LAETOLI CONSERVATION AND SUSTAINABLE USE ROADMAP

State Party: United Republic of Tanzania

Name of the Inscribed Property: Ngorongoro Conservation Area, Tanzania

Area of Interest: Laetoli Paleoanthropological Site (Locality 8, Hominin Footprints Site G)

Description of the Property: The Laetoli paleontological and archaeological area (including Kakesio, Emboremony, Esere, and Noiti), which covers over 200 square kilometers is part of the Ngorongoro Conservation World Cultural Heritage Site located within the Ngorongoro Conservation Area (NCA). The site continues to host some extensive and important scientific research on human origins with a prolonged geological sequence covering the last four million years and containing evidence of human evolution and adaptability in Tanzania. Laetoli holds some exceptional and rare remains of fossil flora and fauna of unrivaled paleoanthropological milieus with important finds of hominins contributing to the scientific understanding of human origins. The evidence includes some well-preserved 3.6 million years old hominin footprints associated with the evolution of upright posture and bipedal gait in humans as well as fossils attributed to *Australopithecus afarensis*, *Paranthropus aethiopicus* and anatomically modern humans-*Homo sapiens.* Furthermore, the occurrence of Maasai Olpul rock art at various rock-shelters at Kakesio, Esere and Noiti also clearly demonstrate the continuous use of the Laetoli landscape from 4 million years ago to the present. Consequently, the overall landscape is considered as a cultural landscape with great potentials of revealing more evidence concerning the rise and developments of anatomically modern humans, modern behavior and human ecology in Tanzania and East Africa in general. Ngorongoro was inscribed as a World Heritage Site in 1979 under natural criteria (vii), (viii), (ix) and (x), and under cultural criterion (iv) in 2010, thus making Laetoli and Olduvai Gorge as World Cultural Heritage Sites within the NCA. The Laetoli hominin footprints, though currently buried using anthropogenic derived methods, the prints pose a continuing conservation challenge not only to the State Party but also to the International scientific community with no major consensus on how best to preserve and sustainably use them in accordance with: the 2016 Ngorongoro Declaration on Safeguarding African World Heritage as a Driver of Sustainable Development, the 2015 Siem Reap Declaration on Tourism and Culture – Building New Partnership Model, the 2005 Xi'an Declaration on Conservation the Conservation of the Setting of Heritage Structures, Sites and Areas, and the 2015 UNESCO Policy for the Integration of a Sustainable Development Perspective into the Processes of the World Heritage Convention (*Resolution* **20 GA 13**).

Size and Significance of Laetoli Paleoanthropological Site

The Laetoli Paleontological and Archaeological Area (including Kakesio, Emboremony, Esere, and Noiti Sites) lies within the Ngorongoro Conservation Area spanning from 35°7'15" E, 3°9'22" S (NW corner) to 35°14'17" E, 3°15'40" S (SE corner) and covering an area of about 250 square kilometers, including the Kakesio-Emboremony tract from 34°58'29" E, 3°16'37" S (NW corner) to 35°6'56" E, 3°23'19" S (SE corner) and the Esere-Noiti tract from 35°7'55" E, 3°16'19" S (NW corner) to 35°14'53" E, 3°22'31" S (SE corner)) in the western plains of the Ngorongoro Conservation Area (Figure 1). As a paleontological and archaeological area, Laetoli is very important in that it is the only upland site in eastern Africa that has so far produced the oldest fossil hominin footprints in the

world. The site was in 2010 declared as a World Cultural Heritage Site within the Ngorongoro Conservation Area. Laetoli is also recognized as part of the Ngorongoro Geological Park, which is the second Geopark in Africa. Laetoli is currently managed by the Ngorongoro Conservation Area Authority (NCAA) under the Department of Cultural Heritage. The **PRIMARY** area of Laetoli paleoanthropological localities is approximately 150 square kilometers while the **SECONDARY** areas, which includes Kakesio, Emboremony, Esere, and Noiti amounts to about 100 square kilometers as demarcated by survey beacons:

a. **Laetoli:** -3.14467338/35.06541163, -3.13507477/35.23157984, -3.27630238/35.22059351, -3.28315758/35.05854517.
b. **Kakesio:** -3.18852085/35.02970606, -3.19952085/35.12446314, -3.30646494/35.11622339, -3.30372293/35.0077334; and,
c. **Esere-Noiti:** -3.24561791/35.08781929, -3.25521548/35.2086689, -3.36489547/35.24712104, -3.3676373/35.08232612) (WGS84 UTM Zone 36).

Laetoli paleontological exposures occurs on an undulated Plains characterized by erosional and exposed outcrops of volcanic sediments on the Western Zone of the NCAA (Figure 1). It is one of the most important paleoanthropological sites in eastern Africa, where fossils were first discovered in the area in the 1930s by German explorers (Kohl Larsen), however, the significance of Laetoli for hominin evolution was fully appreciated when Mary Leakey's research began her research in the 1970s (Leakey and Harris, 1987). The site has yielded fossil hominins from the Upper Laetolil Beds (3.6-3.85 Ma), Upper Ndolanya Beds (2.66 Ma), and Upper Ngaloba Beds (>200 ka). The sample of hominins from the Upper Laetolil Beds is small (just over 30 specimens), but it still represents one of the largest and geologically oldest samples of *Australopithecus afarensis* material includes the holotype of *Praeanthropus* (Garusi I) and the lectotype of *Australopithecus afarensis* (L.H. 4: Hennig, 1948; Weinert, 1950; Şenyürek, 1955; Johanson et al., 1978; White, 1987; Harrison, 2011a).

Furthermore, Laetoli is also important for preserving trails of hominin footprints (Hay and Leakey, 1982; Leakey and Harris, 1987), presumably made by *Australopithecus afarensis*. The footprint trails provide crucial evidence to substantiate inferences based on the postcranial anatomy that bipedalism was an important component of the terrestrial locomotor behavior of Pliocene hominins (Leakey and Hay, 1979; Day and Wickens, 1980; White, 1980a; Charteris et al., 1981, 1982; Leakey 1978, 1979, 1981, 1987a; Hay and Leakey, 1982; Stern and Susman, 1983; Susman et al., 1984, 1985; Tuttle 1987, 2008; Latimer et al., 1987; White and Suwa, 1987; Tuttle et al., 1990, 1991, 1992; Latimer, 1991; Susman and Stern, 1991; McHenry, 1986, 1991, 1994; Feibel et al., 1996; Agnew and Demas, 1998; Stern, 2000; Ward, 2002; Meldrum, 2004; Schmid, 2004; Aiello and Harcourt-Smith, 2004; Sellers et al., 2005; Berge et al., 2006; Reichlen et al., 2008, 2010; Crompton et al., 2012; Harcourt-Smith, 2015; Masao et al., 2016).

Hominins from the Upper Ndolanya Beds include the first specimen of *Paranthropus aethiopicus* discovered by Terry Harrison and his co-workers in 2002 south of the Equator (outside the Turkana Basin), and one of the oldest and securely dated specimens attributed to this taxon (Harrison, 2002, 2011a). Additionally, localities to the south and southwest of Laetoli have yielded small paleontological collections from the Lower Laetolil Beds (3.85 Ma to older than 4.36 Ma), but no hominins have yet been recovered from these sediments. A partial cranium of an archaic *Homo* sapiens was recovered from the Upper Ngaloba Beds (Late Pleistocene) in association with Middle Stone Age artifacts (Day et al., 1980; Magori and Day, 1983; Ndessokia, 1990). Apart from hominins,

the rich fossil record from the Upper Laetolil Beds and Ndolanya Beds offer unique insights into the faunal and floral diversity of Africa during the Pliocene, and they provide a well-dated biostratigraphic reference for comparisons with other Plio-Pleistocene faunas in the world. Furthermore, the inferred palaeoecological setting at Laetoli is unusual for hominin-bearing sites in East Africa in the absence of sedimentological and paleontological evidence for extensive bodies of water (i.e., rivers or lakes) and in being less densely wooded (Harris, 1985; Leakey and Harris, 1987; Andrews, 1989, 2006; Cerling, 1992; Andrews and Humphrey, 1999; Musiba, 1999; Kovarovic et al., 2002; Kovarovic, 2004; Su, 2005, 2011; Harrison, 2005, 2011b, 2016; Kovarovic and Andrews, 2007, 2011; Kingston and Harrison, 2007; Musiba et al., 2007; Su and Harrison, 2007, 2008, 2015; Andrews and Bamford, 2008; Peters et al., 2008; Rossouw and Scott, 2011; Kingston, 2011; Kaiser, 2011; Bishop et al., 2011; Barbonis, 2014; Louys et al., 2015).

A. Premise: (Concern for current conservation situation - water presence, fragility of substrate, potential negative effects of current reburial system)

At the Ngorongoro Conservation Area expert meeting on Laetoli footprints and museum, that took place from March 18 – 19, 2019 at the UNESCO Headquarters in Paris, France; it was agreed upon that the State Party (the United Republic of Tanzania) will prepare an exhaustive report and a proposal for a short- and long-term conservation strategy of the Laetoli hominin footprint site. The premise of this report is to:

a. Address current factors affecting the property and share the State party's concerns on the current conservation situation at Site G (the hominin footprints site) within Locality 8.

b. Legitimize the State Party's decision to reopen the footprints within an enclosure and properly monitor them as part of a long-term conservation strategy while allowing them to be viewed by visitors.

c. Share the proposed best practices that will be implemented at the property (which include supporting infrastructure, human capital, site interpretation and presentation, and future research priorities)

d. Present a long-term research and conservation plan for Laetoli paleoanthropological site and a framework for the landscape approach/strategy for the site.

The Laetoli hominin footprints have and continue to pose conservation challenges that require a well-informed, science-based solutions, which will pave a way for sound conservation measures and sustainable use of Laetoli paleoanthropological site as desired by the State Party. To establish the best practices, regular monitoring of the hominin footprints site was strongly recommended by UNESCO (Sec. **36 COM 10A)** and the Laetoli Project Advisory Committee at their meeting (November 22 – 26, 2014 at Kudu Lodge in Karatu, and further recommendations put in place at the December 20-23, 2019 at the Laetoli Urgent Meeting at the NCA Headquarters), therefore, the last time the hominin footprints were re-opened for regular monitoring was in June 25 – July 10, 2016. (For the southern- and northern-end of the trail). The NCAA recognized that there was a need of establishing a periodic monitoring and evaluation plan on the state of conservation of the hominin footprints trail at Site

G and S, as it was recommended to the State party by UNESCO and the World Heritage center in 2019. Therefore, the State party reviewed the report submitted by an international team of rock conservation experts, which was commissioned by the Ngorongoro Conservation Area Authority in 2013-16 and decided to reopen two portions of the hominin Site G footprints trail (the northern and southern ends) as well as the new trail at Site S. The decision was made in consideration with the following documents:

a. The Recommendation on International Principles Applicable to Archaeological Excavations, formulated at the UNESCO General Conference of the United Nations Educational, Scientific and Cultural Organization (New Delhi, 1956).

b. The European Charter on the Protection of the Archaeological Heritage (London 1969, revised in Valetta, 1992).

c. The Convention Concerning the Protection of the World Cultural and Natural Heritage (The World Heritage Convention, Paris, 1972).

d. The Xi'an Declaration on the Conservation of the Setting of Heritage Structures, Sites and Areas (Xi'an, 2005).

e. Menorca Declaration on Development and Use of Best Practices in the Management of Archaeological World Heritage Sites (Menorca, Spain 2012).

The State Party conducted a fourteen-days re-excavation and monitoring exercise from June 25 to July 10, 2016. The monitoring exercise included the reopening of two (two-square meters') portions of the southern- and northern-end of Site G trail as well as three trenches at Site S (discovered footprints trails during the EIA and CHIA in 2014 south of G prints) to allow for visual inspection and collection of multifaceted geological data that were used in evaluating the state of footprints preservation and proposing sound conservation solutions of hominin footprints trails G and S at Laetoli. The footprints were reopened for a very short time (one to two days maximum) and then they were reburied using the same conservation method that was employed by the Getty Conservation Institute after several decades of initial burial of the footprints by Mary Leakey and her team in 1987.

Major Conservation Concerns in 2016:
Though well intentioned, the conservation efforts and the anthropogenic derived re-burial of the prints has in fact caused more harm than anticipated. Based on visual observation and analyses of the data collected (2011, 2014, and 2016), the State Party is gravely concerned with the current state of preservation of the Laetoli hominin footprint trail at Site G in that:

A. Covering of the footprints has created an artificial environment and thus altering the footprint tuff. The process has contributed to environmental conditions that have allowed for bioturbation and proliferation of termitary and tunneling along the edge of the footprint surfaces.

B. By covering the footprints, the process rather than allow for a better trans-evaporation of underground water, it has resulted in prolonged water saturation that has dramatically changed the chemistry of the footprints tuff, thus resulting in irreversible changes of the tuff surface.

C. Sediment dissolution as a process has greatly contributed to the deterioration and loss of details and scientific data originally preserved on the footprint surface.

D. The reburial as a process has never been consistent with smart conservation efforts that allow for real-time monitoring and for the mitigation processes, contra to 2015 UNESCO Policy for the Integration of a Sustainable Development Perspectives into the Processes of the World Heritage Convention (Resolution 20 GA 13). As a result, the process has robbed the State Party an opportunity to develop home-grown conservation solutions that are in par with sustainable development of its cultural heritage property. The conservation process for years alienated local experts from active participation in conservation efforts. It should be noted that in 1996, when the Getty Conservation Institute initiated its conservation project, local and qualified Tanzanian experts not only were excluded from the process but also were expelled from their positions within the Antiquities Department. This included a one geologist and four paleoanthropologists, which the Government had spent enormous resources to train them at a doctoral level. Ironically, UNESCO Charter, which has dogmatically preached for inclusion of local experts in conservation efforts of cultural heritage assets to empower local authorities and communities, in this case the process failed to achieve such goals.

1. Analysis and review of different Conservation case-scenarios based on observations and tests conducted at Site G and S (2013, 2014 and 2016).

1.A Partial re-excavation with a temporary enclosure:

<table>
<tr><td colspan="2">Short characteristics of temporary enclosure and other conditions necessary and essential for producing conservation activities and tests.</td></tr>
<tr><td colspan="2">• Temporary enclosure must be constructed at the south end of re-burial mound of site G.
• Temporary enclosure must be constructed without any permanent foundation as a lightweight building or tent with sidewalls. It must protect re-excavated part of pit from direct sun, wind, sudden rain or any other weather or human impact.
• Temporary enclosure must be equipped with electricity, ventilation and system of temperature and humidity control.
• Temporary enclosure must be constructed only for short period of time not longer than one dry season (3 months). To the beginning of rainy season temporary enclosure must be taken to pieces and pit must be re-buried with usage of existed system of conservation mound.</td></tr>
<tr><td>Pros</td><td>Cons</td></tr>
<tr><td>1. Re-excavation will allow monitoring the footprint tuff surface and looking for changes happened since the re-excavation made in July 2016.</td><td>1. Temporary re-excavation exposes footprint tuff surface to next twice changing of environmental conditions: first – at re-excavation; second- after –re-burial</td></tr>
</table>

2. For 2-3 months it is possible to carry out conservation tests and improve worked out conservation methodology if requisite temperature and humidity environmental conditions are controlled.	2. Control of temperature and humidity conditions and its changing on demand inside of temporary enclosure is complicated up to impossible and expensive. In any way temporary enclosure will be a construction with small area and with relatively low height. It will produce environment of glasshouse (greenhouse) 3. Daily broad changing of temperature and humidity can cause additional stress for microfractures on the footprint tuff surface. Also, it creates difficulties for producing of conservation operations because variance between environment inside enclosure and technical data of conservation materials and compounds. 4. Footprint tuff surface must be re-buried with the same system of reburial mound. It will apply restrictions for the results of future monitoring. It will show changes of tuff surface with and without conservation activities happened in the system and at the conditions of re-burial mound (groundwater, sand pressure, natural temperature, and humidity fluctuations). 5. Dissolution of calcite will continue. It will lead to continuation of prints surface smoothing. 6. Re-buried footprints will not attract tourists.

1B. Partial re-excavation with a permanent enclosure:

Short characteristics of permanent enclosure and other conditions necessary and essential for producing conservation activities and tests.
• Permanent enclosure must be constructed at the south end of re-burial mound of site G and must protect re-excavated part of pit from direct sun, wind, rain or any other weather or human impact. • Permanent enclosure must be original full building equipped with electricity, ventilation and system of temperature and humidity control. • Permanent enclosure must have appropriate for building and footprint tuff drainage system. • Permanent enclosure must be equipped with indoor dust and microorganisms' protection system (for example: two entrance volumes with triple doors system and ventilation with filters and different air pressure levels inside and outside). • Footprint tuff must be protected from accidental physical damage by tourists.

Pros	Cons
1. Environment conditions for re-excavated part of footprint tuff will be noticeably shifted just one time (during re-excavation). 2. Conservation and monitoring process will not be restricted in time. It will allow producing consistent and well-considered conservation tests and works with concomitant and constant monitoring. Conservation test and monitoring will be produced at constant environment. Consequently, influence and behavior of conservations compounds will be defined directly and more exactly. 3. Due to sizes of permanent enclosure footprints will be accessible for small groups of tourists.	1. Complicated architectural and technical task due to joint of permanent enclosure and rest part of unexcavated reburial mound. It is concerned with: • permanent enclosure's foundation. • drainage systems of permanent enclosure and part of unexcavated reburial mound and joint of two different drainage systems. 2. Building of permanent enclosure above only part of reburial-mound will lead to changes in present footprint tuff conditions at the rest unexcavated part of re-burial mound. Consequently, it led to necessity of temporary short-term periodical re-excavations of footprint tuff at indicated area for monitoring purposes 3. Dissolution of calcite will continue at the rest part of unexcavated reburial mound. It will lead to continuation of prints surface smoothing at unexcavated area

1C. Total re-excavation – with a permanent enclosure:

Short-term characteristics of permanent enclosure and other conditions necessary and essential for real-time conservation activities and tests.
• Permanent enclosure must be original full building equipped with electricity, ventilation and system of temperature and humidity control. • Permanent enclosure must be mounted with high resolution cameras that will collect photos to be used in real-time monitoring using photogrammetry analyses. • Appropriate climate and drainage system must be implemented to keep the right amount of moisture and temperature to the footprints tuff (footprint tuff drainage system). • Permanent enclosure must be equipped with indoor dust and microorganisms' protection system (for example: two entrance volumes with triple doors system and ventilation with filters and different air pressure levels inside and outside). • Footprint tuff must be protected from accidental physical damage by tourists.

Pros	Cons
1. Environment conditions of footprint tuff will be noticeably shifted just one time (during re-excavation). 2. Conservation and monitoring process will not be restricted in time. It will allow producing consistent and well-considered conservation tests and works with concomitant and constant monitoring. Conservation test and monitoring will be produced at constant environment. Consequently, influence and behavior of conservation compounds will be defined directly and more exactly. 3. Full-scale monitoring and conservation will be available. 4. Footprints will be accessible for tourists. Permanent enclosure will be the main exposition of Laetoli museum complex with important historical, anthropological and conservation concernment. 5. Permanent enclosure with designed and applied drainage system and other features will be tested and monitored in natural condition. Consequently, this experience and knowledge will allow to design and construct permanent enclosure (-s) above footprints at the site S.	1. Drainage system is rather complicated in design works and modeling. It must conform to next conditions: • excluding the possibility of flooding in areas with footprints inside the building during rainy seasons. • exclude effect of subsurface moisture rising by capillary action. • exclude significant over drying of underlying aeolian tuff which can cause its intense fracturing that results in tension (stress) for layer of footprint tuff.

1D. New reburial system (open-air or under an enclosure):

Short characteristics of new re-burial system and other conditions necessary and essential for producing conservation activities and tests.
• Open-air reburial system: re-burial mound without any protection of its materials from direct sun light, rain, and wind. Existing reburial mound is open air system. • Under an enclosure reburial system: re-burial mound covered by an appropriate shelter (a light-weight structure) that will protect the footprints from direct sun light, rain, and wind. • Completely other type of reburial systems is hard to be designated due to the existing reburial system proposed and implemented by the Getty Conservation Institute. It corresponds with and even exceeds main and universal principles of conservation (re-burying) of archeological sites. Some shortcomings of this system have been revealed during its more than 20-years of existence at Site G. Consequently, the most advantageous and predictable solution for new reburial system is a reformation of existing Getty reburial system according to in-situ

investigations, monitoring results, defects of footprint tuff and laboratory studies. According to results of research works next changes can be proposed:

- Fine grained calcite crumb can be added to bottom layer of sand in re-burial mound system. It will partially decrease level of footprint tuff's surface smoothing due to calcite dissolution. Calcite crumb can be obtained by crushing of calcite marble (or limestone) OR
- Replacement of black reburial sand with crushed laminated tuff.
- Changing of geotextile and biobarrier layers. Decision must be done upon the results of fully re-excavation of re-burial mound.
- Re-organization of the existing drainage system. The type of drainage system will depend on the selected type of new re-burial system (open air or under an enclosure).

Pros	**Cons**
1. Re-excavation will allow monitoring the footprint tuff surface and looking for changes happened since the last time the prints were re-excavated. 2. During the 2-3 months it is possible to carry out real time conservation tests and improve the worked-out conservation methodology (requisite temperature and humidity) and monitoring of the prints in controlled environmental conditions. 3. not expensive compared with other options such as partial or total re-excavation.	1. New reburial system (either as open-air or under an enclosure) will not be well predictable. In both cases it will be hard to predict exactly how changes in reburial system will affect the footprint tuff's surface (discoloration, surface smoothing, dissolution, micro-fracturing et c.) 2. Temporary re-excavation for organization of new reburial system will double-expose the footprint tuff surface to changes of environmental conditions: first – at re-excavation; second- after –re-burial 3. Control of temperature and humidity conditions for conservation test is complicated up to impossible. 4. Daily changes in temperature and humidity can cause additional stress for microfractures on the footprint tuff surface. 5. Footprint tuff surface will be re-buried with the partially new system of reburial mound. It will apply restrictions for the results of future monitoring. It will show changes of tuff surface with and without conservation activities happened in the system and at the conditions of re-burial mound (groundwater, sand pressure, natural temperature, and humidity fluctuations). 6. Drainage system must be designed and modeled according to type of new reburial mound: open-air or under an enclosure 7. The re-buried footprints will have no socioeconomic values and will discourage visitors and tourist interest.

1E. Doing nothing (leaving the prints in current conservation state):

Short-term conservation characteristics of Doing nothing (maintaining the status quo)	
• Doing nothing – means doing no conservation but periodically doing monitoring works. • Currently the footprints at site G have no anthropological scientific significance due to the changes on the sediment surface preserving the prints. However, the prints still have high historical (initial discovering) and conservation significance, therefore they could be properly conserved in an enclosure with constant monitoring to provide visitors with the real paleoanthropological and cultural experience.	
Pros	**Cons**
1 Money saving option – very low costs	1. Low responsibility of anybody for slow step by step destruction of footprints surface. 2. Lost opportunity for conservation tests and missed attempt to decrease destruction or fix the state of footprints. 3. Each temporary re-excavation for monitoring purpose will expose footprint tuff surface to next twice changing of environmental conditions: first – at re-excavation; second- after –re-burial 4. We will lose the possibility to use side G as a place for natural modeling of environment influence at the footprint tuff in condition of permanent enclosure. This information is highly important and indispensable for discussion of design, project and building of an on-site museum at site S. 5. Nowadays re-burial mound has no interest in tourists.

2. Options & Interpretation for each Scenario

After reviewing the reports from the re-excavation and post-excavation analyses, the State Party opted for a partial exposure and construction of a controlled exposure of the prints on the southern end at Site G based on the following premises.

1. According to the analyses and weighing on the *pros* and *cons* of all suggested and considered case scenarios here is only one expedient solution and attempt for long-term preservation of footprints by means of its re-excavation and conservation under controlled environmental conditions.

2. Single risk and shortcoming of this scenario is the difficulties of forecasting of the drainage system with subsequent complicated modeling and prediction of ground water behavior and the impact on footprint tuff. The drainage system must be forecast according to all engineering and architectural

conditions of northern Tanzania. Furthermore, it must correspond to several conditions highly important for preservation and conservation of footprint tuff:

- Eliminate the possibility of flooding in areas with footprints inside the building during a rainy season.

- The design must consider the effect of subsurface moisture rising through capillary action, which has already been mentioned by the Getty Conservation Institute team (Getty 2011b, p. 3). This in long term may result in the appearance of efflorescence, discolorations and powdering on the surface.

- At the same time a drainage system project must consider the influence of moisture and changing conditions (draining, drying et. c) of the underlying aeolian tuff and its effect on the footprint tuff layer (tension, stress) due to the drying process of the aeolian tuff.

3. According to all other revealed aspects of case-scenarios with "Total re-excavation - with permanent enclosure" has only "pros" gradation marks. Based on experts' opinion, the footprints at site G have lost their significant scientific value due to changes of the shape and other anthropogenic imperfections on their surface. However, the footprints have other equally important values as object of historical, touristic, educational, conservational science and engineering interests. If the footprints continue to be buried under current conditions, these other listed values will have no meaning and may not work while the footprints are found in current re-burial system. Shortcomings of the existing re-burial system were revealed during the periodic monitoring and reopening of the prints followed by the 2016 research work. Their main "negatives" effects were mentioned under item "Doing nothing".

4. Subsequently, total re-excavation of the footprint tuff at site G and building of a permanent enclosure with appropriate foundation, well-designed drainage system and controlled T-H conditions will yield significant and positive conservation results and will allow for solving different interrelated tasks: development of site management best practices and operational guidelines, development of tourism, education, conservation, and preservation process. In turn, this will permit long-term conservation work and constant monitoring paving approaches on how to improve the proposed and worked out most appropriate conservation technique. Also, these works will be natural modeling system of new environmental influence on the re-excavated footprint tuff. Consequently, the gained information (data and knowledge) will allow to design appropriate enclosure (-s) at the site S which is under highly scientific anthropological importance.

5. All other suggested and considered case-scenarios have more "cons" than "pros", their risks differ in wide range. In some cases, it is rather hard to design and model two joint drainage systems. In other cases, it is hard to control T-H conditions for conservation works. In our opinion the "New re-burial system" scenario is most complicated and risky. It will be hard to predict the outcomes (particularly the impact) of new reburial system on the footprint tuff's surface (in terms of discoloration, surface smoothing, dissolution, and micro fracturing). This task seems to be more complicated rather than the design of a drainage system for the permanent enclosure over the whole site G trail.

6. Analyses of current conservation condition of footprints at site G have revealed following important items: (a) site G footprints have considerably lost their scientific value due to sediment dissolution but continue to retain their aesthetic value; (b) leaving the footprints reburied and or introducing a new reburial mound of any type will lead to further sediment (footprint tuff) degradation due to micro fracturing, sediment dissolution and smoothing. According to the results of the commissioned research works and case-scenarios' analyses conducted; the following can be concluded:

   - "No development at Laetoli footprints area is possible without working out of a "Total re-excavation with a permanent enclosure and real-time monitoring in controlled environment" scenario. Therefore, building of a permanent enclosure will lead to added value of the heritage property and reinforce the historical, educational, and touristic meaning and role of Laetoli area as a World Heritage Site.

   - Preservation of footprints by means of conservation works and monitoring become a case study that will guide future conservation efforts and best practice examples for other footprints sites in Africa such as Engaresero (lake Natron in Tanzania), Koobi Fora, Ileret (Lake Turkana in Kenya), Melka Kunture and Gombore III (Upper Awash Valley in Ethiopia), and Namib Sandsea (Walvis Bay in Namibia). Acquired experience in the first place can be used as a testbed and model projecting for future enclosure for the footprints at site S. In that case projecting and conservation experience at site G will allow to develop protocols and conservation conditions for all year-round scientific investigations at site S.

3. **Research, Community Engagement and Landscape Approach**

The State Party is currently preparing the following documents: A Research Guideline and Paleontological and Archaeological Collection and Repository Plan. The proposed research guidelines will have one major objective, namely to critically re-examine and refine the paleoecology of Laetoli by using a broader range of evidence from a diversity of fossil taxa (i.e., plants, invertebrates, reptiles, birds and mammals), modern-day ecosystems (i.e., soils, vegetation, invertebrates, and vertebrates), and paleoenvironmental proxies (i.e., sedimentology, geomorphology, palynology, phytoliths, coprolites, stable isotopes, mesowear, ecomorphology, and gastropod and mammal community structure).

A better appreciation of the paleoecology offers insights into early hominin ecology and paleobiology, which have implications for ongoing debates about the mode and tempo of speciation and extinction among Pliocene African hominins. The paleoecology of the Upper Laetolil Beds has been reconstructed as an open woodland, shrubland and grassland mosaic, with closed woodland and gallery forest bordering seasonal watercourses. However, the evidence points to the Upper Laetolil Beds being more mesic and more densely wooded than the modern-day Laetoli ecosystem. Turnover in the composition of the Laetoli large mammal fauna during the one-million-year gap in the fossil record between the Upper Laetolil Beds and Upper Ndolanya Beds (3.6 Ma to 2.66 Ma) points to a shift towards somewhat drier habitats with a greater proportion of grasslands in the Upper Ndolanya Beds. Yet, alternative lines of evidence indicate that the Upper Ndolanya Beds may have been relatively mesic and dominated by open and closed woodlands, therefore future research at Laetoli

will aim at teasing out such issues and providing a better scenario that will be used in development and the creation of interpretive material to complement the hominin footprints by telling the evolutionary story of our ancestors in a changing Laetoli landscape during the Plio-Pleistocene to the Anthropocene.

4. Roadmap for Conservation Efforts in 2021-2022

At the Ngorongoro Conservation Area: Expert meeting on the Conservation of the Laetoli footprints and the museum project, which took place at the UNESCO Headquarters in Paris from March 18-19, 2019; it was agreed that the State party will adhere to the decision of the Committee on the Joint World Heritage Centre in that the State party will develop a roadmap with both short-term and long-term conservation and sustainable use of Laetoli paleoanthropological site. Following were key items recognized:

1. *Condition of the road leading to Laetoli*: site accessibility and control of traffic to the site itself. Creating a Buffer Zone and identifying Core sites for conservation, research, and sustainable tourism development (limiting the number of visitors to the site until proper measures of protection are in place)
2. *Soil erosion threatening the site*: here a question was raised on how to create a balance between preservation and allowing some natural processes such as erosion to continue taking place and revealing more fossiliferous deposits
3. *The nature of the footprint's tuff preserving the prints*: the footprint tuff is a highly altered rock with secondary calcite and montmorillonite as major minerals (up to 90 vol. %) and compositionally it is low-silica rock with high content of Ca and volatiles (CO_2 and H_2O), which might explain why the current conservation method may have resulted in surface destruction of the footprint tuff due to a significant load and calcite dissolution.
4. *The current footprint tuff condition*: mechanical and physical weathering have been observed and may be a result of the current conservation procedure at the site. This may have also led to the contamination of the surface by sand particles from the reburial mound which show strong adhesion to the tuff surface.
5. *Yellowing of the footprint tuff*: this is due to the aging process of the Bedacryl used to consolidate and preserve the footprints. Polygonal fracturing of the footprint tuff due to Bedacryl surface coating and/or in areas contaminated with strongly adhering sand particles.
6. *Footprints are decaying and becoming softer and sandy*: it was proposed that the footprints should be sheltered in an enclosure with controlled temperature and humidity to improve preservation of the prints and allow active monitoring
7. *What are the other available options apart from uncovering the prints*: It was strongly suggested that the State party exhaust other available options apart from uncovering them in place of continued deterioration? The 2016 Periodic monitoring undertaken by the NCA revealed accelerated dissolution of the prints (comparative analysis of images from 2011 – 2016) as well as the dangers of periodic re-excavation of the prints for monitoring.
8. *State Part should continue searching for technical details*: this will require a partial re-opening of the footprints and the study findings and proposal thereafter be put before a peer-reviewed process followed by a meeting of the Advisory Body and State Party in Arusha. This was proposed to be conducted in 2020 but due to the outbreak of Covid-19 it was very difficult to

convene a group of experts in Tanzania, everything was postponed pending to the pandemic outbreak and ensuing conditions.

Questions raised at the meeting which form a roadmap include the following:

a. As part of a long-term conservation plan, will the proposed enclosure be a museum or a visitor's center? If it is a museum, what is the justification for having a second museum 20 km away from Olduvai Gorge?
b. How shall we ensure the connection between Laetoli and Olduvai Gorge Museum?
c. Have there been any visits to other museums involved in similar works for comparative purposes?

Apart from addressing the questions above, other key elements of the road map will include the following:

- Identification of threats and opportunities in conservation and presentation of the Laetoli footprints.

- Need for comparative analyses with other fossil footprints sites (this was done some years ago – new analyses must be conducted again) but other fossil hominin footprints such as those at Ngaresero (Lake Natron, Tanzania), Melka Kunture (Upper Awash, Ethiopia), Ileret (Lake Turkana Kenya) and Walvis Bay (Namibia) are best candidates for such comparative studies.

- Exhaustive discussion and analysis of alternative solutions for conservation and preservation of Laetoli footprints: considering impacts of each alternative, including treatments required on the footprints (and their effect – any treatment must have been satisfactorily tested prior to use).

- Feasibility of the conservation plan (this must include technical and financial aspects).

- Development of a long-term maintenance and monitoring system; this must include a site management plan, best practices, and operational guidelines.

- Stakeholders' consideration and involvement in decision making in the development of the project?

- What are the larger development implications (positive and negative) of the project on the area, on the World Heritage Site, on the Region etc.

- What types of developments are proposed? Infrastructure, roads, hotels, services, and any other types of development that might have an impact on the site.

4. Proposed Tasks Ahead of the Team Meeting

Before any exhaustive plans and a full development of a roadmap, here are the key tasks ahead of us to consider when we meet on our next zoom meeting aside from those identified above

1. Carefully develop a proposal for a re-excavation and monitoring of the footprints at Sites G and S (select trenches) with a time frame rather than piecemealing it. I propose a quick two-week re-excavation in January after a complete proposal of the guiding roadmap has been developed.
2. Aerial and GPR mapping of the site (aerial mapping must be for the entire site rather than Locality 8 and identify all other mammalian footprints sites and run some test trenches to determine their current preservation conditions). This must be done in summer during the dry season – one must set aside at least three to four weeks' time to be able to accomplish this.
3. A comprehensive hydrogeological study of the site with surface water runoff models at Locality 8 (Sites G and S). There will be a need to identify some experts familiar with the Rift Valley System who have done some comprehensive hydrogeological studies – such as Gail Ashley's work on underground aquifers just to mention as an example. We may engage such people in various capacities during the re-excavation of the prints. If we identify some international researchers, we must make sure that their counterparts are local Tanzanian experts to serve as a pipeline for knowledge transfer through the project.
4. Use a landscape approach to develop long-term conservation, preservation, and sustainable use of the site (including identifying research priorities, training of site managers and community outreach/participation programs). This will include a comprehensive Cultural Heritage Impact Assessment
5. Identify other experts that will be involved in various aspects of the project and develop clear goals, tasks, professional work agreements and data sharing policies (who owns the data and how other stakeholders can use and or share that data outside the team).
6. Identify peer-reviewers of the proposed conservation project, periodic monitoring and excavation reports and all other technical documents including those from previous years. We will need to compile all these documents in a proceeding that will make it easy to be peer-reviewed.
7. Decide on site visits to other fossil hominin footprints sites for detailed and exhaustive comparative analysis. Consider sites in Namibia, Kenya, and Ethiopia to be very relevant for the comparative analyses. There are other sites outside the continent in Europe (*Homo antecessor* footprints) and North America (White Sands Human Footprints) to consider if one needs to expand the scope of the analysis.
8. Develop a financial model as requested by the WHC outlining each project development stages and their costs. This was one of the key elements of contention at the 2019 Paris meeting. There must be a way in which one could develop such a financial model without getting bogged-down into details and costs that may be hard to forecast.
9. Identify key research areas that are relevant to the conservation and sustainable use of the site. This must include a capacity building plan, research operational guidelines (making sure that future research adhere to the developed and implemented protocols).
10. Develop a community/public education/engagement program