heavy and long-lasting rains. They also possibly lead to identifying needs in terms of “capacity-building programs for national experts and heritage professionals to cope with disaster risk reduction/preparedness and overall site management”⁸.



Pictures by Arch. N. A. Sangha: Cleaning of debris in SD (Citadel) area immediately after rains

Thanks to the good organization of the mission by the conservation team at Mohenjodaro, all areas of the site were visited and examined, allowing to take stock of the level of destruction and first measures already implemented. A visit to the protective dykes and spurs was also

⁸ UNESCO- WHC web site : <https://whc.unesco.org/en/news/2484>

organized, and additional reports and documents available in the Office library were taken into account. The conservation laboratory was also visited with presentation of all testing procedures.



SD Area, the best preserved



Moneer area, in a preoccupying state of conservation

As a general appreciation, it is clear that the conservation works that had been undertaken for several decades⁹ were very useful. Thanks to them, many built structures are still in an acceptable state of conservation. The site remains impressive, more specifically as the conservation team immediately engaged in cleaning works making already possible for visitors to access the main areas (SD & DK, VS in progress¹⁰).

It should be noted though that the state of conservation varies area by area. The SD area being the best preserved while the Moneer area, that probably received less attention in the past, is in a preoccupying state of conservation (see pictures above).

The great majority of the structural degradation resulted from an insufficient capacity of the walls capping to absorb water combined with the formation of large flows of water against wall basis and, at some places, water stagnation. That weakened the basis of walls while there have also been infiltrations from the top of the walls with a majority of the destruction resulting of combined processes, involving leaning of walls (base) and further infiltration between the wall and rooms floors (top and floors levels).

⁹ There has been a series of large campaigns of restoration organised by UNESCO and UNDP by the last three decades of the 20th century, resulting in a well restored site, established facilities and a conservation manual (1997) giving guidelines for the regular maintenance and repairs, being still the reference for the conservation team at Moenjodaro.

¹⁰ Areas have been named after the name of the archaeologist who excavated them (initials); SD for A.D. Siddiqui, VS for M. S. Vats, DK for K. N. Dikshit and HR for H. R. Hargreaves.



Typical wall deformation with crack at DK Area



Gully type of erosion of drainage system at DK area

While undertaking the first overall assessment, the main circumstances and processes of decay were studied. Overall, there seem to be 3 main causes of decay:

- . superficial drainage;
- . salts crystallization and hydration inside mortar and bricks, and;
- . pre-existing weaknesses in the wall structures.

These three main causes are discussed in the three next three chapters of this report.

A specific additional point is the visitor's pathways which at some places were seriously affected by the flows of water. Many of the tubes installed at water flows levels have proven to be under-equipped for the heavy flows. Besides, some paths have slopes leaning towards archaeological remains or tend to block water flows, situations that have already led to weakening the walls basis that do need to be revised.



Damaged pathway between SD and L areas



Slopes of pathway led to self and wall damages (L area)

Finally, an important issue has also been observed, representing an additional opportunity for scientific research. As a result of the heavy rains, erosion gullies have developed deeply on some of the many untouched archaeological mounds. This has resulted in revealing some unknown archaeological assets (see pictures hereunder). Some of those appear to have specific interest (e.g. east side of the citadel) as a new archaeological corpus. It will also be important to analyze some situations that may require preventive measures (avoiding degradations in case of new heavy rains).



Probably a portion of city wall (near HR area)



At the east side of the citadel: traces of a staircase?

3. Findings of the mission: drainage

The heavy rains that have affected Mohenjodaro by the end of August 2022 have resulted in numerous and sometimes large flows of rainwater, a situation that had not been taken into account by previous studies, most of them dating back from the last century. Major difference with what had been observed in the past is that with both the repetition and intensity of the rains for 10 days, the absorption capacity of both wall capping and floors has been reduced or even eliminated due to their level of saturation.

In the Conservation Manual (Treatment descriptions – 13), the wall capping is presented as: *“The aim of the wall capping is to provide a protective covering over the wall that will minimize the flow of rainwater into the wall from the top. Wall caps have been used for more than 30 years and have proven effective at providing important protection against penetrating rain which would ultimately destabilize the walls. ...”* This is absolutely right, but what is also the effect of these caps is absorption of a good part of rain water. But when the cap is saturated the water then flows down the wall and continues on the ground / floor.

Concerning the floors, there are several sub-chapters (treatment descriptions – 15, 16 & 17) including sloping, levelling and reinforcement of gullies, all described as ways of keeping reasonable run-off and transporting it to safe discharge areas. It is also indicated that in some cases, terracing, ponding and shallow trenching could be good solutions in case of little collection surfaces. The use of drainage pipes is not so much encouraged: *“The installation of pipes through the walls should only be carried it as a last resort for reducing serious problems of run-off accumulation in closed areas. Very careful consideration should be given before disturbing ancient walls, and all alternatives should be explored. ...”* The manual also suggest the use of drains, as being “important character-defining features at Moenjodaro” (Treatment descriptions – 22), and further recommends the preparation of comprehensive drainage plan (Maintenance – 4).

Though these recommendations took into account what had been considered at that time as being the worst rainy season at Moenjodaro (298 mm between July and September 1994) this was far from what was experienced last August (779.5 mm in 10 days). As a result, the capacity of the drainage system in place, even if actually very well mastered (very high know-how on that, with very fine work observed) has been seriously challenged leading to most of the major damages observed, resulting either from stagnant water inside some of the rooms (some of them have no water outlet system and had required pumping of large amounts of water), formation of huge flows of water at the basis of some walls and also floor/ground erosions (gullies) that, at some points, have led to damage walls. Gaps in the backfilling under some room’s floors have also led to the formation of depressions with at times the formation of underground flows of water.



Failure of drainage system at SD area © N. A. Sangha: Temple at HR area, with traces of high water level



Undermining of wall by run-off, SD area © N. A. Sangha Ancient drainage systems damaged, south of SD area

One should note that the system used at Moenjodaro for the treatment of the floors (sundried mud bricks laid on a layer of sand) though giving satisfaction for draining water flows placed a negative impact when run-off developed large gullies which manage to fully erode the surface bricks, with very little resistance of the sand layer and acceleration of the erosion process.



Gaps left by eroded sand under mud brick floor SV area Pushta protection affected by water infiltration HR area

Besides that, this system is allowing water infiltration through the bricks and then through the layer of sand down to the original fabric. The resulting issue is that this humidity is like trapped under this layer of sand with the only potential of being evaporated through wall structures, at times above ground level, but also when structures are forming terraces (more specifically the case of the stupa zone, but not only), and as such, increasing the potential of crystallisation of salts on their surfaces (see next chapter).



Traces of high humidity content under floor SD area Traces of high humidity on retaining wall. SD area

At a larger scale, it was noted that the overall drainage system sometimes involves collection of rainwater from large areas and instead of driving the run-off far from the archaeological remains, drives it inside narrow streets. This is the case more specifically at DK area where the large street at the eastern side drives water towards south but as it is blocked by archaeological debris mounds turns right inside the old city fabric, to finally be drained towards the western canal. But there are many other similar situations where high run-off is guided towards archaeological remains instead of “to safe discharge areas”.



Main street at DK area. Water collected is blocked at its south end thus entering the old city fabric

In addition to those, at times paths constructed for visitors also play a negative role within driving run-off towards the wall structures with a high potential for a negative impact (mortar erosion, weakening of brick strength).



Path blocking run-off, HR area



Concrete path with slope driving run-off to a wall. L area

Suggestions made:

In order to reach a better level of preparedness to the possibility of repetition of similar raining events as occurred this year, it appears necessary to:

1. Revise the flooring method, by replacing the sand layer with regular mud mortar, possibly with a first layer for preparing the slight slopes to be obtained at the surface of the bricks layer (bricks on the edge only);
2. Revise the overall drainage system for each area in view of minimizing quantities of run-off more specifically those that occur in narrow streets. That involves exploring possibilities of the inserting more channels for the larger collection areas concerned;
3. Identify in past archaeological reports the presence of ancient drainage channels as well as ancient water spouts or other systems to possibly be put them back into service;
4. Make sure that each room / space has a water run-off exit system;

Elaboration of basic documentation (plans) as decision making tools

To that end, it has been proposed to prepare a series of plans for each site areas (7) that indicates the current situation of water run-off flows, specific points where important gullies have been formed and specific points where wall basis erosion was observed probably as a result of run-off on their sides. These will serve as a base for preparing new plans indicating what will be the desired new drainage situations.

These plans will indicate the following elements:

- rooms (or courtyards) without water flows outlet (full blue colour);
- flows of water (using simple blue lines with increasing size at each additional flow to the first one);
- presence / use of ancient canals (green colour);
- narrow streets with potentially high flows (red colour);
- collection areas of exit canals with possibility of detailing more taking into account specific sensitive assets (like narrow streets) (transparent light colours for differentiation of each collection zone);
- paths floors endangering the walls structures (concrete slabs, precast slabs with slopes leaning towards walls) (orange colour)
- large canals more specifically those directly linked to archaeological structures (ex; DK area).(large blue colour)
- main gullies formed and places where wall were damaged due to drainage weaknesses (suggested with using red colour).

To respond to the shared point of view that priority should be given to retrieve the original ancient system of drainage, it has been proposed that the previous archaeological reports will be analysed to identify all ancient systems (house level (gutters, courtyard pipes or drainage system, ...) , streets level, canals, ..., and when possible provide information so that they can be mapped for each area.

As a more general guideline for the future, drainage should be considered at numerous levels, starting from top of walls and moreover large areas above walls (that act as retaining walls) that at times drain important flows. That thus includes:

- Walls (more specifically large walls)
- Rooms (with specific attention to rooms without rainwater outlet)
- Streets
- Main streets
- Squares
- At the level of the various areas :
- Ancient drainage canals
- Peripheral canals
- Dikes and spurs

Overall site drainage plan

An additional plan will be made for the whole site, by indicating the main canals, the circular canals and where those drain the water up to the Indus River on the east and the Dadu canal on the west.

Condition of these canals will be indicated with five types of conditions considered:

1. Clean;
2. Silts deposits;
3. Huge silts deposits;
4. Presence of plants;
5. Presence of trees.

In terms of priorities for the short term for works to be implemented by the conservation team, it is proposed to revise floors and water outlet systems for :

1. Rooms without water outlet system to be identified and corrected > according to main plan (repartition of collection zones)
2. Narrow streets (with priority to those where gullies have developed)
3. Floors endangering the walls structures (to be relevelled – system changed)
4. Large canals more specifically those directly linked to archaeological structures (ex; DK area)

Further:

Gradual replacement of “sundried earth bricks on sand” floors with implementing the agreed upon technique that entails replacement of sand layer with a mud mortar layer (with a first layer for preliminary levelling). Priority zones for that include:

- floors at the stupa platform level (rooms) and provision of water outlets.
- the drainage system of the successive platforms (rooms) at the north side of the stupa.
- the drainage system of the successive platforms (rooms) at the western side of the stupa with for the larger surfaces provision of several water outlets. (wall to also be rebuilt here).

Potential of ramming technique for repair of gullies formed in the ground:

Looking at what had already been done by the conservation team to start repairing the gullies in some affected zones (slopes), a demonstration has been made during the mission on the rammed earth technique which would be very much adapted to that, if attention is paid to:

- . preparing the existing ground with watering it in advance, so as to get a humid state of the earth in place;
- . mixing new raw earth with water towards obtaining a humid state (ball test); possibility to add river gravels;
- . laying the new earth layer taking into account a compaction ratio 1,5 / 1. Maximum earth layer raw, 15 cm, maximum layer compacted, 10 cm.

Tests of this technique have been undertaken on Tuesday 25:



Successful repair of a gully at the entry of SD area



Unsuccessful test on “bricks on sand” floor.

6. Findings of the mission, the presence of salts and their effect

As quoted in many of the reports consulted, the presence of salts at the site and its destructive impact has been noted very soon after archaeological excavations were made starting from the 1920s. Thus, there has been numerous studies on that aspect with for a long period of time, focus being given to the idea that the main cause of the presence of salts was the water table. Many and costly efforts were developed to lower it (including water pumping) but the expected impact was not reached.

Besides that, more detailed studies were made to understand the destructive effect of salts on the building materials. Those are well summarized in a scientific article written by A.S. Goudie after visiting Pakistan in 1975-76 as part of the Cambridge archaeological mission to Pakistan (Goudie A. S., 1976). In this article, Goudie is concluding that there are two phenomenon that have destructive effects, linked mostly to the presence of Sodium sulphate, which are:

- . Surface crystallization linked to water evaporation and
- . Expansion when transforming from dehydrated state (thenardite) to an hydrated state (mirabilite)

This second phenomenon being favored by potential accumulations within time and the variation of the solubility with temperature, explaining that more destructive effects are observed in the cooler days of the year and on the northern (less exposed to sun) elevations.

These phenomenon are not specific to Moenjodaro. They also exist at other archaeological sites along the Indus River, and are also present in other regions, like in Egypt, at Medamoud archaeological site (Joffroy, 2022) and in Syria, at Mari (Bendakir, 2009). If conditions are different from place to place, what can be stated is that the high presence of salts at these sites are most probably the result of the continuous capillarity process which occurs through the porosity of the built structures and the evaporation of this water (damp) when exposed to air and to solar radiations. Hot and arid climates favor that with dry air (having a humidity ratio diminishing with heat) tending to aspirate capillarity water from the water table. In addition, the continuity of capillarity capacity in built structures are more important than that of debris and/or ground level which has often a powder like surface that avoids evaporation. As a result, water movements are more important in the built structures than in the debris at their side that forms the "archaeological tell". And ultimately, the issue is that the water evaporates, but not the salts, resulting in a constant evolution of salt presence. This process has been almost continuous for several thousands of years, explaining the high presence of salts, though mostly near to the surface of the archaeological mound and thus exposed archaeological remains.

For long, attempts to reduce the capillarity rise of water have been thought as being the solution. The idea was to lower the water table and the response was to establish a series of tube wells allowing to pump water from the water table towards the Dadu canal. In 1986, 26 tube wells were put into operation (NUST, 2011). But the extraction was costly when the change in the water table level appeared to be limited. The overall system was finally abandoned in 1997.

Actually, in Moenjodaro, presence of salt is visible up to the stupa base level (Clifton, J.R. 1980). This is not unique as the phenomenon can be observed at other places (e.g. Mali in Syria). This tend to prove that capillarity is often able to reach tremendous heights (stupa base is 19 m above water level). If that could be considered as the higher limit for capillarity action, any attempts to lower the water table would probably be insufficient for most of the archaeological remains which in their great majority are much lower in altitude.

This was already recognized, by the end of the 80s and as such, the conservation manual provides specific orientations to tackle the issue in another way. Three main activities are proposed, which are also part of the yearly regular maintenance schedule that include:

- . applying mud slurry on the surface of the walls, that behaves as a sacrificial layer in which salt crystallizes;
- . applying mud plaster, which plays a similar role, though having greater impact in places prone to condensation and as such salt expansion.
- . removal of salt-laden earth and replacement with “sweet-earth”, including the removal of waste from sacrificial coatings.



Presence of salts at DK Area



Use of mud slurry to form a salt crust against bricks

These measures are fully part of what is being done at the site today by the conservation team and on regular basis. Though salt presence and related decays appear to be still very much present. One of the hypotheses for this is that the efforts made up to now do not insist enough on salt removal. The removal was done, but probably insufficiently. As an example, it was witnessed at the beginning of the mission that the undergoing brushing of salty sacrificial mud slurry is not linked to removal from the site. That led to suggest that a system would be set so that the slurry dust would be collected and dropped outside the archaeological site perimeter. This measure was immediately adopted by the director of Moenjodaro Conservation Office (MCO).



Removal of salty mud slurry, SD Area, using geotextile to collect and transport dust away from the site, 22.11

Hopefully this will contribute to a gradual diminution of salt content at the site. One of the hypothesis being that the structural fabrics are not only affected by the salt originating from the water table, but also from salt present on the ground level which can be dissolved during rains with potentially this salty rain water to penetrate the flooring and then migrates towards

the wall through the capillarity process. That can explain the high salt content at some places.



Flooring with high salt content, HR Area



Archaeological debris pits are an other source of salts

Another potential factor is that of the presence of gaps inside the walls, whether they be inside the original fabric or located at the interface of the old fabric and that of the restoration works. That would explain the presence of huge quantities of salts inside the walls, very visible when the restored fabric has collapsed. That calls for specific attention when restoring to make sure that gaps are fully filled and also that if the old and “new” fabric are not well connected, cracks can appear which then represent a double threat that of this high presence of salts in addition to the structural weakness. When structures are weakened at the wall base (elevation side exposed to water flows or stagnation, or simply damp) they often develop cracks that drive rainwater down. Processes of dissolution of salt and migration again inside the structural fabric are most probable, a kind of vicious circle which constantly increase the problem.



Salt inside the wall visible after collapse, HR Area



Structural cracks allowing infiltration and salt dissolution

As known for many years, salt is one of the major factor that affects the condition of the archeological remains at Moenjodaro. Thus it will require more specific attention. At least five solutions will be discussed and further explored during next UNESCO expert mission and further:

- . being more systematic and radical concerning the removal of salt contaminated matters (soil, bricks) and making sure that those be delivered as far as possible , at least outside the circular canal;
- . being more cautious when doing restoration works and make sure no gaps left inside the structures in order to avoid accumulation of salt;

- . making some more tests (with repetition of same sample treatments on wall elevations to cover all orientations –:South, west, North, East) on the efficiency of the various methods used (mud slurry and mud plaster) with also trying to treat gaps in the masonry elevations in a more specific manner;
- . where full reconstruction is necessary, taking advantage of the possibility thus offered (the whole surface of the wall being accessible) to insert a damp proof course at ground level that would then be fully operational for stopping water capillarity and consequently salt rise in the walls;
- . undertaking tests on burnt bricks so as to get data for their selection before use, some of them being very resistant to salt expansion while others having poor resistance to it.

7. Findings of the mission: wall structures

As mentioned in the report prepared in September 2022 by the Moenjodaro Conservation Office, the walls structures of Moenjodaro have experienced numerous destruction phenomena, resulting in a huge variety of current state of conservation as well as issues to be addressed. This is a bit contrasting with what had been reported in 1994 by R. Hughes, who visited the site after the heavy rains which also occurred on this year, though on a longer period of time which can explain the difference. There is also in the text a quote concerning the rainfall which is a bit contradictory with the official data.

“During July, August and September a considerable amount of rain fell throughout most of the Sindh. Extensive damage occurred in the urban setting, such as Karachi, and in most rural areas. Many villages were severely damaged. Moenjodaro received in total about 25 inches of rain (0.64m) and therefore it is surprising, and most pleasing, to report that only minimal structural damage occurred. It is generally felt that only 25 to 30 cases of wall collapse due to rain could be identified. The fabric character of these walls points to their already severely poor condition. The degree to which most walls survived is attributable to the emergency underpinning works that the consultants set in place in 1992 and 1993. Without these emergency works the loss of original features would have been most considerable. The main effect of the rains was considered by the consultant to be the wash-out of internal mud mortar, and here it was most interesting to note how the mud from the capping bricks was often washed down into the internal wall structure as well as down wall surface. Most walls fell as a result of shear-slumping down through the wall core. Some collapses may have been triggered by surcharge pressures of soil behind (the extra weight and volume). Foundation failure and overtopping were not noticeable.”

Obviously, the damage this year is far worse than what happened in 1994, after a long period during which Moenjodaro had been given much attention with very strong assistance brought by UNESCO and other partners for almost 20 years. And though, the recent measured rainfall has been much higher and within a very short period of time (less than two weeks), a reason for higher destruction level could also be less preparedness. Actually some of the destructions seem to have occurred in a similar way as what Hughes is reporting, with weaknesses at the top of the structures with insufficient capping protection.

Though what appears clear is that many destructions observed have often a double origin. At first, the wall bases may have been weakened by the water run-off of water stagnation, entailing a tendency of the wall (or when the case, the restored part of the wall, usually that forming the façade) to lean out. This having occurred, cracks are up to the top making possible infiltration of water as described by Hughes, which fasten the weakening process up to collapse.



Two column types of wall (L and DKG areas) illustrating well the typical collapse process starting from the base

Though this typical phenomenon as described above is developing in many different ways and is also much favored when the burnt bricks at the wall bases are already prone to salt degradation that has a serious effect on their bearing capacity.



Wall collapses where salt attack has played a strong role at DKG (left) and HR (right) areas.

Another factor which appears to favor wall collapses is that most of the restored parts of the walls have little connection to the original parts. This is something very common at many archaeological sites around the world as there is a global reluctance to touch the original fabric either through removing parts of it to make sure that there is proper bonding between the old and the new, or to install connecting assets (e.g. tie rods). In such cases, the weakening of the external part of the wall base has a much quicker effect than it would be on a full homogeneous (well bonded) wall as the surface concerned is far less.



Two stages of the process of separation between the new and the old parts of walls, DKG area.

A particular aspect of some of the walls at Moenjodaro is that they have been treated with concrete, either in the form of slabs as damp proof courses at the base of the walls, or for one of the upper burnt brick layers. If this has probably had a positive effect over time, these two systems have not prevented collapse last August.

Concerning the damp proof courses, most of them are only on a small portion of the wall, thus not really functioning as damp proof course. And for the upper layer at the top of the wall, though it has allowed to maintain partly the structure, what was supposed to serve as a protection and a sort of the beam did not prevent some collapses, leaving some of the wall structures in a strange form with the upper part overhanging over huge gaps.



Damp proof course at DKG partly efficient



Concrete layer between the two last brick courses at HR

Finally, what has been most destructive at Moenjodaro last August is similar to what had been described by Hughes in his 1994 report (at 1.2). . “Some collapses may have been triggered by surcharge pressures of soil behind (the extra weight and volume). Actually, in many instances, walls have been pushed by the backfilling needed to get rooms at different levels (often above street level) This is generally connected to the issue of drainage more specifically when looking at it from the beginning, the top of the walls, at times very large and being able to collect huge amounts of water.

And the situation is even worse when there are no or too little water outlets from floors which are above streets levels, that entail water penetration in the infill, bringing about the extra weight and volume as described by Hughes. This has led to some of the major collapses, including a paramount one, the collapse and also dangerous leaning out of a major part of the exit canal from the baths at SD area.



Pressure against walls by backfilling of platforms / rooms floors, DKG area (left) and SD area (right)



Instability of retaining wall at the southern side of canal from bath in SD area.

Most of the sensitive situations of walls are linked to issues related to drainage and presence of salts. Thus, in addition to maintenance / repair needs (wall capping and underpinning), those threats should also be addressed “locally” to avoid repetition of similar phenomenon in the future at the same places.

In view of the preparation of an emergency plan to be implemented before next monsoon season, it has been discussed and agreed upon with Moenjodaro conservation team that this variety of situations should be mapped using the following classification:

1. Good state of conservation or minor degradations;
No need for intervention apart from regular maintenance
2. Degradations but having led to a still stable situation
No need for urgent intervention
3. Degradations linked to failure of the drainage system
Minor intervention to be linked with revision of drainage works (urgency 1)
4. Degradations with remaining potential of brick falls
Need to carefully dismantle “near fall” masonry parts and undertake cleaning
5. Sensitive wall structures (high walls with underpinning needs, severe leaning, ..)
Masonry structures that need a minimum engineering study before intervention (propping, strutting, and detailed preparation / description of method to be applied)

6. Places of specific interest (most of them already spotted, wells, canals, ...)

Potential added value for the site if restored to be studied.

These data will be presented on plans which will be prepared taken as a basis the existing plans that have been prepared for each areas that compose the site.

The preparation of these plans should not be a break to the continuity to the efforts currently being developed by the conservation team at the site.

Apart from the regular maintenance being carried out which addresses the presence of salts (brushing of walls) priority will be continuing on the cleaning of the site with removal of debris, proper stacking of old and recent bricks that will later be re-used.

Apart from drainage which is a high priority, being the more visited places, SD and L areas will also be given priority starting with the provision of water outlets in rooms that do not have any and then addressing cases where the pressure of rooms filling (or weakness of the basis of the retaining wall) have entailed leaning out of the wall.

These works will be done according to the specifications presented in the Conservation manual (1997) while for the final layer of the flooring, the brick on the edge course will be laid on mud mortar in replacement of sand layer.

In the meantime, situations that needs more reflection and potentially verification of the subsoil (presence of remains) will be studied. That will include at least:

- . the side walls of the canal from baths at SD area;
- . the "well preserved house" at DKG area;
- . one of the houses at DKG Area with extensive water collection from its northern side;
- . the temple in area HR;
- . the baths canal at HR area;
- . the well (on a platform) situated at the north-west end of area HR (A).

8. Findings of the mission, others

8.1. Stupa

The stupa is part of the structures which have been affected during the August 2022 rains, though what has been collapsing is from the top cupola and appears to be only a little part of the protection that has been built around the original structure. The situation does not appear to be dramatic, probably the result of the care by Moenjodaro Conservation Office during rains which has made the effort to protect the whole cupola with a tarpaulin. Today, the situation appears to be stabilized with the old structural remains still protected by the geotextile layer.

Though time was too short during the mission to make a serious condition survey of this important heritage asset, a specific condition survey of this structure will be undertaken during the second UNESCO expert mission that will require organizing easier access (ladders or scaffolding) so as to be able to check the condition of the part under the geotextile.



Stupa from south west side



Picture showing fallen part and protective geotextile

Another observation is that the walls at the base of the stupa appear to be leaning out. This is also a point of attention that needs to be tackled during next mission, taking as a base the restoration reports that could give some indications on what has been done there (or not) and when? Though, such a question will probably need a long period of observation / monitoring to have a precise idea of whether there is a movement or not. This will not prevent a reflection on what could be the reasons (potential infiltration of water above this wall) and to install preventative measures.



The retaining wall at the base of the stupa (west side) is clearly leaning out

8.2. Stupa base (citadel core)

A similar question which arose from the visit of SD area is that under the base of the stupa most of the walls at the northern side show signs of bending. This could simply be a local problem linked to pressure made by the successive backfilling at the side of the walls but may also be a sign of more deformation of the overall citadel “mound”.

If a more detailed condition survey of these walls (type of leaning and visibility of cracks in the perpendicular walls) could give an indication, it would be good to check whether it is not the overall mass of the citadel which tend to settle down.

In fact, this could be the result of the presence of humidity inside the core of the citadel under the stupa, made more than possible by the flooring system (bricks on a sand layer) installed also at the upper platform which represents a huge water collection area while being very much exposed to rains. And two months after the heavy rains of August, many of the walls, including on the south side (better exposed to sun) were showing darker zones indicating the presence of damp.



Stupa from L area



North side of citadel showing bended walls

8.3. Fallen mud brick wall

In DKG area, part of a mud brick wall (probably originating from the more recent period – Buddhist) has fallen down. This wall is protected by an iron sheet roof, making it clear that the collapse originates from insufficient drainage at its base, possibly linked with accumulation of sand (from wind) and debris in the narrow passage located at its western side.



Overall protected wall (fallen part at the left)



The fallen part (south west end)

The fallen part needs to be removed before the next monsoon season as it is now like a dam. As it has no real potential for being restored this collapse then should be taken as an opportunity to undertake an in-depth study (archaeological) of this fallen portion that would entail its careful dismantling. The data to be collected should include:

- . size of brick used (L., l., h.);
- . thickness of mortar (horizontal and vertical joints)
- . type of soil used both for the bricks and the mortar - all possible analysis that can be made, at MCO (grainsize distribution and Atterberg limits) and elsewhere in a specialized university laboratory (X ray, diffraction, ...).

Additional information have also to be collected from the still standing wall. It has very good potential where the collapse has occurred with now a fully visible section of the wall. Observations there will help checking dimensions and moreover what will be difficult in the fallen part, to measure the width at several heights, and deduce original form which was probably slightly inclined with a wall much larger at its base than at its top.

Apart from that when the cleaning is done a detailed inspection of the wall surroundings will be made to check drainage. The roof condition should also be inspected. That can be part of next UNESCO mission if the fallen part has already been removed / studied.

8.4. Newly revealed archaeological structures

The torrential rains of last August have not only affected the already revealed archaeological remains but also have increase the size and more specifically the depth of existing gullies in the archaeological mounds all around the site.

As a result, there are numerous places where structures have been revealed and are now quite visible. Some appear to have become at risk when new monsoon seasons will be coming. That would be quite a loss, knowing the potential that those still buried structures represents, as being fully original while those now visible at most of the areas (those open to the public) have been restored several times. However today, there are some difficulties to differentiate the original from the new.



Two examples of newly revealed structures that can be seen in various places at the site

Taking stock of that situation, the proposal is that a survey of these places be made (listing, mapping, minimum characterization), possibly by students of the archaeological dpt. of Sindh Universities under the supervisor of their professors and overall coordination by MCO staff. Criteria should be set so that a plan of action may also concern these newly revealed structures so as to ensure that those who would need preventive protection could be treated.

An exception given to the above proposal could be the structure observed at the eastern end of the citadel where what could have been the steps to the Buddhist stupa may have appeared. That might represent a major plus for the site and, as such, might be given consideration if a team could be mobilized to undertake a first cleaning exercise whose result might lead to programming a fully structured archaeological exploration / survey.



On the eastern side of the citadel area, the huge flows of water collected by the upper platform have revealed some structural elements which could be the original steps to the stupa.

8.5. Visitors paths

The visitor's paths that have been built in Moenjodaro either within the excavated areas or between them have also been subject to destruction. These have occurred mostly where gullies have evolved substantially, but also in most of the places where runoff is collected. Even where some specific assets (pipes) had been installed, many of them proved to be insufficient to support the intensity of the flows. Even some very heavy concrete slabs have been moved some of them substantially.



Concrete slabs of various sizes have been affected giving an idea of the violence of the runoffs



Burnt bricks paths have suffered but are easy to repair The roads at the top of the dikes have also suffered

Worse is that at times the paths have led substantially to destruction of the ancient structures. This is due to the fact that some of these paths are very near to the structures with at times, either:

- . channeling runoff towards the wall bases;
- . representing a break to the runoff and as such forming puddles at wall basis.

For these two phenomena, concrete slabs which hardly absorb any water have been the cause of the worst cases.



L Area, path leaning towards wall base



HR area, concrete slab path blocking runoff

The revision of these paths is a huge work in itself and thus requires a specific study. To get an overall idea of the situation (quantitative and qualitative) to be able to prepare that, it has been agreed to :

- Prepare a plan of the overall site indicating main paths with recognizing :
 - Materials used (in situ casted concrete slabs, concrete slabs large size, concrete slabs medium size, burnt bricks, earth floors.
 - The state of conservation
 - Good
 - Needing minor repairs
 - Needing serious repairs
 - Destroyed and needing full reconstruction (or reconsideration / relocation)
 - Location of gullies where pipes should be added under paths.
- Prepare same plans for each area (7) but at a larger scale, for detailing the situation for each of them

8.6. Building materials

An issue which also comes out of the first overall evaluation of the condition of the archaeological structures at Moenjodaro relates to the quality of the building materials. The conservation manual provides indications on materials standard but does not insist much on that. As a result, there might have had insufficient attention given to that while this now appears to be a paramount issue.

Actually, there exists many evidence that there are substantial differences in their behavior as even at same locations, the state of conservation is very different. The case of the burnt

bricks is particularly illustrating that with in the presence of salts bricks in the same course can be in perfect state while another besides it is almost fully disintegrated. The issue of soil selection for mud bricks making and mortar, also seems to be somehow underestimated, as there is, probably for several years now (as there are signs in the eroded wall capping) the use of soils that contain quite a huge amount of vegetal matters (plant roots). The loads of soils at the entry of DKG Area appear to be in that line which is a bit surprising when knowing that there is a laboratory and a lab operator which could check the soils already at the quarry level.



The variety of quality of burnt bricks is very visible on this wall at DKG area, very good state at the base, almost fully disintegrated in the middle, acceptable at the top



Soil just delivered at DKG Area with high humus content



Same type of soil applied on wall capping at SD Area

This calls for launching a process for re-installing a more systematic process for the quality of the materials being used at Moenjodaro, both for the earth and for the burnt bricks:

. for the soils :

- Checking presence of salts
- Checking the presence of humus
- Verification of grainsize distribution and Atterberg limits

. for the burnt bricks:

- Identifying ways of testing bricks by nondestructive methods, so that the best bricks be used in the most exposed and the less resistant ones be rater used in the upper parts of the walls.
- Checking potential differences in quality (density, porosity, compressive strength, wet compressive strength, abrasion) at a variety of brick producers

This should be done immediately as an intermediate measure while in the meantime ways of ensuring higher quality of the building materials be established, including more experiments and testing of them with considering : earth, earth bricks, earth mortar, earth plasters, earth slurries, burnt bricks production and selection mode, and possibly, exploration of stabilization of earth mortar to better match performance with increased challenge potentially being again brought about by heavier rains. Tests would be on several aspects. A full list will be prepared after the second mission, but as a first list, the following would be required: compressive strength (taking onto account actual requirements), wet compressive strength, abrasion tests, porosity / capillarity, behavior in a salty environment (drying/wetting cycles).

That will require acquisition of specific equipment that needs to be identified (and also where to acquire it) to reinforce the lab capacities, with also taking into account the need to train additional young professional that will be able to take over the works already been done at MCO laboratory.

The objective would be:

to upgrade the equipment and personal qualification of the existing laboratory at Moenjodaro to establish a more systematic quality control of the raw and building materials used for the restoration works and to launch a campaign of tests / experimentation for upgrading the quality of the material used in the most exposed parts of these restoration works (wall basis, floors, ...) to guarantee more durability and best response in case of major rainy events.

This would entail :

1. To renew / some of the existing soil and water testing equipment.
2. To complement it with additional equipment;
3. To extend testing procedures to building materials compressive tests (dry / humid) and to capillarity tests;
4. To train at least two members of the Moenjodaro conservation Cell to the use of the equipment
5. To train the overall team of Moenjodaro conservation Cell to make the best use of the results of the variety of tests
6. To set up a regular quality control process.

To give an idea, here is a first raw cost estimate for each of these items :

1. Small equipment : 4 000 USD
2. Additional small equipment : 4 000 USD
3. Press for compression tests and accessories : 25 000 USD
4. 2 x 3 months internship in a laboratory : 15 000 USD
5. On site one week training workshop (+ one week preparation) : 15 000 USD
6. Experts fees and workshop : 10 000 USD

This remains the basis. For the experimentation and testing campaign, more expertise (to be determined during next mission, but probably several months to address all issues) would be needed and possibly fees would be required if expertise do not exist within Sindh Ministry of Culture or in a Partner University in Sindh or elsewhere in Pakistan.

8.7. Current “Manual for the conservation and maintenance of Moenjodaro”

The manual for the conservation and maintenance of Moenjodaro was elaborated in 1997 in the framework of a UNESCO / UNDP contract. It was prepared by Franck Briscoe who referred or collaborated with many national and UNESCO experts who had earlier participated to the huge UNESCO campaign for the restoration of Moenjodaro also including expertise from ICCROM, ICCOMOS and ICOM.

In its summary this manual suggest the following important ideas and concepts:

“This manual is intended to be a reference tool for those in technical or administrative positions I the conservation and maintenance of Moenjodaro. It is primarily a collection of information about how conservation has been conducted at Moenjodaro between 1974 and 1997 under the International safeguarding campaign, and the principles and scientific basis that have informed and guided its application. The treatments described have been chosen for their technical and cost effectiveness, for the minimal negative impact the have on the ancient fabric, and with exceptions, for their “reversibility”. These methods have been tested, and some have already been is use for many years at Moenjodaro.

The manual has been organized so that it can be revised without requiring the entire document to be reprinted. Just as the site is constantly changing – due to the effects of weathering, necessary interventions to preserve the site, and the introduction of new conservation methods – this manual will require regular updating and refinement accurately to reflect how the conservation of this important World Heritage Site is being carried out.”

This text clearly calls for a dynamic use of this manual. Though for the last 25 years, it remained unchanged and the staff at Moenjodaro often relate to it during discussions, even though some of its prescriptions or recommendations are not fully taken into account.

The fact that the document is not available in electronic format does not help, but moreover it seems that there is some kind of fear to adopt new ideas (when they actually exist) as the procedures to revise this document are not clear: who could propose, who should be consulted, who would decide?

Whatever the situation is concerning this document, as called for in this introductory note, it is clear that this manual needs some level of revision while making sure that the precious information that has been compiled in it be kept. Some are truly precious, with very sensitive and accurate information provided on how conservation theories can be applied at Moenjodaro and how important aspects concretize on the practice in the field, both for maintenance and more exceptional conservation works. Some practices that had been established during this exceptional 20 years UNESCO campaign remain quite innovative for some its aspects. They have given very good results for these last 25 years and some should even be more considered elsewhere at other World Heritage Sites throughout the world.

But looking at the situation, with considering both the extent of restoration works to be undertaken and the need to revise the level of risk due to heavy rains as seems to be established by climate change, it becomes obvious that at least a new 3 years campaign be launched that would address reconsideration of all points of the conservation manual with, when necessary (and only when necessary) revision of the prescriptions and standards to be followed.

7. Intermediate conclusions and plan for the follow-up activities

The emergency international expert mission following the August 2022 heavy rains at Mohenjodaro World Heritage property was organized from 21 till 28th October. After a preparation phase and the study of the preliminary reports prepared by Mohenjodaro conservation office, the mission at the site conducted technical inspections of all site areas and technical meetings.

Thanks to the good organization of the mission by the conservation team at Mohenjodaro, all areas of the site have been visited and examined which allowed to take stock of the level of destruction and first measures already implemented. A visit to the protective dykes and spurs was also organized, and additional reports and documents available in the office library were consulted. The conservation laboratory was also visited with presentation of all testing procedures by the current lab technician.

A first conclusion is that the heavy rains that have occurred by the end of August 2022 place real challenges on the archaeological remains. While it is clear that conservation works implemented for several decades were proven very useful, despite all efforts made by the conservation team during the 10 days of rains, there has been numerous destructions. Today, there is hardly any archeological structure which has not been affected in a way or another. Still many built structures are in an acceptable state of conservation and the site remains impressive, more specifically as the conservation team has immediately engaged in cleaning works making already possible for visitors to access the main areas (SD & DK, VS in progress).

The mission focused on observing and establishing a shared understanding of what had happened at the site, notably their circumstances and processes of decay.

9.1. Intermediate conclusions:

On the technical aspects:

. The great majority of the structural degradation are the result of an insufficient capacity of the walls capping to absorb water combined with the formation of large flows of water against wall basis and, at some places, water stagnation. That weakened the basis of walls while there have also been infiltrations from the top of the walls with a majority of the destruction resulting of combined processes involving leaning of walls (base) and further infiltration between the wall and rooms floors (top and floors levels).

. The main degradation circumstances and processes have been identified. They have now to be described and analyzed. Overall, there have been 3 main causes of decay (superficial drainage, salts crystallization and hydration inside mortar and bricks, and pre-existing weaknesses in the walls structures), nothing really new, but with an increased level of threats to the site, resulting in more decays;

. The specifications contained in the 1997 conservation manual are pertinent. Where fully implemented they have had some level of efficiency, though with insufficient capacity to cope with the level of the solicitations brought about by the intensity and repetition of heavy rains for a tenth of days;

. Thus some of the contents in the conservation guide need to be revised according to new potential threats (climate change with potential repetition of higher instant rainfalls). That mainly concerns the following conservation practices : drainage system and flooring method, bonding between old and new materials, quality of mortar and bricks at wall basis) that will be followed by proposals for the development of complementary research / experiments to be implemented for developing complementary solutions to those existing (or upgrading the properties of the building materials);

On new archaeological potential:

. As a result of the heavy rains and formation of gullies on some archaeological mounds, some structures have been revealed. They appear to have specific interest (e.g. east side of the citadel) as a new archaeological corpus and it would also be important to analyse some situation that may require preventive measures in order to prevent degradations in case of new heavy rains.

In terms of human resources

. The existing conservation team is probably limited in number. Despite their high motivation, the staff probably faces difficulties to undertake all necessary maintenance and preventative works as proposed in the conservation manual. It needs to be discussed further in exploring potential for additional recruitments of workers with a variety of skills (masons, one carpenter, foremen, laborers) at Mohenjodaro (increase of regular budget);

. The team was impacted by the damaged state of the property but has remarkably addressed the situation during and after the rains. It has kept good moral and appears to be highly motivated in tackling the situation;

. Taking into account the extent of what is still to be done after the recent heavy rains (cleaning of debris, stacking of bricks, earth movements for drainage system), the team urgently needs to be seriously reinforced.

9.2. Proposed preliminary plan of actions:

In the light of the extent of the conservation works to be implemented after the destructions resulting from the heavy rains and that such an important conservation project will require several years (estimated to be 3 years), it is proposed to take this situation as an opportunity to invest in an in-depth reflection on a better preservation of Mohenjodaro site (and its conservation team) and on the risk reduction against the potential future impacts of climate change. Such a project would include research and experimentation on a variety of aspects: selection of materials, improvement of mortar / bricks resistance; increased salt control/ mitigation; major changes in drainage system and should end with a revision of the current conservation manual (25 years old) and also the Master plan (approved 50 years ago).

It should be noted that such a large project would require specific funding, probably around 1.5 million USD (see appendix 5). Such a project will need time to be developed and its description cannot be prepared before getting the results of the detailed condition survey (mapping and quoting) that has been elaborated and launched during the mission. It is also necessary that time be left to both national and international experts to reflect on its extent (key issues) and how each topic / theme should be addressed. Of course, time will also be needed to identify and secure the necessary funding sources.

Having this in mind, it is still very important to address immediate conservation needs with the goal of minimizing the exposure of the structures at the site before the arrival of next monsoon (starting from July 2023). It is thus necessary that immediate decision be made to reinforce capacities of Mohenjodaro conservation team, during, at least, a first four month period to:

. Make sure that the conservators / architects at Mohenjodaro can spend most of their time on the preparation and finalizing of the maps and plans indicating state of conservation and to establish the estimates of quantities for each area, and collecting of information (surveys, archaeological reports) for the most sensitive areas and preparing first technical proposals for undertaking the repairs with the guidance of the international expert (actual works to be launched during its second mission);

. Make proper communication system (Internet coverage) available among experts (national and international) for smooth remote communication and data inputs. As a backup the local

team can do the remote meetings in Larkana;

- . Make sure that the existing field team fully concentrate on the most urgent technical work that they already fully master: underpinning, simultaneous repair of retaining walls and room drainage, creating water outlet systems where they do not exist, starting from the citadel area, then DK, HR and VS;

- . Make available an extra budget (regular budget has been already allotted to take immediate measures during rains);

- . Make available funds for recruitment of 28 workers allowing the deployment of 4 independent teams that will be in charge of the cleaning of debris, transporting and properly stacking bricks to be re-used, large movements of soil and debris (e.g. drainage of temple main room in HR area);

- . Deploy (or redeploy) two additional assistant conservators for assisting in the surveys and the supervision of works at the site;

- . Confirm mission given to the national expert to undertake a specific study on "Ancient drainage systems" as they appear in archaeological reports so that the antique solutions can be given priority when taking conservation decisions;

This means that the preparation of the condition survey plans should not break the continuity to the efforts currently being developed by the conservation team at the site. To that end, it is recommended to urgently allot an overall amount of 70 000 USD to Moenjodaro conservation team (see above and details in appendix 4), with some items (deployment of assistant conservators for example) potentially being covered "in kind", in order to complete the implementation of the emergency interventions (stabilization of structures at risk) and a first set of drainage improvements (priority to rooms that do not possess any water outlet system) while also ensuring that the whole regular yearly maintenance schedule be addressed at all areas of the site (7).

Apart from the regular maintenance being carried out which addresses the presence of salts (brushing of walls) priority will be continuing on the cleaning of the site with removal of debris, proper stacking of old and recent bricks that will later be re-used.

The second priority will be given to the most important corrections to be made to the drainage system starting with simple cases and then gradually tackling more complex situations. Being the more visited places, SD and L areas will be treated first, starting with the provision of water outlets in rooms that do not have any and then addressing cases where the pressure of rooms filling (or weakness of the basis of the retaining wall) have entailed leaning out of the wall.

These works will be done according to the specifications presented in the Conservation manual (1997) while for the final layer of the flooring, the brick on the edge course will be laid on mud mortar in replacement of sand layer.

In the meantime situations that needs more reflection and potentially verification of the subsoil (presence of remains) will be subject to first studies and possibly proposals for intervention(s). Those will include at least:

- . the side walls of the canal from baths at SD area;
- . the "well preserved house" at DKG area;
- . one of the houses at DKG Area with extensive water collection from its northern side;
- . the temple in area HR;
- . the baths canal at HR area;
- . the well (on a platform) situated at the north-west end of area HR (A)

9.3. Issues in response to some of the initial Terms of Reference of the mission

The terms of reference for the expert mission was suggesting the following deliverables: a) situation analysis, b) assessment form/Tool, c) list of equipment / Material and d) report o training / guiding the national tea on damage assessment and stabilization.

As can be seen in the core of this report, the first overall assessment of the situation has led to adopt a more global approach rather than taking those one by one. More precisely, in regard to what needs to be done in between the two planned mission:

- . rather than assessment forms for individual structures, as they are too many (e.g. , what has become clear is that what is needed are plans and further bill of quantities for each situation described in the plans (levels of destruction, surfaces to be treated, etc.),
- . in terms of equipment / material, most of what is needed is already available at Moenjodaro conservation office. The only suggestion on that has been to improve internet connection while the needs have been expressed above rather in terms of personnel;
- . for the training / guiding issue: having quickly had a good impression on the existing capacities at the site, the stance adopted has rather been to first share an understanding of the degradation processes observed and to discuss how those could be represented and measured and when possible, already discussing potential adjustments to the existing practices.

9.4. Second UNESCO expert mission

The second international mission of the UNESCO expert (already included in its Terms of reference) is planned for January 2023, while a regular zoom meetings schedule and email exchanges (already on-going) will be organized twice a month until then to follow-up progress of both detailed condition survey and works at site.

The second mission of the expert will make use of all the data that will have been collected and processed during the next two months, including on working time for works at site, training needs, etc., as well as from the specific study to be made by the national expert on “Ancient drainage systems”. As applied during the first mission, work will be undertaken taking into account suggestions made by Moenjodaro team and local experts on the basis of shared understanding of various aspects of the situation.

The second mission will aim at finalizing the detailed plan for the in-situ works to be undertaken (elaboration of plan of desired situations for each type of asset: drainage, walls, paths, salt management, building materials performances verification, etc.). However, if main stakeholders would be convinced by the relevance of launching a full revision of the conservation and management plan of the site, part of the time allocated to the international expert could be devoted to assist in the preparation of a project document to be presented to potential donors.

Appendixes

Appendix 1 – List of persons and institutions met / contacts

Moenjodaro Conservation Office team

S.#	Name of the officer/Official	Designation	Profession
1	Mr. Syed Shakir Ali Shah	Director, Moenjodaro Conservation Office	Archeologist
Archaeological Museum Mohenjo-Daro			
1	Mr. Rohal Amin	Curator	
2	Mr. Ihsan Ali Abbasi	Assistant Curator,	
3	Ali Hyder, Gadhi	Archeological Engineer	Engineer
4	Mr. Shabir Ahmed Joyo	Archaeological Conservator	A.C.
5	Mr.Arshad Ali Jatoi	Upper Division Clerk,	
6	Mr.Altaf Hussain	Lower Division Clerk,	
7	Mr. Aijaz Ali Mashori	-do-	
8	Mr.Raheem Bux Wasan	Site Supervisor,	
9	Suhban solongi	Conservation Forman	
9	Mr.Saindad Jatoi	-do-	
10	Mr.Wajid Ali	-do-	
11	Mr. Muhammad Saleem Mashi	-do-	
12	Mr.Javed Ali	-do-	
13	Mr. Muhammad Ismail	-do-	
14	Mr.Muhammad Azam	Site Cooly, B-2	
15	Mr.Allah Rakhio	Site Attendant	
National Fund for Mohenjo-Daro			
1	Mr. Naveed Ahmed Sangah	Architect Engineer	Architect
2	Mr. Imtiaz Ali Domki	Conservation Assistant	
3	Mr. Ali Gul	Conservation Foreman	

Members Technical consultative Committee

1	Dr Kaleem ullah Lashari	Chairman	Archaeologist
2	Prof. Altaf Aseem	Professor of archaeology	Archaeologist

Soch Media

1	Ms. Suahela Qureshi	Director	Journalist
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Numerous pictures are available at : <http://archnet.org>

Appendix 3 – List of plans to be established by Moenjodaro conservation office

List of plans to be prepared by Mohenjo-daro conservation team in view of the preparation of a long term plan for the restoration of Moenjodaro and its preparedness to climate change following the warning provided by the heavy rains conditions experienced in august 2022.

This list has been discussed and slightly revised by the end of the first UNESCO expert mission:

1. Drainage plan for the overall site :

This plan will indicate the presence of the main canals, the circular canals and where those drain the water up to the Indus river on the east and the Dadu canal on the west.

Condition of these canals will be indicated with five types of conditions considered:

1. clean;
2. silts deposits;
3. huge silts deposits;
4. presence of plants;
5. presence of trees.

2. Drainage plans for each site area (7)

In order to be able to prepare a plan for improving the drainage systems at Moenjodaro plans of the existing situation have to be prepared for each area. These will serve as a base for preparing a new plans indicating what will be the desired new situations.

These plans will indicate the following information:

1. rooms (or courtyards) without water flows outlet (full blue colour);
2. flows of water (using simple blue lines with increasing size at each additional flow to the first one);
3. presence / use of ancient canals (green colour);
4. narrow streets with potentially high flows (red colour);
5. collection areas of exit canals with possibility of detailing more taking into account specific sensitive assets (like narrow streets) (transparent light colours for differentiation of each collection zone);
6. paths floors endangering the walls structures (concrete slabs, precast slabs with slopes leaning towards walls) (orange colour)
7. large canals more specifically those directly linked to archaeological structures (ex; DK area).(large blue colour)
8. main gullies formed and places where wall were damaged due to drainage weaknesses (suggested with using red colour).

3. Plans showing the state of conservation of walls:

In view of the preparation of the detailed emergency plan to be implemented before next monsoon season, it has been discussed and approved that this variety of situations should be mapped using the following classification:

1. Good state of conservation or minor degradations;

- No need for intervention apart from regular maintenance
- 2. Degradations but having led to a stable situation
 - No need for urgent intervention
- 3. Degradations linked to failure of the drainage system
 - Minor intervention to be linked with desired revision of drainage works
- 4. Degradations with remaining potential of brick falls
 - Need to carefully dismantle “near fall” masonry parts and undertake cleaning
- 5. Sensitive wall structures (high walls with underpinning needs, severe leaning out ..)
 - Masonry structures that need a minimum engineering study before intervention (propping, strutting, and detailed preparation / description of method to be applied)
- 6. Places of specific interest (most of them already spotted, wells, canals, ...)
 - Potential added value for the site if restored to be studied.

Additionally to these plans a plan will be prepared for each area indicating:

- 1. Portions of walls whose capping is in good condition
 - 2. Portions of walls whose capping need maintenance
 - 3. Portions of walls whose capping need full reconstruction
 - 4. Minor underpinning needs (1 to 2 brick layers maximum).
4. Plans showing pathways and indicating the state of conservation and their potential negative impact (direct / indirect) on some of the structures:

Pathways, though not part of the original fabric of the site are important for two main reasons:

- . they allow visitors to circulate in the site and thus those should ensure full security
- . some paths are located in non pertinent locations and moreover, at times represent a threat to the original structures.

In order to prepare the elaboration of a fully comprehensive plan for the revision of these existing paths it is proposed to prepare:

- 1. a plan of the overall site indicating main paths with recognizing :
 - a. Materials used (in situ casted concrete slabs, concrete slabs large size, concrete slabs medium size, burnt bricks, earth floors.
 - b. The state of conservation
 - i. Good
 - ii. Needing minor repairs
 - iii. Needing serious repairs
 - iv. Destroyed and needing full reconstruction (or reconsideration / relocation)
 - v. Location of gullies where pipes should be added under paths.
- 2. plans for each area (7) but at a larger scale, for detailing the situation for each of them with the following information:
 - a. State of conservation:

- i. Good
 - ii. Needing minor repairs
 - iii. Needing serious repairs
 - iv. Destroyed and needing full reconstruction (or reconsideration / relocation)
 - v. Location of gullies where pipes should be added under paths.
- b. Potential negative impact on original wall structures
 - i. Useful, but needing revision of slopes
 - ii. Unnecessary and needing to be removed

Appendix 4 – Proposal for an immediate capacity reinforcement for Moenjodaro conservation office.

Budget estimate for a first 4 months immediate capacity reinforcement at Mohenjodaro for undertaking urgent stabilization works:

A lot of work has already been done by the existing team of workers at the site since the large destruction that occurred by the end of August 2022. That includes the cleaning of the debris at SD area, cleaning the baths and reconstructing its side walls, and stabilizing some walls with underpinning. The cleaning efforts have also been extended to L and DK areas. But looking at the progress already made for the necessary cleaning it is clear that without a serious reinforcement of its capacity (human resource and equipment), it will take too long for this team to complete that work and as such will delay the implementation of what needs to be done for the actual stabilization and also to together launch a campaign for better preparation before.

To undertake and overall ensure that all conditions are met for the team to be efficient, it is proposed, as a first important measure that a capacity reinforcement budget (elaborated in below table) be immediately provided to Mohenjodaro site for the next four months, before a more detailed cost estimate of the more comprehensive restoration plan be prepared (during January 2023).

Such a four months capacity reinforcement would comprise :

- . Recruitment of about 28 workers (laborers but also masons and foremen) so as to establish 4 new operational teams that would be in charge of the still required cleaning of the site and all preparatory works. That would allow the existing staff which has the skills for it to concentrate on the stabilization works themselves: releveling of drainage system, underpinning and reconstruction of walls that have a retaining role.
- . Recruitment or temporary deployment of 2 assistant conservators;
- . Provision of two laptops and the necessary softwares;
- . Provision of building materials (mainly fresh soil and burnt bricks, and wood for propping / strutting purposes);
- . Provision of sufficient tools for the additional workers (pickaxes, shovels, wheelbarrows, rams, ...);
- . Satellite connection for internet, to established proper communication with national and international partners and experts, for the preparation of the long term restoration plan;
- . Logistical support for transport of materials, reception of guests, journalists, and communication.

Budget estimate:

	Designation	Q	Unit	Cost / Unit	Total
1	Team of workers (8 persons)	16	Month	1700	27200
2	Assistant conservators	8	Month	900	7200
3	Building materials		Bulk amount		16000
4	Tools and small equipments		Bulk amount		10000
5	Computers (Laptop) with softwares	2	Pieces	2000	4000
6	Satellite internet box	1	Piece	2500	2500
7	Satellite connection	4	Months	100	400
8	Logistic support	4	Months	500	2000
				Grand total	69300

Appendix 5 – Preliminary estimate for a suggested 3 years project

Budget for the necessary 3 years project (with short, middle and long term objectives) for full recovery of the state of conservation of the site and the implementation of climate change mitigation measures.

The overall budget for this large project has been estimated to 1,5 million US Dollars, Though the figures indicated hereunder do need to be taken with care, the idea being here to give an overall global idea of what such a project would probably involve so as to ensure that:

- . most damaged parts of the site will have been restored;
- . the visitors paths have been put back in service with eliminating the less adapted to the benefit of more discreet solutions;
- . there is better visibility in the aspect of the restoration works of structures dating back from different periods (more specifically differentiating the most ancient to the Buddhist one).
- . revised restorations techniques with improved capacity to resist to heavy and repeated rains conditions have been experimented and are proved
- . the team in charge of the conservation has reinforced capacities (quantitative, qualitative), office and site work equipment;
- . upgraded lab facilities and systematic control processes are in place;
- . conservation manual has been revised;
- . conservation and management plan for the whole site has been prepared.

Preliminary estimate :

Budget for the works themselves (materials and labor) : 400 000 USD

Tools and equipment for works (mixer, scaffolding, etc, ..): 100 000 USD

Mobile pumping station : 25 000 USD

Office equipment (hard and soft) : 30 000 USD

Upgrading of Lab + training : 73 000 USD

Expertise (national & international) : 140 000 USD

Research, experimentation and testing : 90 000 USD

Students involvement : 30 000 USD

Logistic support : 65 000 USD

Revision of conservation manual : 40 000 USD

Elaboration of management plan : 80 000 USD

Communication : 30 000 USD

Backstopping and missions : 247 000 USD

Overhead costs : 150 000 USD

Total : 1 500 000 USD

Appendix 6 – Specific estimate for upgrading of MCO lab facilities and skilled personnel

Objective: to upgrade the equipment and personal qualification of the existing laboratory at Moenjodaro to establish a more systematic quality control of the raw and building materials used for the restoration works and to launch a campaign of tests / experimentation for upgrading the quality of the material used in the most exposed parts of these restoration works (wall basis, floors, ...) to guarantee more durability and best response in case of major rainy events.

This would entail:

1. To renew / some of the existing soil and water testing equipment.
2. To complement the existing capacity additional equipment;
3. To extend testing procedures so those necessary for better mastership of building materials compressive tests (dry / humid) and to capillarity tests;
4. To train at least two members of the Moenjodaro conservation Cell to the use of the equipment
5. To train the overall team of Moenjodaro conservation Cell to make the best use of the results of the variety of tests
6. To set up a regular quality control process.

To give an idea, here is a first raw cost estimate for each of these items :

1. Small equipment : 4 000 USD
2. Additional small equipment : 4 000 USD
3. Press for compression tests and accessories : 25 000 USD
4. 2 x 3 months internship in a laboratory : 15 000 USD
5. Expert for onsite one week training workshop (+ one week preparation) : 15 000 USD
6. Experts fees and workshop : 10 000 USD

Total first estimate: 73 000 USD.

This remains the basis. For the experimentation and testing campaign to be developed during the next three years, more expertise (to be determined during next mission, but probably several months to address all issues) would be needed and possibly fees would be required if expertise do not exist within Sindh Ministry of Culture or in a Partner University in Sindh or elsewhere in Pakistan.