THE APRIL 2022 FLOODS IN KWAZULU-NATAL – A HYDROLOGIST’S PERSPECTIVE
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This article for laypersons was prompted by a live SABC News Channel 404 interview with the writer on 22 April 2022 on the “Floods in KZN”, with Questions 1 to 5 Supplied by the SABC

Q1: What role if any, has Climate Change (CC) had in these recent floods?

a. By way of background, let’s first of all summarise what rainfalls were measured in the 24-hour period from midnight to midnight on 11-12 April 2022:
   - Margate had 311 mm
   - Mt Edgecombe and Pennington 307 mm
   - Virginia Airport 304 mm
   - King Shaka Airport 225 mm
   - Port Edward 188 mm
   - Pietermaritzburg 99 mm
   - Mtunzini 66 mm
   - Greytown and Mooi River 44 mm

   with the effects of these heavy rains on flooding exacerbated by soils being wet because 50-150 mm rainfall had fallen in the week prior to the floods, while in the Umlazi river flooding occurred because of safety releases from the upstream Shongweni Dam (to prevent the dam wall breaching), resulting in a surge flow downstream which exceeded Umlazi canal’s capacity (see photo).

   Preliminary calculations by Prof. Jeff Smithers of the Centre for Water Resources Research at the University of KwaZulu-Natal estimate the 1-day rainfalls along the coastal areas from Margate to Virginia Airport to have been of the order of the 1 in 50 year to the 1:100 year event, while further inland at somewhat higher altitudes around Pinetown the storm could have dumped rainfalls closer to the 100 to the 200
year return periods, based on rainfall figures from the eThekwini (Durban) City Engineers’ Department.

b. Let’s remind ourselves of the type of damage done by the flooding to infrastructure, with TV and newspaper reports including damage to
  o roads (including N2 and N3 highway closures),
  o transport (cars swept away),
  o communications (mobile phone infrastructure, with around 400 Vodacom and 500 MTN towers impacted because of electrical outages),
  o electrical systems,
  o water (feeder lines broken)
  o over 3 900 houses destroyed, approximately 8 100 partly destroyed, with 13 500 households affected, and over 600 schools damaged/closed,
  o port operations suspended, as well as
  o 3 paper mills closed,
as shown in the photos overleaf.

c. What caused these heavy rains? It was NOT a tropical cyclone, as sometimes stated, but a so-called cut-off low pressure system along South Africa’s east coast which persisted for 3-4 days and which was associated with the heavy rains, as the accompanying map from the SA Weather Service (note: with rainfall in cm and not in mm) shows.

![Rainfall Map]

And, we had a two-day Level 5 warning/alert by the SA Weather Service of this subtropical depression code-named “Issa” which was moving in a south-westerly direction, with the Level 5 alert later upgraded to Levels 8 and 9 (out of a maximum of 10) once impacts and the scale of flooding were better understood – so we were forewarned!

d. We are in a so-called La Nina phase, so we must expect heavier than usual rains this year, with floods generally occurring in clusters during La Nina years, as has also been reported in Australia.
e. And now on to the climate change part of the question: How does climate change alter rainfall patterns?

i. Climate change impacts are projected into the future by complex computer models called Global Climate Models (GCMs) and these can output, either by direct or by indirect computation, daily rainfalls as well as daily maximum and minimum temperatures from 1960 to 2100.

ii. These GCMs are conditioned by emissions into the atmosphere of CO₂ and other Greenhouse Gases (GHGs) and their projections into the future, which are influenced by anticipated economic and other factors.

iii. These emissions are the drivers of global warming, and with the warming, a more energized atmosphere results in, amongst others, changes in rainfall, its spatial distribution, the rainfall’s intensity, and in changes in the frequencies of occurrences and magnitudes of heavy rainfall events, as well as in the southern hemisphere by a southward shift in, for example, tropical cyclones.

f. Did CC play a role in these floods? If one goes by Government responses to the April 2022 floods, the answer would be a certain “yes”, with the various spokespersons’ link to climate change sometimes being quite unequivocal and even dramatic. Inevitably, many politicians visited flood-affected areas, with these including the State President, the Ministers of Police and of Co-operative Governance, the Province’s Premier and Mayors. They, and others, issued many statements, some no doubt out of conviction after what they saw, but possibly also linked to either political expediency, point-scoring, jumping onto the climate change bandwagon by blaming it on unrelated issues, to hide shortcomings of their own governance or out of sheer ignorance of our flooding history. In regard to the link between these floods and climate change President Ramaphosa, when inspecting damage, stated “This disaster is part of climate change. It is telling us that climate change is serious, it is here”, while a KZN Government tweet read that this was “one of the darkest moments in history” and Desigan Naidoo of the Institute of Security Studies commented that “These April 2022 flood events are the expression of climate change in the form of frequent, high-intensity extreme weather events” and also that “the floods ... are arguably one of the most visible and deadly signs of climate change in the country to date”. However, according to scientific experts at SA Weather Service this particular cut-off low pressure system could not, with any “quantifiable precision”, be attributed to climate change.

So, opinion on the direct links of these floods to climate change are divided, with no consensus (as yet) in the scientific literature on any trends in the currently observed data in terms of impacts of climate change on floods.

g. We need to remember again that climate change, as real as it is, has become a buzzword and often the scapegoat behind which many observations and social / governmental inefficiencies can be conveniently hidden.

h. To pick up on a previous point, with the April 2022 floods many spokespeople tend to forget about our history of flooding in KwaZulu-Natal and more specifically in the area around Durban.

i. From Young’s 1960 scientific paper on Floods in Natal in the Royal Meteorological Society’s journal “Weather”, as well as Badenhorst and co-workers’ Survey of the September 1987 Natal Floods published in 1989 by the
Foundation for Research and Development, and newspaper articles, although not necessarily written by scientists, we can glean that history tells us of significant recorded floods in the Mgeni system, along the coast of KwaZulu-Natal and inland up to the Drakensberg in for example 1856, 1868 (late August, with gale force winds “dumpring” 262 mm on Durban in 36 hours), 1869, 1878, 1905, 1917 (discharging 5 700 cubic metres per second into the Mgeni estuary), 1935, 1943, 1947, 1953, 1959, 1976, 1984 and 1987. Some interesting and relevant facts on a selection of these floods, taken from the above sources, are given below.

i. 1856: From 13 to 15 April, for example, 686 mm rainfall was recorded in the Durban area over a 3-day period (Natal Mercury of 18 and 25 April 1856), with the Mgeni breaking its banks, straightening its course, inundating much of the city, with the Isipingo Flats becoming a lake and with the then young sugar industry receiving a major setback.

ii. 1905: Believed to be the edge of a tropical cyclone, from 31 May onwards coastal rains and hail were experienced, spreading as far inland as Dundee, but with Durban receiving 381 mm in 15 hours, Pinetown 398 mm in 15 hours and with 200 drowned in the Mhlatuzane and Umbilo rivers.

iii. 1917: From 23-26 July, 432 mm fell in 4 days, apparently with little damage, but no 3 months later in October, 320 mm was recorded Durban in one day.

iv. 1984: In the Domoina tropical cyclone floods, the Richards Bay-Sodwana area, for example, measured 950 mm and an area of 107 000 km² received in excess of 370 mm, with over 80 000 people left stranded. These are probably the heaviest rains experienced over much of KwaZulu-Natal since official measurements commenced around the 1850s.

v. 1987: The late September floods, on the other hand, resulted from a cut-off low pressure system which moved (adveceted) cold, moist air over the southern parts of South Africa, commencing with general rains over Transkei and KwaZulu-Natal which were concentrated mainly on 28 and 29 September, with parts of the Province receiving over 900 mm rainfall, and with 506 known fatalities. Badenhorst and co-workers estimated this to be an event with a recurrence interval of 120-150 years.

vi. Significantly, the late Zoltan Kovacs from what is now the Department of Water and Sanitation, undertook a major comparative scientific assessment of the 1984 and the 1987 floods in KwaZulu-Natal, which was published in 1988 in The Civil Engineer in South Africa as a Preliminary Hydrological Assessment of the Natal Flood. His major findings are summarised in the table below. From the table it may be seen that large amounts of rainfall fell over considerable areas, interestingly with Domoina covering larger areas for rainfalls up to 700 mm, but with the 1987 floods covering larger areas where more than 800 mm rainfall fell.

<table>
<thead>
<tr>
<th>Rainfall (mm) Exceeded</th>
<th>Area Covered (km²) Domoina 1984</th>
<th>Area (km²) Covered 1987 September</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>94 000</td>
<td>69 000</td>
</tr>
<tr>
<td>300</td>
<td>69 000</td>
<td>41 000</td>
</tr>
<tr>
<td>400</td>
<td>47 000</td>
<td>25 000</td>
</tr>
<tr>
<td>500</td>
<td>18 500</td>
<td>14 400</td>
</tr>
<tr>
<td>600</td>
<td>9 000</td>
<td>6 300</td>
</tr>
<tr>
<td>700</td>
<td>1 750</td>
<td>1 500</td>
</tr>
<tr>
<td>800</td>
<td>125</td>
<td>510</td>
</tr>
</tbody>
</table>
i. Given the above overview of major floods and the question of the April 2022 floods having a direct link to climate change, it can thus be appreciated why Du Bois, although not as a climate scientist, commented with conviction in a newspaper piece on 20 April 2022 that these floods were “part of a natural occurrence”, “not an aberration” and that “they cannot be ascribed to climate change”, and also why the SA Weather Service experts stated that this particular cut-off low pressure system could not, “with any quantifiable precision”, be attributed to climate change.

j. What, then, were the root causes of the flooding and associated damage?
   i. Without doubt, the excessively high rainfall from the severe cut-off low pressure system code-named “Issa”, falling on already moist soils, were the key driver of the floods.
   ii. Exacerbating the damage in the informal sector, however, were
      - the huge rate of informal urban influx and growth, with people residing often in
        - informal houses
        - often with no solid foundations and
        - frequently on steep slopes, or in
      - low lying areas, often on floodplains, and where a city such as Durban should continue looking at incorporating these areas into their planning strategies, thereby making these more formal, and additionally, looking at enforcing current legislation with respect to where people can and cannot build.
      and with
      - poorly maintained drainage systems, and frequently with
      - litter abounding in culverts and drains which then blocked the free flow of water

   while in the more formal sector
   - housing complexes and business districts have large impervious areas where rainfall results in near-direct runoff, with
   - drainage systems designed in days gone by, and
   - in some business districts drains blocked with litter again being a problem.

In regard to the construction of stormwater infrastructure it should, however, be noted that there are physical, economic and possibly even social limits in their design, and thus even well designed and maintained infrastructure will on occasion be inadequate to meet the demands made on it during a very extreme event.

k. It is interesting to compare our deadliest flood in terms of lives lost with the world’s deadliest floods, and the statistics in the table below show that, devastating as our worst post-1850s flood of 1987 was, its death toll of 506 pales into relative insignificance compared with other floods, ranking only 102\textsuperscript{nd} on the international scale.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Death Toll</th>
<th>Location</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 250 000</td>
<td>China</td>
<td>1931</td>
</tr>
<tr>
<td>2</td>
<td>1 450 000</td>
<td>China</td>
<td>1887</td>
</tr>
<tr>
<td>3</td>
<td>650 000</td>
<td>China</td>
<td>1938</td>
</tr>
</tbody>
</table>
Q2. Does Government respect Climate Change and its potentially adverse effects?

a. To the above question, on the one hand the short and positive answer is “yes”, Government does respect climate change and its potential adverse effects. For example,

i. We have excellent climate change legislation such as our National Climate Change Strategy; as well as Departmental Climate Change Strategies, for example, at DWS (NWRS), DAFF, DEA (co-ordinating role), and others.

ii. National Government participates actively internationally at policy level, e.g. sends delegations to CoP (the annual Conference of Parties).

iii. Indirectly, Government was closely linked to the most recent Inter-Governmental Panel on Climate Change’s (IPCC’s) Report, with the international headquarters for the report writing having been in Durban.

iv. Many National Departments have climate change divisions, e.g. water, agriculture, environmental affairs, Traditional Affairs and others ....

v. At District and Local Government level there are progressive municipalities which recognize and make provision for climate change, and less progressive ones, with very progressive ones that I have had the pleasure of working with and researching for including eThekwini (Durban), Tshwane (Pretoria), Cape Town and KwaDukuza (Stanger).

vi. Para-statal organizations play a major role in either undertaking climate change research, or in funding it, e.g. the CSIR.

b. On the other hand, my perception is that the actual research and action come via Universities and para-statal organizations,

i. such as the Water Research Commission (WRC) which funds significant basic and applied climate change research in the water sector, and the CSIR which undertakes significant climate change research,

ii. with Universities at the forefront of internationally recognized climate change research including the Universities of Cape Town, of KwaZulu-Natal (in hydrology, and more specifically in regard to flooding through the National Flood Studies Programme), of the Witwatersrand and of Stellenbosch, as well as others,

while the climate change sections in government departments deal predominantly with policy, administration and meetings, with the relevant climate change sections having no to very little bio-physical research capability, outsourcing their research needs and, in my experience, having difficulty in converting science findings into actions on the ground.
Q3. Do we deal aggressively with the changes we need to make?

I do not believe we do. We have a number of non-climate science issues which are possibly as important as the climate science issues when it comes to flooding. For example, we have to
i. work at our population at large in regard to human management and attitudes (we have become a “throw-away society”);
ii. work at maintenance of our stormwater related infrastructure and not only on “constructing and then neglecting”;
iii. sort out the challenges / problems of the poor and the in-migrants, who often reside on floodplains, which have been formed by past floods and are prone to be flooded again and again, or who reside on steep slopes vulnerable to landslides when wet;
iv. and we have to appreciate that land use change is often more important in regard to flooding than climate change, and this on two fronts:
- first, in cities, where urbanization and associated hardened surfaces of roofs and roads are impervious to rainfall and result in direct flood-producing runoff (which we showed conclusively in a recent Pretoria case study to be more significant than climate change effects), and
- secondly, in rural areas where overgrazing and loss of protective surface cover results in direct surface runoff, severe flooding and in soil erosion.

Q4. History has shown us that these floods may keep occurring in the future, and they may become more frequent and more severe: What do we need to do now to start effectively dealing with them?
a. We need better science on extreme climatic and hydrological events associated with climate change.
   i. All too often, climate change research in the water field (and in other fields) focusses on annual changes on large spatial scales. However, we need to focus on local issues such as proximity to flood-prone streams, or focus on local slopes susceptible to landslides when wet, or on local types of soils which become saturated easily. And, what about more research on the building material used for housing? Or, preventing construction of houses on floodplains within the 100-year floodline?
   ii. Will flooding be more frequent and / or more severe across South Africa in future? In places, yes, but not everywhere. Note that climate change effects are not the same / equal throughout South Africa. Locally in KwaZulu-Natal, for example, for Pietermaritzburg our research shows that in next 30 years rains of 100 mm per day are projected to increase by more than 8%, rains of 150 mm/day by more than 37% and falls of 200 mm/day by over 50% while, interestingly (and significantly), for those same thresholds of rainfall around Durban the models show little change from the present.
   iii. We furthermore need to appreciate the so-called “amplification effect” in regard to flooding, viz. for a change in rainfall of 10% runoff changes by ~ 20% or more.
iv. We need to remember also that flood volumes accumulate as one moves down a river system, and so the effects of a climate change related rainfall increase in the Drakensberg, for example, would be experienced over 100 to 150 km downstream in the Thukela river system to the east and over 1000 km away in the Orange system to the west.

v. Remember also, that what is now the 100-year floodline, where it has been delineated and based on historical climates, may under future climates based on GCM projections become the equivalent of today’s 50-year floodline, as was shown by our recent research for Tshwane municipality. That would be an example of the translation of science into practice, especially when such these floodlines are incorporated into Strategic Development Plans.

vi. We therefore have to do “smart science” at the spatial scales that really matter, and make the outcomes of the research known not only in scientific journals, but more importantly also to the relevant local authorities for them to act upon.

Q5. How do we undo the damage of the present floods?

a. We cannot, as such, “undo the damage”.

b. What we can do is to be better prepared by maintaining our water related infrastructure, for example, by keeping culverts and stormwater drains clear of rubble. The concept of maintenance seems not to be in many of our dictionaries any longer. An interesting physical and social science research project would be to calculate the cost of proper stormwater system maintenance over the years vs. the additional cost of flood damages and life because the stormwater systems were not functioning efficiently during, say, a 1 in 2-year, or a 1:10 or a 1:20-year flood, let alone a 1:50 or a 1:100-year flood.

c. We need to take high alerts from the SA Weather Service seriously.

d. We need to plan ahead, especially regarding the locations and densities of informal settlements. We need to take seriously what for many is the obvious, and following Olivia Kunguma from the University of the Free State and Desighan Naidoo from the Institute of Security Studies we should, in the short term, focus for example on

- informed town planning
- land zoning
- building codes
- flood legislation
- smart early warning systems, combined with an efficient and well-capacitated rapid response systems in order to save lives, property, infrastructure, and have quick recovery systems in place and, again,
- respect the 100-year floodline – which has been delineated for a purpose, albeit with an element of uncertainty in their calculations,

while in the medium term we need to

- concentrate on climate-proofing our infrastructure
- update building codes and standards to accommodate anticipated climate change impacts,
- pay attention to re-designing drainage infrastructure by refining our computer modelling of floods and the risk assessment associate with them,
- prevent settlements on steep slopes and on floodplains, and
- efforts into practical issues surrounding climate change impacts on the water sector,

and into the longer term
- reduce greenhouse gas emissions and
- close the gap between policy and implementation.