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Zur Erinnerung an

Rolf Kohring (1959 - 2012)

Herausgegeben von Thomas Schlüter und Christa Werner

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Editorial

This volume (1 and 2) of "documenta naturae" is a multidisciplinary effort by various scholars and practitioners, who in one way or another want to sustain the memory of Rolf Kohring who untimely died at the age of 51 in early summer 2012. Rolf Kohring has published during his rather short career more than 200 scientific papers, among them some books, mainly dealing with topics related to palaeontological themes and research, but he was interested in all aspects and problems of our world. In this context, the contributions in this volume are also very diversified and concerned with fossil invertebrates, vertebrates, hydrology, mineral resources, cardiology, geo-education, linguistics and African languages.

We owe gratitude to the contributors of this volume without whose enthusiasm, cooperation and dedication this volume had never been published.

T. Schlüter and C. Werner, June 2013

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Zukunft

Karin Henoch*

Zu Vorzeiten schon
mussten sie
die Klügeren sein,
die verächtlich Belächelten,
in Saufgelagen bezoteten,
selbstlos fleißigen Bienen.
Klüger sein hieß überleben.

Zeigen durften sie
ihre Klugheit nicht.
Da brannten sie
auf den Scheiterhaufen
zu Hunderttausenden.
Sie werden noch heute
vergewaltigt, gesteinigt,
gedemütigt auf vielerlei Art.
Ausnahmen gab es
Immer, nur wenige.

Ich sage euch, Schwestern:
Wir haben noch viel zu tun.
Der Grenzfluss liegt
nicht hinter uns.
Er fließt dort vorn.
Lernen wir Meisterinnen zu sein,
bauen wir haltbare Brücken,
auch für die, die uns
immer noch belächeln.

Pfeil und Bogen sollten wir,
den Amazonen gleich,
dennoch in Reichweite haben.
Für alle Fälle.

Aus dem Lyrik/Prosa Band „Nosce te. VerDichtungen / Tagtraum“, Berlin 2004 (Selbstverlag)

***Karin Henoch**
Zum Gedenken an meine Begegnung mit Rolf Kohring
und damit auch die Begegnung mit Tilly Edinger, postum

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Mitarbeiter – Verehrer – Lebensretter: Philipp Schwartz (1894-1977) im Umfeld des Frankfurter Neurologischen Instituts

Gerald Kreft

Lieber Gerald,

vielen Dank für Dein Schwartzes Paper, werd es gleich heute Abend in der U-Bahn auf dem Weg nach Hause lesen...

cheers

Rolf

Zusammenfassung: Mit seiner Begründung der Emigrantenselbsthilfeorganisation „Notgemeinschaft deutscher Wissenschaftler im Ausland" im Jahre 1933 erlangte der Pathologe Philipp Schwartz für die Wissenschaftsgeschichte des 20. Jahrhunderts eine herausragende Bedeutung, die bislang öffentlich kaum gewürdigt wurde. Die vorlegende Untersuchung beleuchtet erstmals seine vielschichtige Stellung in der Geschichte des Frankfurter Neurologischen Instituts: Schwartz stand in der von Ludwig Edinger ausgehenden deutsch-jüdischen Traditionslinie der Neurowissenschaften in Frankfurt am Main. Er arbeitete mit dessen Nachfolger Kurt Goldstein, dem Begründer der Neuropsychologie, zusammen und rettete schließlich Ludwig Edingers Tochter Tilly, der Begründerin der Paläoneurologie, mit Hilfe der Notgemeinschaft das Leben.

Schlüsselwörter: Notgemeinschaft deutscher Wissenschaftler im Ausland, Frankfurter Neurologisches Institut, Tilly Edinger, Ludwig Edinger, Paläoneurologie, Kurt Goldstein.

Abstract: Founding the "Emergency Committee for Displaced German Scholars" in 1933, the pathologist Philipp Schwartz had been of tremendous importance for the history of sciences in the 20th century. This approach focuses on his untold place in the history of the Neurological Institute in Frankfurt on Main: Schwartz stands in line with the German-Jewish tradition of neurosciences in Frankfurt that were founded by Ludwig Edinger. He co-worked with Edinger´s sucessor Kurt Goldstein, who had established neuropsychology, and he saved the life of Edinger´s daughter Tilly, founder of paleoneurology.

Key words: Emergency Committee for Displaced German Scholars, Neurological Institute Frankfurt, Tilly Edinger, Ludwig Edinger, Paleoneurology, Kurt Goldstein.

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1 Einleitung

Philipp Schwartz war ein international renommierter Pathologe. Herausragend ist seine Rolle bei der Emigrationshilfe für Wissenschaftler, die im nationalsozialistischen Deutschland entlassen und verfolgt wurden. Gebührende Annerkennung hat Schwartz dafür nicht erfahren; auch nicht posthum. In denkwürdigem Kontrast zu seiner Bedeutung für die Wissenschaftsgeschichte des 20. Jahrhunderts, existiert bis heute keine eingehende Darstellung seines Lebens und Werks. Die folgenden Ausführungen sind Teil meines anhaltenden Versuchs, dieses Desiderat zu schließen.[1] Sie fokussieren sich auf ein bislang unerschlossenes Kapitel, nämlich Schwartz´ vielfältige Bezüge zur Geschichte des Neurologischen Instituts in Frankfurt am Main. Wie sehr er in Traditionen dieses ältesten Hirnforschungsinstituts Deutschlands stand, ergibt zunächst ein Rückblick auf dessen Zusammenarbeit mit dem Frankfurter Anatomischen bzw. Pathologischen Institut in Frankfurt am Main (2). Von hier aus erscheint Schwartz nicht nur als Kollege, sondern als Weggefährte und Freund zumindest zweier herausragender Protagonisten der Geschichte des Neurologischen Instituts: Kurt Goldsteins, des Begründers der modernen Neuropsychologie (3), und Tilly Edingers, der Begründerin der modernen Paläoneurologie (4).

2 Neurologisches und Pathologisches Institut in Frankfurt am Main

Die Anfänge des Neurologischen Instituts gehen zurück auf das Frühjahr 1883. Damals ließ sich Ludwig Edinger (1855-1918) als Praktischer Arzt und Spezialist für Nervenkrankheiten in Frankfurt am Main nieder. Der wiederauflebende Antisemitismus hatte seine Hoffnungen auf eine Universitätslaufbahn zunichte gemacht, nicht aber seine Leidenschaft für die Wissenschaft gebrochen. Seine vergleichenden Studien zur Evolution des Wirbeltiergehirns machten ihn zum Begründer der modernen Neuroanatomie und wurden 1914, als die Frankfurter Universität ihre Pforten öffnete, gekrönt durch das erste Ordinariat für das Fach Neurologie in Deutschland.[2] Solche Karrieren waren für deutsch-jüdische Wissenschaftler seinerzeit nichts Ungewöhnliches.[3] Spezialisierung in institutionellen Nischen bei unbeirrtem Festhalten an den eigenen, hochkulturellen Idealen zeichnete auch Philipp Schwartz´ Werdegang aus. Dabei nahmen seine Forschungen ihren Ausgang an eben jenem Objekt, dem schon Edinger seine Aufmerksamkeit gewidmet hatte.

Ludwig Edinger und Carl Weigert

1883/84 sezierte und mikroskopierte Edinger während der Abend- und Nachtstunden in seinem hinter der Praxis gelegenen Schlafzimmer Gehirne menschlicher „Früchte“.[4] Mit der neuen Markscheidenfärbung des Leipziger Pathologen Carl Weigert (1845-1904) entdeckte er bislang unbekannte neuroanatomische Strukturen, deren Veröffentlichung ihn schlagartig berühmt machte. Bereits 1885 vermittelte er Weigert, der aufgrund seiner jüdischen Herkunft ebenfalls keine Professur hatte erhalten können, auf den vakant gewordenen Posten des Direktors der Senckenbergischen Anatomie in Frankfurt am Main. Weigert wiederum stellte Edinger hier

[1] Kreft 2004a, Kreft 2007, Kreft 2011, Kreft und Lilienthal 2011, Kreft 2012.
[2] Kreft 1999a und 2006b.
[3] Volkov 1990a, Volkov 2001.
[4] Edinger 2005, 110.

einen Arbeitsplatz zur Verfügung. „Kaum ein Tag verging," schrieb Edinger über ihre fast zwanzig Jahre währende Zeit inniger Verbundenheit, „an dem wir uns nicht sahen [...] Alles, was den Einen von uns beschäftigte, diskutierte er mit dem Anderen, und ich weiß nicht, wie viel ich von dem, was ich später arbeitete, etwa direkt ihm geistig angehört."[5]

Seit 1885 erschienen Arbeiten aus dem Neurologischen Institut.[6] Eine stetig wachsende Zahl in- und ausländischer Wissenschaftler kam nach Frankfurt, um bei Weigert und Edinger zu lernen. Dabei „war das Laboratorium eigentlich immer überfüllt [...] Die Reihe der Arbeitenden war oft so gedrängt, dass einige aufstehen mussten, wenn einer das Zimmer verlassen musste."[7] Erst 1903/1904, als die Enge vollends unhaltbar geworden war, erhielt das Neurologische Institut einen eigenen Raum in der Senckenbergischen Anatomie, den Edinger aus eigenen Mitteln als Laboratorium einrichtete. Diese stammten nicht nur aus seiner erfolgreichen Privatpraxis als Nervenarzt. Inzwischen war er mit einer Bankierstochter und Erbin eines Millionenvermögens verheiratet, die ihn bei der Verwirklichung seiner zukunftsweisenden Ideen rückhaltlos unterstützte.[8]

Ludwig Edinger und Bernhard Fischer-Wasels

Pläne zum Neubau der altehrwürdigen Senckenbergischen Anatomie hatten bereits Weigert, der 1904 unerwartet starb, vorgelegen. 1907 war es dann endlich so weit. Das gesamte zweite Stockwerk des Gebäudes bezog nunmehr das Neurologische Institut, das Edinger vollständig selbst finanzierte und 1914 in die Frankfurter Stiftungsuniversität überführte. Dabei steht sein Engagement exemplarisch für die Akkulturation der zumeist jüdischen Frankfurter Universitätsstifter. Diese wollten "ihre kulturelle Zugehörigkeit und patriotische Gesinnung auch durch Taten beweisen und auf diese Weise alten wie neuen Vorbehalten, versteckten wie offenen Anfeindungen begegnen, welche ihre Lage auch nach der rechtlichen Gleichstellung kennzeichneten."[9]

Im 1907 eröffneten Gebäude trug das frühere Weigertsche Institut nunmehr den Namen Senckenbergisches Pathologisches Institut. Zu dessen Leiter wurde 1908 Bernhard Fischer-Wasels (1877-1941) berufen.[10] Über diese räumliche Nähe hinaus, konzipierte Edinger sein Neurologisches Institut selbst noch einmal interdisziplinär, als „Arbeitsstätte zur Erforschung des Nervensystems auf den verschiedensten Wegen".[11] Seine neuroanatomische und neuropathologische Abteilungen waren eingebettet in lokale und internationale neurowissenschaftliche Netzwerke (Edingers *Psychologischer Verein* sowie die *Brain Commission*). Überdies sah der Universitätsvertrag die Angliederung einer Neurologischen Klinik und Poliklinik vor.[12]

Bevor der Erste Weltkrieg alle Zukunftspläne durchkreuzte, hatten Edinger und Fischer 1913 eine aufsehenerregende Arbeit über das missgebildete Gehirn eines im Alter von 3¾ Jahren

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[5] Ebd., 110.
[6] Edinger 1907.
[7] Edinger 2005, 109.
[8] Kreft 2005a, 41, 45 sowie 127-128; Kreft 2006a.
[9] Kümmel 1993, 284.
[10] Nach dem Tod seiner Ehefrau Clara (geb. Wasels) im Jahre 1925 nahm Fischer deren Mädchennamen in seinen Familiennamen auf und nannte sich fortan Fischer-Wasels (Demeter 1991, 41).
[11] Goldstein 1918, 140.
[12] Kreft 2005a, 167 ff. , 223 ff. et passim ; Kreft 2005b.

verstorbenen Kindes veröffentlicht.[13] Diese Untersuchung ging über die eingehende neuropathologische Sektion hinaus: sie berücksichtigte Informationen über das Verhalten des Anencephalen und interpretierte Korrelationen zwischen pathologischer Hirnanatomie und Psychologie im Lichte der von Edinger eingeführten vergleichend-neurologischen Terminologie: „Wir haben hier zum ersten Male ein menschliches Wesen vor uns, das ganz auf sein Paläencephalon [Urhirn] angewiesen war, dem das Neencephalon [Neuhirn] ebenso fehlte wie einem Fische.“[14]

Bemerkenswert ist an dieser Studie nicht nur ihre wissenschaftliche Bedeutung, hatten anencephal Geborene doch bislang kaum die ersten Tage überlebt. Erst im historischen Rückblick werden hier übergreifende Zusammenhänge sichtbar. Der Fallbericht beschäftigte damals die seriöse Tagespresse, wurde aber auch von „Wegweiser und Wegwarte“, einer „Deutsch-völkischen Vorzeitung“, aufgegriffen und ging von hier aus in die 1929 erschienene zweite Auflage des antisemitischen „Semi-Kürschner“[15] ein: „`In der physiologischen Literatur spielt seit langem der berühmte Hund eine große Rolle, dem der bedeutende, vor allem durch seine bahnbrechenden Untersuchungen `Über die Verrichtungen des Großhirns´ bekannte Mediziner Prof. Dr. Friedrich Goltz [1834-1902] das gesamte Großhirn entfernt hatte, und der in diesem Zustande noch 3 Jahre lang lebte.´ So lesen wir in einem Berliner Blatte, dessen Namen man ohne Not nicht gerne nennt, vom 8. ds. Monats. Und der Anlass zu dieser schmählichen Erinnerung ist die Tatsache, daß jüngst ein fast 4jähriges verstorbenes Kind seziert worden ist, das kein Großhirn mehr hatte. Dieses Kind hatte fast seine ganze Lebenszeit hindurch in dauerndem Schlaf gelegen; aber vom 2. Lebensjahre an habe es immer geschrieen (wie sich das zusammenreimt, wissen wir nicht), und wenn man´s auf den Kopf drückte, hörte das Schreien auf. L. Edinger und B. Fischer sind es, die über diesen Fall berichten“.[16]

Der infame Charakter dieses Eintrags bestand in der assoziativen Nähe von *Vivisektion* eines Tieres und *Autopsie* eines Menschenkindes. Durch Hinzufügung der Falschaussage, Edingers Ehe mit der Jüdin Anna Edinger wäre „kinderlos“, wurde überdies insinuiert, seine Forschungen seien die grausige Ausgeburt jüdischer Unfruchtbarkeit.

Liest man diese antisemitische Hetze, in der »arische Wissenschaft« und nationalsozialistische »Euthanasie« bereits *in nuce* enthalten waren, als kulturhistorische Chiffre, so weist sie auf bis zur Unkenntlichkeit verzerrte soziale Tatbestände hin. Um die Wende zum 20. Jahrhundert war der moderne Trend zu rückläufigen Geburtenraten bei gleichzeitig geringerer Kindersterblichkeit unter der jüdischen Bevölkerung in Deutschland stärker ausgeprägt als bei der nicht-jüdischen.[17] Gleichzeitig setzten sich hierzulande vor allem Ärzte jüdischer Herkunft für das Kindeswohl ein und bildeten bis 1933 einen überproportional großen Anteil unter den Spezialisten auf dem Gebiet der Pädiatrie.[18] Diese im deutsch-jüdischen Akkulturationsprozess säkularisierte „Biophilie“[19] zeigte sich – wie wir sehen werden – auch in Philipp Schwartz´ frühen Forschungen.

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13 Edinger und Fischer 1913.
14 Ebd., 560. Vgl. Kreft 2005a, 87.
15 Semi-Kürschner 1913.
16 Sigilla Veri 1929, 141 f.
17 Volkov 1990b, 139 ff. Vgl. Kreft und Hoßfeld 2005, 374 sowie Kreft 2003, 416 ff.
18 Seidler 2000. Vgl. Kreft 2004b, 152 f.
19 Lapide 1998, 90.

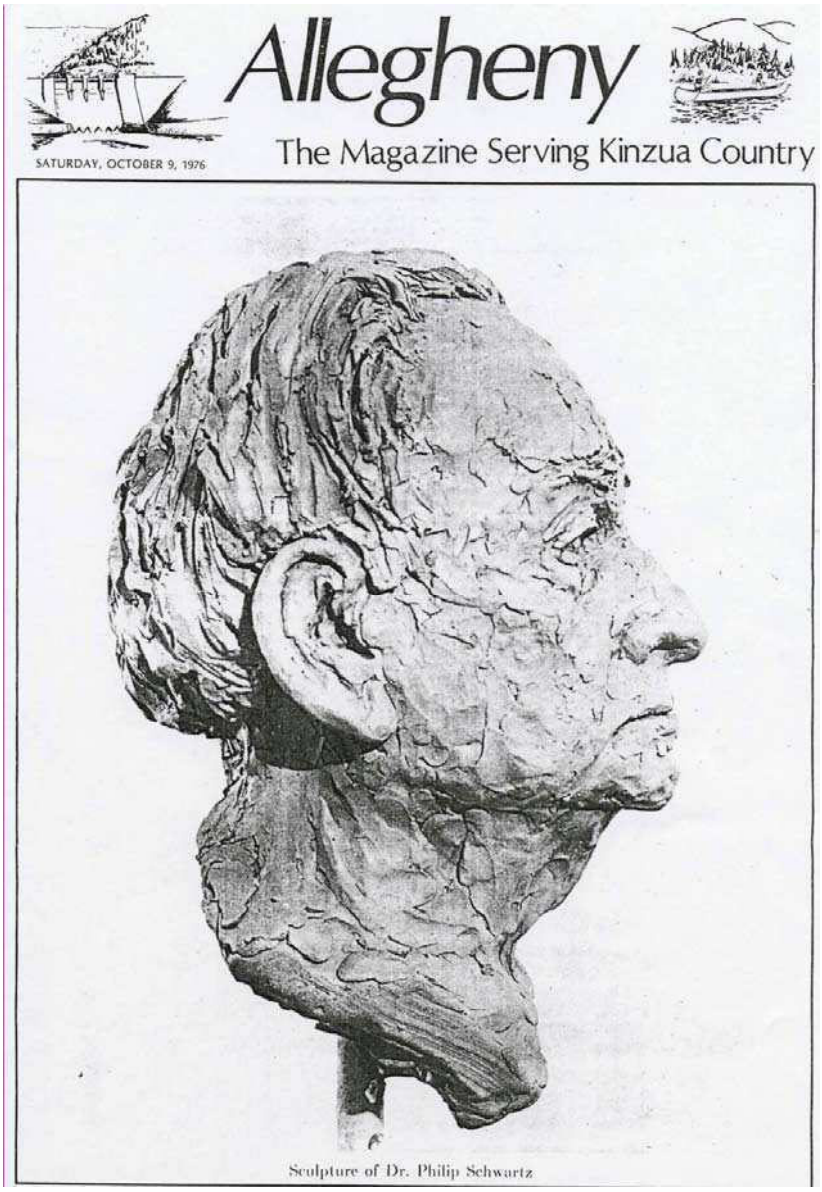

Abb. 1: Skulptur Philipp Schwartz´ auf der Titelseite des US-Magazins »Allegheny«, 9. Oktober 1976.

3 Philipp Schwartz und Kurt Goldstein

Philipp Schwartz (Abb. 1)wurde 1894 in Werschetz, im österreich-ungarischen Banat, geboren. Nach seiner ärztlichen Approbation reiste er 1919 mit dem Zug von Budapest nach Paris, wo er sich zum Chirurg fortbilden wollte. Als er in Frankfurt einen Zwischenstopp einlegte, um eine befreundete jüdische Familie zu besuchen, lernte er Fischer-Wasels kennen, der ihm von seiner Zusammenarbeit mit Ludwig Edinger erzählte und ihn für dieses Thema begeisterte.[20]

Studien zum Geburtstrauma

Schwartz wurde Assistent am Pathologischen Institut und habilitierte sich 1923 mit einer neuropathologischen Untersuchung zerebraler Geburtsschädigungen.[21] „Die Anregung, auf diesem Gebiet systematisch zu arbeiten“, erklärte Fischer, „erhielten wir schon vor einer Reihe

[20] Kreft 2011, 135.
[21] Heuer und Wolf 1997, 345.

von Jahren durch jene eigenartige Beobachtung, die unser zu früh verstorbener Kollege L. Edinger und ich im Jahre 1913 unter dem Titel `Ein Mensch ohne Großhirn´ [....] veröffentlicht haben [...] Seit jener Zeit habe ich nach analogen Veränderungen gefahndet und eine Reihe von Gehirnen sammeln können, die nunmehr bei der systematischen Durcharbeitung des Gebietes von Herrn Dr. Schwartz benutzt werden konnten. Herr Dr. Schwartz hatte ganz selbständig sich den Nachweis der Geburtsschädigung des Gehirns und seiner Folgen zur Aufgabe gemacht. Wir glauben, daß sich bei dieser systematischen Durcharbeitung eine volle Aufklärung dieser merkwürdigen Bildungen hat geben lassen, daß sie nichts weiter sind, als die Ausgänge schwerer traumatischer Schädigungen des Neugeborenengehirns, die ihre Ursache wenn nicht ausschließlich, so doch fast regelmäßig in den Einflüssen des Geburtsvorganges haben.“[22]

Eine rückblickende Würdigung aus dem Jahre 1975 würdigte Schwartz´ Arbeit als wissenschaftspolitische Zäsur. Die Befunde über das „in seiner Häufigkeit nicht für möglich gehaltene Vorkommen von geburtstraumatisch bedingten Hirnblutungen beim Neugeborenen sind, zusammen mit seiner Theorie der Entstehungsmechanismen dieser Geburtsschädigung, zweifellos eine der großen säkularen Entdeckungen der Pathogenese der Neugeborenensterblichkeit wie auch der zerebralen Schädigungen bzw. der Behinderungen des Kindes. Die Feststellungen von Schwartz fielen in eine Zeit, in der nicht nur die Fehlbildungen und Entwicklungsstörungen des Kindes, sondern auch die hohe Neugeborenen- und Säuglingssterblichkeit als solche aufgrund weit verbreiteter `sozialdarwinistischer´ Auffassungen (Dobzhansky) als überwiegend genetisch bedingt betrachtet wurden.“[23] Indem Schwartz soziale und ökonomische Bedingungszusammenhänge für seine Befunde geltend machte und für gesetzliche Maßnahmen zur Sicherung junger Familien eintrat, erscheint er aus pädiatrischer Perspektive als „Vater der Perinatologie“.[24]

Schwartz´ Forschungen beruhten auch auf Untersuchungsmaterial, das er aus den Beständen des Neurologischen Instituts zur Verfügung gestellt bekam.[25] Dieses wurde geleitet von Edingers Nachfolger Kurt Goldstein (1878-1965), der mit seinen Untersuchungen an hirnverletzten Soldaten des Ersten Weltkrieges die moderne Neuropsychologie begründete. Gleichwohl erscheinen unter seiner Ägide auch weiterhin vergleichend-neuroanatomische und neuropathologische Arbeiten.[26]

Studien zum Hirninfarkt

Anknüpfend an seine Untersuchungen zur Neuropathologie des Geburtstraumas beschäftigte sich Schwartz mit durch Schlaganfall bedingten Schädigungen des Erwachsenengehirns. Dabei hob seine zusammenfassende Studie 1930 hervor, „daß apoplektisch auftretende Zerstörungen der

[22] Fischer 1924, III.
[23] Pechstein 1975, 1139. Ob von Schwartz´ Zeitgenossen Missbildungen und Sterblichkeit bei Neugeborenen *ausschließlich* „aufgrund weit verbreiteter `sozialdarwinistischer´ Auffassungen (Dobzhansky) als genetisch betrachtet wurden“ mag hier dahingestellt bleiben. Fragwürdig erscheint überdies, in welchem Sinne Thedosius Dobzhansky (1900-1975) als Sozialdarwinist zu bezeichnen wäre (vgl. Dunn und Dobzhansky 1970, 56-62). Anfang der zwanziger Jahre hatte er jedenfalls zu den angesprochenen Fragen gar nichts publiziert (Beurton 1998, 1-3). Ich danke Prof. Dr. Uwe Hoßfeld und Prof. Dr. Thomas Junker für Hinweise auf diese Problematik.
[24] Hellbrügge 1978. Kreft und Lilienthal 2011, 11-13.
[25] Fischer 1924, IV.
[26] Kreft 2005a, 67 sowie 235 ff.

Hirnsubstanz unter Umständen durch traumatische Beschädigungen des Kopfes [z.B. Geburtstrauma] vorbereitet werden können."[27]

Überdies betonte er erneut einen Primat des physiologischen Aspekts, diesmal gegenüber der traditionellen Auffassung, die Hirnblutung sei Resultat eines unabwendbar voranschreitenden arteriosklerotischen Prozesses. Schwartz´ Untersuchung „diente in erster Linie der Erkenntnis, daß apoplektische Hirnschädigungen von organischen Fehlern der Hirngefäße unabhängig, durch rein funktionelle Veränderungen des Kreislaufs verursacht werden können, und daß derartige, durch rein funktionelle Kreislaufstörungen [z.B. Bluthochdruck] veranlaßte Hirnläsionen die praktisch wichtigste Gruppe der als Apoplexien bezeichneten Erkrankungen darstellen".[28]

Mit dieser Perspektive, durch therapeutische Senkung des Bluthochdrucks einem Hirninfarkt vorzubeugen, erweiterte Schwartz Möglichkeitsspielraum und Qualität menschlichen Lebens. Dabei stützte sich seine Monographie auf bereits veröffentlichte Einzelstudien, die er in Zusammenarbeit mit Kurt Goldstein unternommen hatte, der dabei „die klinischen Beziehungen bearbeitete."[29]

Assistent am Neurologischen Institut

Im Sommer 1926 kam es am Neurologischen Institut zu einem Zerwürfnis zwischen Goldstein und seinem langjährigen Assistenten Walther Riese (1890-1976), der ebenfalls jüdischer Herkunft war.[30] Mit Rieses Weggang wurde die einzige bezahlte Assistentenstelle am Neurologischen Institut vakant.[31] In dieser Situation bat Goldstein die Edinger-Stiftung, „an Stelle des Herrn Dr. Riese vom 1. Juni 1926 ab an Herrn Privatdozenten Dr. Ph. Schwartz die Assistentenstelle zu übertragen und zwar nur vertretungsweise bis über die endgültige Besetzung eine Entscheidung getroffen worden ist. Herr Dr. Schwartz ist mit der vertretungsweisen Übernahme der Stelle einverstanden."[32]

Bei diesem Arrangement zwischen dem Neurologischen und dem Pathologischen Institut handelte es sich um ein *Gentlemen´s Agreement*, das Schwartz´ vorübergehend ein reguläres Gehalt verschaffen sollte. Er konnte bislang nämlich als „Ausländer im städtischen Dienst nicht angestellt werden," hatte seinen „gesamten Lebensunterhalt selbst bestritten und sogar einen Teil der Kosten von wissenschaftlichen Arbeiten übernommen [...] Infolge der eingetretenen Geldentwertung steht Herr Schwartz jetzt vor der Vernichtung seiner Existenz und besitzt so gut wie nichts mehr, um selbst bei den bescheidensten Ansprüchen leben zu können."[33] Folgerichtig erklärte Fischer-Wasels nach Ablauf des Jahres: „Herr Privatdozent Dr. Ph. Schwartz, der seit dem 1. VI. 26 vertretungsweise als ausserpl[anmäßiger] Assistent am Neurologischen Institut tätig war, kehrt am 1. V. d[ieses] Jahres wieder an mein Institut zurück. Da er nun keine anderen

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[27] Schwartz 1930, 258. Ich danke PD Dr. med. Dominique S. Tews für den in eckigen Klammern eingefügten Hinweis.
[28] Ebd., 259. Ich danke PD Dr. med. Dominique S. Tews für den in eckigen Klammern eingefügten Hinweis.
[29] Ebd., IV. Vgl. Schwartz und Goldstein 1925a; Schwartz und Goldstein 1925b; Schwartz und Goldstein 1926; außerdem Schwartz 1926.
[30] Kreft 2005a, 248 f., 339 und 341. Vgl. Benzenhöfer und Kreft 1997.
[31] Kreft 2005a, 231.
[32] Der Direktor des Instituts [Kurt Goldstein] an den Vorsitzenden der Ludwig Edinger Stiftung, Herrn Stadtrat Dr. Schlosser, 7. Mai 1926 (Edinger-Archiv).
[33] Personalhauptakte Philipp Schwartz, Blatt 5; Antrag auf Bewilligung einer laufenden Wirtschaftshilfe vom 16. Juni 1924 (Kuratorium der J.W. Goethe-Universität Abt. 14/Nr. 17; Universitätsarchiv).

Einkünfte hat, beantrage ich hiermit für ihn die weitere Verleihung des Stipendiums, das ihm vor der erwähnten Vertretung zur Verfügung gestellt war.“[34] „Er hat all die Jahre am Frankfurter Pathologischen Institut unentgeltlich gearbeitet und sich geradezu durchgehungert.“[35]

Tradition deutsch-jüdischer Neurowissenschaftler

1927 wurde Schwartz außerplanmäßiger Professor und 1930 naturalisiert.[36] Zusammen mit seinem Nachfolger am Neurologischen Institut, dem ebenfalls jüdischen Hans Max Cohn (1900-?), veröffentlichte er im gleichen Jahr eine umfangreiche Untersuchung zur Ausdehnung anatomischer Erkrankungen im Zentralnervensystem, die u.a. von „zwei Beobachtungen, die mit dem Namen Edinger verbunden sind“, ausging.[37] Und seine neu aufgenommenen pathologischen Studien zur Tuberkulose verstand Schwartz als Beitrag zu jener Forschungsrichtung, die „das Verhalten des *Organismus als Ganzheit* den Kochschen Bazillen gegenüber“ untersucht: „Es handelt sich dabei nicht um einfache Wiederaufnahme bzw. Fortsetzung der alten naturphilosophischen Tüfteleien über `Konstitution´ und `Disposition´, sondern um die zielbewusste Untersuchung der Veränderungen der Gewebe und Säfte als Reaktionen auf das Eindringen eines Parasiten von außen und ihre Bedeutung für den Krankheitsablauf.“[38] Solche Auffassungen des Organismus als lebendiger Ganzheit verbanden Schwartz mit der von Edinger ausgehenden und über Goldstein ausstrahlenden deutsch-jüdischen Traditionslinie der Neurowissenschaften in Frankfurt am Main.[39]

Die »Notgemeinschaft«

Am 1. April 1933, im Zuge des reichsweiten »Judenboykotts«, wurde Kurt Goldstein in Berlin verhaftet und in ein »wildes Konzentrationslager« der SA verschleppt. Fünf Tage später kam er nur unter der Auflage frei, das Land sofort zu verlassen. Er flüchtete nach Zürich. Dorthin war Philipp Schwartz bereits am 23. März entkommen – dem Tag, an dem der Reichstag mit dem »Ermächtigungsgesetz« Adolf Hitler alle Staatsgewalt übertrug. Hier begründete er, u.a. zusammen mit Goldstein, die bedeutendste deutschsprachige Emigrantenselbsthilfeorganisation, die »Notgemeinschaft Deutscher Wissenschaftler im Ausland«.[40] Ziel war es, von den Nationalsozialisten vertriebenen Wissenschaftlern Anstellungen an ausländischen Universitäten zu vermitteln. Im Fachbeirat zur Auswahl geeigneter Kandidaten war Goldstein für die Medizin zuständig.[41] In der Zusammenarbeit zwischen *Notgemeinschaft*, britischen und US-amerikanischen Hilfsorganisationen gelang es, die meisten der in Deutschland entlassenen Akademiker auf neue Stellen im Ausland zu vermitteln.

Auch wenn die diesbezüglichen Zahlenangaben in der Literatur differieren, handelt es sich um eine Größenordnung von 1500 bis 2500 Personen. Allein in der Türkei kamen aufgrund der von Philipp Schwartz 1933 geführten Verhandlungen bis 1945 über 300 Wissenschaftler unter

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[34] Ebd., Blatt 11. Prof. Bernhard Fischer-Wasels an das Kuratorium der Universität, 28.2.1927.
[35] Ebd., Blatt 17/18. Prof. Bernhard Fischer-Wasels an das Kuratorium der Universität, 13.7.1927.
[36] Kreft 2011, 136.
[37] Schwartz und Cohn 1930, 45.
[38] Schwartz 1935, 4 (kursiv im Original).
[39] Kreft 2004a, 102; Kreft 2004 b, Kreft 2005a.
[40] Kreft 2012.
[41] Schwartz 1995, 65; Erichsen 1994; 58; Widmann 1973, 54.

(zusammen mit ihren Angehörigen und Mitarbeitern über 1000 Personen).[42] „Wir sahen uns beauftragt“, formulierte Schwartz das Selbstverständnis der *Notgemeinschaft*, „den wahren Geist der deutschen Nation in der Welt zu vertreten. Diese Mission erfüllte uns mit Stolz und Zuversicht“.[43] Aus diesen Worten sprach das Selbstbewusstsein von Juden, die sich im deutschen Kulturraum akkulturiert hatten. Wiederholt tauchte dieses Motiv bei Schwartz´ auf, etwa wenn er betonte, wie gerne die Vertreter der türkischen Regierung von ihm hörten, „dass die von mir vorgeschlagene Professorenliste vom Lehrkörper keiner deutschen Universität übertroffen wird, `besonders jetzt, wo sie die besten verjagt haben´.“[44]

4 Philipp Schwartz und Tilly Edinger

Zu den letzten Wissenschaftlern jüdischer Herkunft, die an einer Forschungseinrichtung im nationalsozialistischen Deutschland arbeiteten, gehörte Tilly Edinger (1897-1967). Die jüngere Tochter Ludwig Edingers begründete in den zwanziger Jahren mit Hilfe der einzigartigen Sammlungen des Senckenbergischen Naturforschenden Museums sowie des Neurologischen Instituts die Paläoneurologie – die Erforschung der Gehirne ausgestorbener Wirbeltiere. Nachdem sie ihre Assistentenstelle am Edinger-Institut 1933 verloren hatte, wirkte sie am Senckenberg bis zum Novemberpogrom 1938 als „Untergrundkurator“.[45]

15 Pfund Sterling

Bereits am 1. August 1938 hatte Tilly Edinger beim amerikanischen Konsulat in Stuttgart die Einwanderung in die USA beantragt und eine Ausreise-Nummer für August 1940 erhalten.[46] Ihren Freunden und Kollegen in Übersee gelang es nicht, eine frühere Einreise außerhalb der festgesetzten Listen (»non quota«) zu ermöglichen. In dieser Situation erhielt Tilly Edinger von Philipp Schwartz aus Istanbul das Angebot, seine medizinischen Artikel aus dem Deutschen ins Englische zu übersetzen. Dies garantierte ihr ein bescheidenes Einkommen, mit dem sie die Einreisebedingungen für Großbritannien erfüllte. Und im Februar 1939 konnte sie schreiben: "ist mir durch die perfekt gewordene Anstellung als Übersetzerin die Anweisung für ein englisches Visum erteilt worden [...] `Heraus´ kann ich also – free yes, but not settled […].”[47]

In London, wo sie im Mai 1939 ankam, reichte das Gehalt von £15 nur für ein äußerst bescheidenes (Über-)Leben. Diesen Betrag erhielt Tilly Edinger übrigens bis zum Frühjahr 1941,[48] also noch fast ein ganzes Jahr in den USA. Demgegenüber stilisierte sich die „vielbewunderte Sparkünstlerin“[49] im Jahre 1958 so: "Als ich [in den USA im Mai 1940] ankam, erhielt ich von einer Organisation mit Namen Emergency Committee in AID of Displaced

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[42] Erichsen 1994, 54 und 60; Erichsen 1991, 73; Schwartz 1975, 2; Widmann 1972, 17 et passim. Vgl. Kreft 2004a, 110 und Kreft 2011, 139.

[43] Schwartz 1974, 4.

[44] Schwartz 1995, 56.

[45] Siehe insgesamt Kohring und Kreft 2003; hier: 132 ff, 199ff und 502 ff. Zur schizoiden Lage eines nicht emigrierten, »halbjüdischen Arztes« im Nationalsozialismus siehe Kreft 1998.

[46] Kohring 2003, 144 ff.

[47] Tilly Edinger an Alice Hamilton, 9.2.1939 (Museum for Comparative Zoology, Cambridge, Mass.).

[48] Harlow Shapley an Betty Drury, 11.6.1941 (Emergency Committee, New York Public Library).

[49] Vgl. Kohring 2003, 170 sowie Kreft 2003, 538.

Foreign Scholars 50 Dollar im Monat während des ersten Jahres, gebraucht habe ich siebzig. Ich verstehe es heute nicht mehr. Allerdings war damals alles nur ungefähr halb so teuer wie heute. Aber ich bin damit durchgekommen."[50]

Angesichts der Tatsache, dass 1940/41 £ 15,- zwischen $ 56,- und $ 59,- wert waren,[51] ist dieses Vergessen bemerkenswert. Zumal es später für Tilly Edinger allein Alfred Sherwood Romer (1894-1973), ihr neuer Chef am Museum for Comparative Zoology in Cambridge, Massachusetts, war, "der mein Leben gerettet hat! Er lud mich ja unbekannterweise hierher ein, 1938".[52] Liest man allerdings – rückblickend auf die Genese der nationalsozialistischen »Endlösung der Judenfrage« – die dramatisch absinkenden Zahlen jüdischer Flüchtlinge aus Deutschland (1939: 78 000; 1940: 15 000; 1941: 5 000), so verdeutlichen sie, dass niemand anderes als Philipp Schwartz es war, der Tilly Edinger buchstäblich das Leben rettete.[53]

Der große Schwartz

1935 schrieb Tilly Edinger an den Geologen Ludwig Rüger (1896-1955), dem sie eine Berufung an die Universität Istanbul vermitteln wollte: "Zufällig bin ich von früher befreundet mit dem Pathologen Prof. Philipp SCHWARTZ [...] Anfang Juli bat mich P.S., ihm nichtarische Geol[ogen] mit Prof.-Titel vorzuschlagen."[54] Ganz so „zufällig" war diese Bekanntschaft allerdings nicht. So teilte sie im April 1926 dem Neuroanatomen C. U. Ariëns Kappers (1877-1946), den sie kurz zuvor in Amsterdam besucht hatte, mit: „Sehr indirekt höre ich, daß Goldstein den Schwartz (mit Geburtstrauma, ich erzählte Ihnen [davon] am Bahnhof) zum Assistenten genommen hat."[55]

Dass es sich hierbei um eine private Beziehung handelte, dokumentiert der intime Briefwechsel Tilly Edingers mit ihrer jüdischen Busenfreundin Elisabeth Gundolf (geb. Salomon, 1893-1953). Bereits im März 1923 war hier »der große Schwartz« als sprachliches Pendant des „kleinen Schwarz", des Geologen Albert Schwarz, präsent.[56] Und als Tilly Edinger im Sommer 1925

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[50] Tilly Edinger, interviewt von Irmtraud Bach, Mai/Juni 1958. Radio Bremen 1962, 60 f.

[51] Kreft 2003, 529.

[52] Tilly Edinger an Albert Einstein, 25.12.1952 (Museum for Comparative Zoology, Cambridge, Mass.).

[53] Kreft 2003, 528-529. Vgl. Kohring 2003, 153 und 158, der hier den Selbststilisierungen Tilly Edingers folgt.

[54] Tilly Edinger an Ludwig Rüger, 24.8.1935 (Geologen-Archiv Freiburg i. Br.); Großschreibung im Original. Vgl. Kreft 2003, 527. Dieser Teil der Korrespondenz Tilly Edingers wurde von PD Dr. Rolf Kohring recherchiert und mir freundlicherweise zur Verfügung gestellt.

[55] Tilly Edinger an C. U. Ariëns Kappers, 28.4.1926 (Netherlands Institute für Brain Research, Amsterdam).

[56] Tilly Edinger an Elisabeth Salomon 12.3.1923, 27.6.1924, 5.12.1924 (Institute for Germanic Studies, London). Die Identität des „kleinen Schwarz" (ohne „tz") ließ sich ermitteln, da er später am „Institut für Meeresbiologie in Wilhelmshaven" tätig war (Tilly Edinger an Elisabeth Salomon, 17.11.1933), aus dem dann „Albert Schwarz [...] auf scheint´s recht drastische Weise entlassen wurde" (Tilly Edinger an Hans Bluntschli, 17.3.1934; Universitätsbibliothek Zürich). Ich danke William Abbey vom Londoner Institute für Germanic Studies ganz herzlich für seine Mühe, im Frühjahr 2003 die Schreibweise des Namens „Schwarz" bzw. „Schwartz" an den entsprechenden Stellen der Korrespondenz zwischen Tilly Edinger und Elisabeth Salomon zu überprüfen. Da meine Transkription der im Januar 2001 in London auf Band gesprochenen, zahllosen Briefe über solche orthographische Feinheiten hinweggehen musste, ist der hier prräsentierte Indizienschluss in Kreft 2003 noch nicht enthalten. Angezeigt wurde er bereits in Kreft 2005a, 308.

daran ging, in Heidelberg einen Habilitationsantrag zu stellen, „liegt mir der große Schwartz so andauernd mit Argumenten in den Ohren, daß ich es wirklich nun selbst will. Es ist das von ihm sehr rührend, denn er hat ja das größte Interesse daran, daß ich nichts werde und ihm dann irgendwie anheim falle.[57]

Indizien legen den Schluss nahe, dass „der große Schwartz“ und Philipp Schwartz ein und dieselbe Person waren. Bei ihrer Identifikation erschwerend wirkte zunächst, dass Tilly Edinger ihn – wie auch andere ihrer zahlreichen Verehrer – durch die Verwendung eines Kürzels anonymisierte.[58] So berichtete sie Ende November 1926 in der ihr eigenen, unnachahmlichen Selbstironie von einem delikaten Gesellschaftsabend: „da hatte sich *der tz* (frage nicht wieder; *es ist Schwartz*, dessen Handschrift Gundel [Friedrich Gundolf (1880-1931)] in Rom so ungewöhnlich sympathisch fand; der partout mich heiraten wollte, was ihm aber trotz zweijähriger Anstrengung und anschließend noch zweijähriger Zänkerei nicht gelang) verlobt. Klärchen hatte ihn zwar mit seiner Braut eingeladen, war aber dermaßen wütend, daß sie augenscheinlich nur ihn zum Tort [um ihn zu ärgern] mich dazu einlud; ich machte dann [...] zur Bedingung, daß tz es vorher wissen müsse, und dann erst um 1/2 11 [Uhr], und alles ging gut. Tochs gefielen mir sehr gut, aber die Braut auch – ich hätt´ auch eher die genommen als Klärchen, wenn ich schon kein Ty [Tilly Edinger] haben könnte. Aber ich hab´s ja – nebbich [leider].“[59]

Tatsächlich heiratete Philipp Schwartz 1927, d.h. ein Jahr nach der von Tilly Edinger erwähnten Verlobung.[60] Und die voreheliche Liaison mit Tilly Edinger wurde in seiner Familie nicht tabuiert. Schwartz´ Tochter erzählte mir, Tilly Edinger sei ihr vom Namen her bekannt und sie könne sich dunkel erinnern, „dass da mal was war...“.[61]

Über das Ende dieser Liebelei Tilly Edingers geben ihre Briefe näheren Aufschluss. So im Juni 1926: „Niemand kann ich´s doch sagen, dass der tz sich nur deswegen von mir getrennt hat, weil ich mich von Franz [Michels (1891-1970)] küssen lass, und gar nicht nur weil, weil ich ihn partout nicht heirate (den tz). Und nach viermonatiger Trennung denke ich viel mehr an tz als an Franz – und so weiter.“[62] Anfang September des gleichen Jahres, zwei Monate vor dem oben erwähnten Gesellschaftsabend, wusste sie zu berichten: „... mit der gleichen Post kam auch tz wieder geschlichen, der seit Fastnacht mit mir Schluß ist – dessen Brief hab ich zwar überhaupt nicht beantwortet, aber Du hast sicher recht: bei mir hört nie was auf. Ich treues Ty.“[63]

Emigrantenschicksale

Nach dem Zweiten Weltkrieg sind sich die Tilly und Philipp noch einmal begegnet. Anfang Dezember 1949 berichtete sie aus ihrer neuen Heimat nach Deutschland: „Nach den Ferien, aus denen ich Euch schrieb, arbeitete ich, anstatt der geplanten Wochen, nur 4 Tage in New York; dann verführte mich ein grad USA besuchender, ehemals Frankfurter, jetzt Istanbuler Freund,

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[57] Tilly Edinger an Elisabeth Salomon, 7.6.1925 (Institute for Germanic Studies, London).

[58] Entsprechend konnte Rolf Kohring das Kürzel „PE“ als den damals in Frankfurt lehrenden Geologen Axel Born (1887-1935) identifizieren (Kohring 2003, 87).

[59] Tilly Edinger an Elisabeth Salomon, 29.11.1926 (Institute for Germanic Studies, London); kursive Hervorhebungen von G.K.

[60] Zur Familie Philipp Schwartz´ siehe Heuer und Wolf 1997, 345.

[61] Dr. Susan Ferenz-Schwartz, persönliche Mitteilung. Solche Bestätigungen mühsamer Quellenrecherchen wünschte ich mir öfter!

[62] Tilly Edinger an Elisabeth Salomon, 5.7.1926 (Institute for Germanic Studies, London). Der Geologe Franz Michels (1981-1970) gehörte zu den hartnäckigsten Verehrern Tilly Edingers. Vgl. Kohring und Kreft 2003, passim.

[63] Tilly Edinger an Elisabeth Salomon, 16.9.1925 (Institute for Germanic Studies, London).

mit ihm im Auto schnell mal nach Cambridge zu fahren. Merkwürdigerweise war diese Unart (Privatleben vor Berufsleben) ein Segen; kaum zuhause, wurde ich so krank wie noch nie im Leben, mit endlosen Brechdurchfällen – nahm 17 Pfund ab, hatte dann Leucocytose, kam nach 6 Wochen so rumkräuchen noch ins Spital ...“.[64]

Die in der Spontaneität des unverhofften Wiedersehens mit dem alten Verehrer, Schicksalsgenossen und Lebensretter aufbrechenden, emotionalen Abgründe Tilly Edingers lassen ihre Wörtchen „verführte mich“ und „rumkräuchen“ nur erahnen. Während sie selbst niemals an eine Rückkehr nach Deutschland dachte und bis zu ihrem Tode in Cambridge, Mass., lebte, scheiterten Schwartz´ 1952 und 1957 unternommenen Bemühungen, dorthin auf seinen Lehrstuhl zurückzukehren.[65] Im Rahmen der bundesrepublikanischen »Wiedergutmachung« erhielt er 1957 (rückwirkend auf das Jahr 1954) zwar erneut den Professorentitel an der Frankfurter Universität.[66] Durch ein „Versehen“ wurde er erst ab dem Sommersemester 1967 im Vorlesungsverzeichnis als „ordentlichen Professor“ geführt; mit dem Zusatz: „liest nicht“.[67]

5 Epilog

1953 übersiedelte Schwartz aus der Türkei in die Vereinigten Staaten von Amerika und wurde Pathologe am Warren State Hospital, Pennsylvania. Ab 1967, inzwischen 73 Jahre alt, leitet er dort die Forschungsanstalt für Geriatrie.[68] In den USA entstanden zumindest drei große Publikationen, mit denen er die Forschungen seiner Frankfurter Jahre fortführte.[69]

Im Mai 1968 erhielt Wolfgang Schlote (geb. 1932), der später – 1984 bis 2000 – das Frankfurter Neurologische Institut als Geschäftsführender Direktor leitete,[70] einen Brief des Warren State Hospital in Pennsylvania mit der Nachricht, „that your employment as Research Scientist III in the Department of Pathology in our hospital has been confirmed by the Department of Public Welfare in Harrisburg“.[71]

An dem Tag, an dem der damalige Tübinger Privatdozent daraufhin das Flugticket im Reisebüro kaufen wollte, erreichte ihn jedoch die Mitteilung seines designierten Chefs, dass sein Aufenthalt leider verschoben werde müsse, „da das dortige Forschungsinstitut wegen Geldmangels bisher nicht ausreichend ausgestattet werden konnte.“[72]

Wäre dieser Aufenthalt zustande gekommen – was hätte in dieser *Hommage* auf Philipp Schwartz noch alles erzählt werden können?

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[64] Tilly Edinger an Otto Schindelwolf und Familie, 1.12.1949 (Geologen-Archiv Freiburg i. Br.); Unterstreichung im Original.
[65] Vgl. Winkelmann 2005 und Winkelmann 2001, 42-44.
[66] Heuer und Wolf 1997, 345.
[67] Personalhauptakte Philipp Schwartz, Universitätsarchiv Frankfurt am Main, Blatt 24, 27 und 28. Vorlesungsverzeichnis der Johann Wolfgang Goethe-Universität, Sommersemester 1967, 18.
[68] Heuer und Wolf 1997, 345.
[69] Schwartz 1961a (in erweiterter Form Schwartz 1964); Schwartz 1961b sowie Schwartz 1972a (hier werden die gemeinsamen Publikationen mit Goldstein und Cohn zitiert). Siehe auch Kreft 2004a, 106-107 sowie Kreft 2012, 104.
[70] Kreft 1997, 420.
[71] Robert H. Israel an Wolfgang Schlote, 16.5.1968.
[72] Wolfgang Schlote an R. L. Friede, 19.2.1970. Ich danke Herrn Professor Dr. Schlote für die mitgeteilten Informationen sowie Kopien der zitierten Korrespondenz.

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A Random Survey of Patients with Endomyocardial Fibrosis in 4 Hospitals Located in Cassava Producing Areas of Uganda.

J. Freers, M. Rutakingirwa, H. Mayanja-Kizza, L. Serunjogi & B. Smith

Abstract: Endomyocardial Fibrosis (EMF) is a restrictive cardiomyopathy of unknown origin. It is characterized by the formation of fibrotic tissue from the atrio-ventricular valve to the apex of either ventricle in all or in parts and impedes cardiac functions. In Uganda EMF is one of the most prevalent heart diseases. Incidence rates of EMF vary. Times without any newly reported cases are followed by times of high incidences. It has long been speculated that EMF is associated with heavy cassava consumption. In Uganda clusters of EMF cases were found in the districts of Mukono and Luwero which too, are major producers of cassava. It was therefore speculated that EMF might be more prevalent in other major cassava producing areas than previously thought. Patients in three leading cassava producing areas and in one medium cassava producing area with cardiac ailments were therefore via radio announcement invited for free examination. 60 patients were seen in Kayunga Hospital (Mukono District), out of which 14 (23.3 %) had EMF. 26 patients were reviewed at Arua Hospital, out of which 2 (7.7 %) had EMF. 32 patients were screened at Maracha Hospital where no EMF case was found. Also at Hoima Hospital none of the 81 patients screened had EMF, the latter being the one in an area producing medium amounts of cassava. It can therefore be concluded that the figures here obtained do not explain a relationship between cassava ingestion and the development of EMF.

Key words: Endomyocardial Fibrosis, cassava consumption, Uganda.

Zusammenfassung: Während weltweit die Endomyocard-Fibrose (EMF) eine eher seltene Krankheit ist, kommt sie in einigen tropischen Ländern häufiger vor. Sie ist eine restriktive Cardiomyopathie mit unbekannter Ursache. Fibrose Veränderungen vorwiegend am Endocardium – also an der Herzinnenschicht – der Einflussbahnen sowohl des rechten wie auch des linken Ventrikels verhindern nicht nur die normale Pumpfunktion, sondern führen auch zu einer erheblichen Deformität des Herzens, das dann als „Heart of Africa“ bezeichnet wird. In Uganda ist EMF eine der häufigsten Herzerkrankungen mit geographischen Häufungen in einigen Distrikten. Von einigen Forschern ist der Verdacht geäußert worden, dass das Auftreten von EMF mit dem reichlichen Verzehr der Wurzeln der Cassava-Pflanze (*Manihot esculenta*) in Zusammenhang steht, denn auffallend viele Fälle von EMF werden vor allem aus den Distrikten Kayunga, Mukono und Luwero berichtet, den Hauptanbaugebieten von Cassava. Aus diesem Grund wurden gezielte Untersuchungen in anderen Hauptanbaugebieten von Cassava in Uganda durchgeführt, um auch dort die Häufigkeit des Auftretens von EMF zu ermitteln. Patienten mit bestehenden Erkrankungen am Herzen wurden mittels Radioaufrufen dazu aufgefordert, sich einer kostenfreien Untersuchtung im nächsten Distrikt-Hospital zu unterziehen. Als Resultat wurden im Kayunga-Hospital im Mukono-Distrikt 60 Patienten untersucht, von denen 14 (23 %) an EMF erkrankt waren. Von 27 Patienten im Arua-Hospital litten 2 (7,7 %) an EMF. Von den 32 Patienten mit Herzbeschwerden im Maracha-Hospital war keiner an EMF erkrankt, ebenso wenig wie von den 81 Patienten im Hoima-Hospital. Nur in der Gegend des Hoima-Hospitals ist

die Cassava-Anbaurate geringer als in den 3 anderen genannten Gebieten. Die hier vorgestellten Daten bestätigen also bisher noch nicht die Hypothese, dass der Verzehr von Cassava und das Auftreten von EMF ursächlich im Zusammenhang stehen.

Schlüsselwörter: Endomyocard-Fibrose, Cassava-Verzehr, Uganda.

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1 INTRODUCTION

1.1 History of Research and Problem Statement

Endomyocardial Fibrosis (EMF) is a restrictive cardiomyopathy of unknown origin (Bukham et al. 2008). It is characterized by the formation of fibrotic tissue from the atrio-ventricular valve to the apex of either ventricule in all or in parts and impedes cardiac functions. There are scanty reports of EMF from countries of temperate climate (Loeffler's endocarditis). The bulk of disease burden lays in the tropics (Kerala in India, locations in Uganda, Nigeria, Ghana, Brazil). The non-invasive diagnostic tool of choice for EMF as for any other type of cardiomyopathy is the cardiac ultrasonographic examination. The sensitivity of echocardiography is almost as diagnostic as the autopsy.

In Uganda EMF is one of the most prevalent heart diseases. Incidence rates of EMF vary. Times without any newly reported cases are followed by times of high incidences as cardiac clinic records in Uganda's reference hospital Mulago have shown (Freers et al. 1996). In a study on echocardiographic diagnosis of heart diseases in Mulago Hospital EMF was found to be the number one heart disease. Therefore it was sometimes concluded that EMF in Uganda is related to poverty and unbalanced diet, has endemic areas, has a preponderance for certain ethnicities, and is associated with blood-eosinophilia (Freers et al. 1996, Rutakingirwa et al. 1999, Mayanja-Kizza et al. 2000, Andy 1983, Freers et al. 1993). It is of interest that outside these endemic areas EMF is rare. For example EMF is virtually unknown in neighbouring Kenya (Ogola, personal communication 1998).

It has long been speculated that EMF is associated with heavy cassava consumption (Sezi 1966). Work done in India showed clustering of EMF in the Kerala Province, which is a major cassava producing area (Valiathan et al. 1989). In Uganda clusters of EMF cases were found in the districts of Mukono and Luwero which too, are major producers of cassava.

It was therefore concluded that EMF might be more prevalent in other major cassava producing areas than previously thought. Patients with cardiac ailments were invited via radio announcement for free examination and echocardiography screening at four main hospitals in Uganda. Three (Kayunga, Arua and Maracha) are situated in leading cassava-producing areas and one hospital (Hoima) is in an area of medium cassava production here considered as a control group. (Ministry of Agriculture and Food Survey 1996).

60 patients were seen in Kayunga Hospital (Mukono District) out of which 14 (23.3 %) had EMF. 26 patients were reviewed at Arua Hospital out of which two (7.7 %) had EMF. 32 patients were screened at Maracha Hospital where no EMF was found. At Hoima Hospital none of the 81 patients screened had EMF, Hoima being the one in the middle range of cassava production.

1.2 Significance of the Field Work and Hypothesis

Studies undertaken in the Kerala Province in India (Valiathan et al. 1989) suggest that EMF clustering may be related to the presence of a number of dietary co-factors that include excess exposure to Ce, Mg deficiency and the consumption of cassava. These may be of particular relevance for the occurrence of EMF in Uganda where recent studies have shown

> A statistically significant relationship between the consumption of cassava and EMF during a case control study (Rutakingirwa et al. 1999)
>
> The effect of a protein deficient cassava diet on animal hearts (Andy 1983)
>
> The presence of a Ce rich, Mg deficient environment in locations of EMF occurrence (Freers et al 2003)

It has also been consistently noted that the districts of Luwero and Mukono in formerly East Mengo of the Kingdom of Buganda are probably the most affected regions in Uganda (Freers et al. 1996, Rutakingirwa et al. 1999, Mayanja-Kizza et al. 2000, Freers et al. 1993, Shaper et al. 1968). However, clinical records from Mulago Hospital indicate that occasionally cases of EMF are also recorded from areas as far away as Tororo and Arua. Given the distances involved it is difficult to estimate if the occasional occurrence of cases from these districts are due to patients not appearing in Mulago hospital as a result of geographical remoteness or if these patients represent a true reflection of the rareness of EMF in these districts.

Analysis of soils, the prevailing geological environment and cassava consumption in northern and central Uganda indicate that exposure to such factors as a high cassava and low protein diet, meaning an excess of Ce and a Mg deficiency, are common place all over this area and not restricted to Luwero and Mukono Districts. It was therefore considered essential to validate previous observations regarding the reported low frequency of EMF in the outlying districts of central and northern Uganda.

To undertake this validation, 3 hospitals were selected in areas where a broadly similar exposure to the factors detailed above was expected. Additionally, a fourth hospital of a district with medium cassava production was chosen as a control (Hoima District). All of these regions had a similar population density and are holo-endemic areas for malaria.

During the hospital visits and associated dietary investigations the following procedures were performed:

- Echocardiography screening for EMF based on the criteria used in earlier surveys (Freers et al. 1996, Rutakingirwa et al. 1999, Mayanja-Kizza et al. 2000, Freers et al. 1993).
- Sampling of blood and stool for eosinophilia and parasitosis, respectively, to compare parameters of EMF and non-EMF patients.

- An investigation of local dietary practices focussing on the magnitude of cassava consumption within each hospital's catchment, methods of cassava preparation and geophagy (Sserunjogi)

- An individual background assessment of what patients perceived as cardiac disorder and made them visit the hospital.

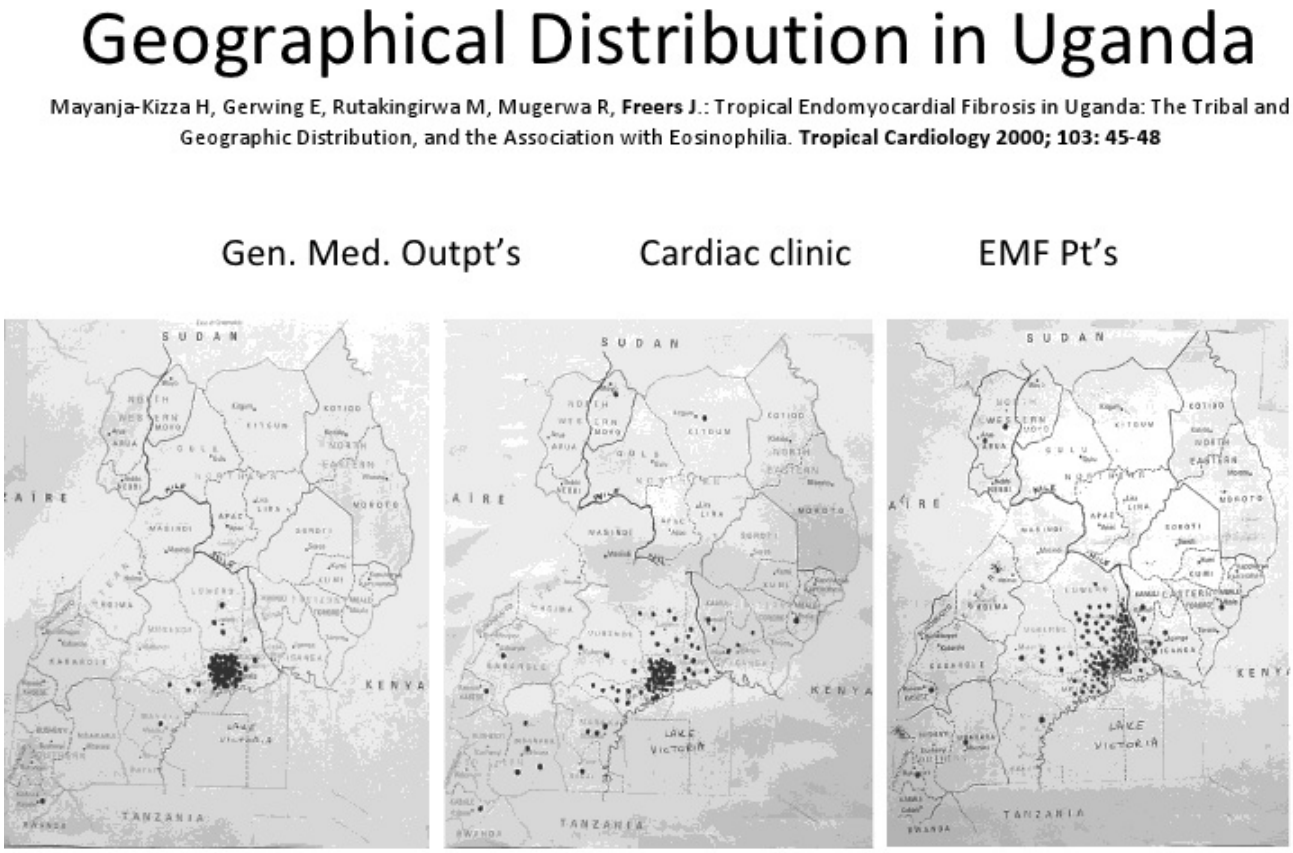

Fig. 1: Cluster of reported EMF cases in Uganda (from Rutakingirwa et al. 2000)

2 METHODOLOGY

2.1 Selection of Subjects

The hospitals selected for these investigations were: Kayunga Hospital (Mukono), Arua Hospital (Arua District), Maracha Hospital (Arua District) and Hoima Hospital (Hoima District). For at least two days prior to attending to each hospital patients with all sorts of heart problems especially those with swelling of the abdomen were invited for a free check up to the hospital. Announcements were made in English and the commonest local language(s) for each region on Radio Uganda. Care was taken to use the same wording. A reminder was broadcast on the morning of the day on which the examinations were to be made. This method of inviting patients was considered to be an efficient method of reaching the local community. Particularly as listening to "birango" (daily personal announcements about deaths, births, marriages etc. in local languages) is common practice in Uganda.

Each hospital administration provided a waiting room, examination room and an echo-screening room. On arrival the personal details of each patient were recorded (age, sex , tribe, place of residence). On a subset of patients, with emphasis on all EMF patients, additional information on

socio-economic status, education, staple food and accompanying sauce, and on the water source was collected. This was followed by a brief clinical history and problem oriented clinical examination before the respective patient underwent an echocardiographic examination using the standard views such as the parasternal long and short axis views and the subcostal and apical 4 chamber views. EMF with its particular echocardiographic picture was at this stage either confirmed or ruled out.

Where appropriate, a prescription was provided to the local hospitals indicating the necessary drugs according to their prescribed practices.

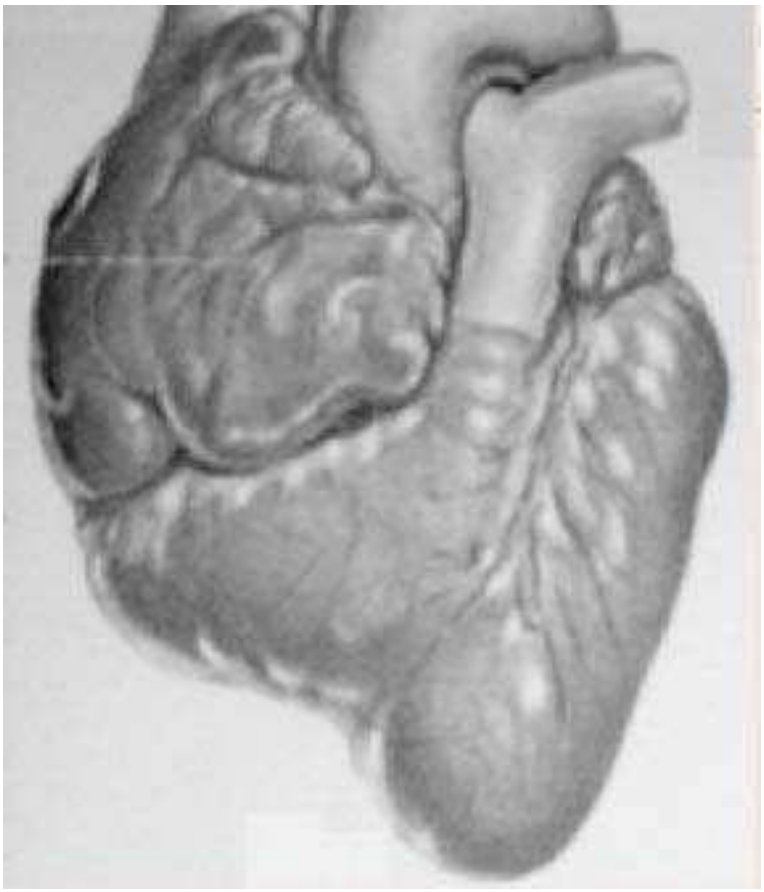

Fig. 2: The typical "Shape of Africa" form of a deformed EMF heart (from Mulago Hospital, Kampala)

2.2 Diagnostic Criteria Used: Echocardiography

Echocardiography was performed using a portable Siemens SX scanner. Like for other cardiomyopathies, echocardiography is the diagnostic tool of choice for EMF. Its accuracy is almost the same as in the autopsy. All structural cardiac changes in EMF as described by pathologists and termed “The Heart of Africa” (Fig. 2) can be visualised by means of echocardiography. The full blown picture of right or biventricular EMF can not be missed and is pathognomonic

.

The picture of right ventricular EMF shows a grossly dilated right atrium and an obliterated right apex. Firm apical fibrosis leads to shrinking of the underlying cardiac muscle which in turn distorts the shape of the heart forming the typical notch between the right and the left ventricle and giving the EMF patient the “Heart of Africa” shape. In an attempt to maintain right ventricular cardiac output the right ventricular outflow tract is dilated and hypercontractile. Tricuspid incompetence results either from valvular ring dilatation or from fibrotic tethering of

cusps or both (Abb.3a and 3b). There is usually gross tricuspid incompetence to an extend that there is no pressure gradient between right atrium and right ventricle. Frequent turbulences of blood flow especially in the right atrium can be visualised on the echo screen.

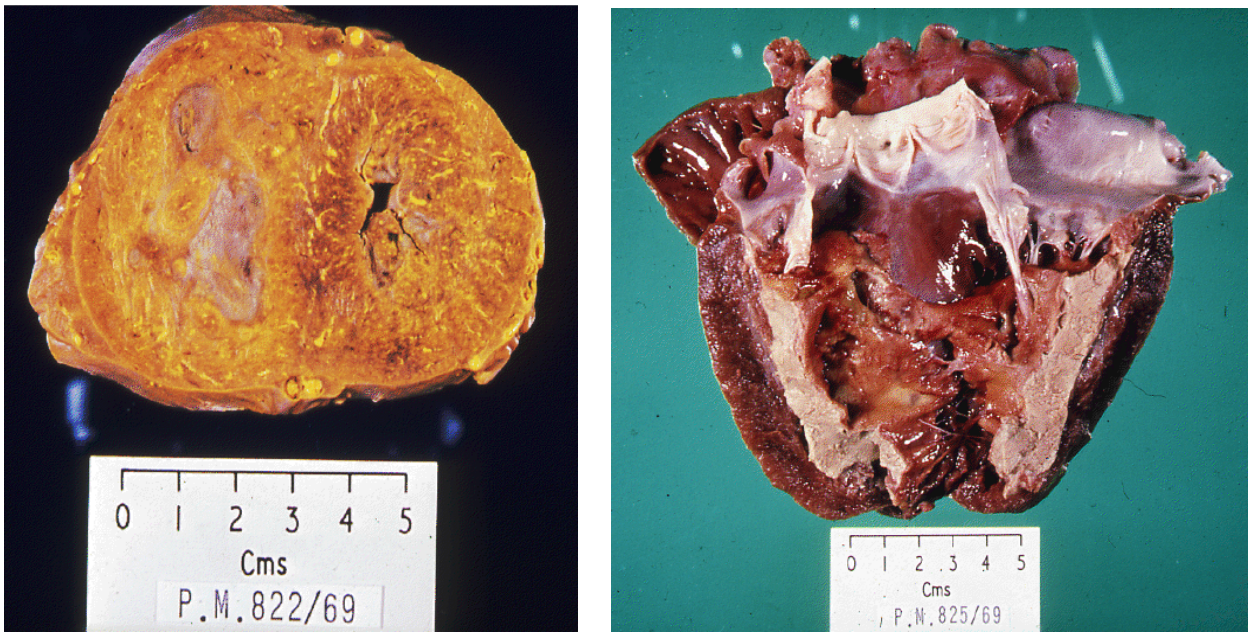

Fig. 3a and 3b: The fibrotic effects of typical EMF hearts (from Mulago Hospital, Kampala)

The most common feature of left ventricular EMF is tethering of the posterior mitral leaflet to the left ventricular posterior wall, resulting in mitral incompetence commonly with a dilated left atrium (Fig. 3). At times there is continuation of fibrosis in the entire inflow tract from the mitral valve down to the apex. Apical fibrosis alone is less common than in right ventricular EMF. Gross distortion of the left ventricle is not a common feature of the left ventricular EMF. This is possibly due to the greater muscle mass of the left ventricle. At times there is fibrosis of the papillary muscle resulting in increased echogenicity of the same.

Fibrotic changes are mostly found in both ventricles (bi-ventricular EMF) but at times they are only seen on one side (12 % pure right and 19 % pure left ventricular EMF).

In 71% of our EMF patients screened with diagnostic echocardiography we were able to demonstrate a more or less massive pericardial effusion.

From all EMF patients and a subset of patients as control group laboratory specimens for hemogrammes (Eosinophilia) and stool (parasites) were evaluated.

Together with each hospital visit a survey was undertaken to determine local dietary habits, with emphasis on collecting samples of various food types, soils and cassava. Methods employed in these surveys, results of dietary assessments and subsequent chemical analysis are described elsewhere (Smith et al. 1998).

3 RESULTS

Observations in Various Hospitals

A. Kayunga Hospital.

Location: 80 km East of Kampala, Mukono District.
Date: 4/3/97.
Total number of patients reviewed: 60.
EMF patients: 14 (23 %)
Males: 29 (48.3 %)
Females: 31 (51.7 %)
Age range: between 7-56 years
Length of stay/residence in Mukono District was between 4-56 years.

Tribes Seen: Baganda 27 (61.7 %), Rwandese/Burundi 7 (11.7 %), Banyankole/Bakiga 6 (10 %), others 10 (16.6 %)

Clinical Observations/Diagnosis: Peptic ulcer disease 13 (21.7 %), Rheumatic heart disease 12 (20.0 %), EMF 14 (23.3 %), Hypertension 4 (6.7 %), Congenital heart disease 2 (3.3 %), AIDS 3 (5.0 %), No plausible cause established, i.e. normal cardiac parameters 9 (15.0 %), other 3 (5.0%). Total = 60(100%).

EMF Patients by Tribe: Baganda 6 (42.9%), Rwandese/Burundi 3 (21.4%), Kenyi 2 (14.4 %), Teso 1 (7.1 %), Samya 1 (7.1%), Adhola 1 (7.1%).

Characteristics of EMF Hearts: 6 hearts had biventricular EMF, 5 had pure left ventricular EMF and 3 had pure right ventricular EMF. Pericardial effusion was found in 4 patients accounting for 20 % of EMF patients.

Laboratory results: The average absolute eosinophile count was equal in the control group and cases (618) even the amount of parasites found in stool or urine was the same (16 %).

Fig. 4: Patients diagnosed with EMF at Mulago Hospital

B. Hoima Hospital

Location: 200 km Northwest of Kampala. Regional Hospital for Hoima and Masindi Districts.
Date: 16-17/7/97.
Total number of patients seen: 81.
Males: 17 (20.9 %)
Females: 64 (79.1%). Age range between 6 months to 84 years (0.5-84 years).
Length of residence in Hoima/Masindi Districts was between 6 months to 80 years (0.5-80 years).
Patients came from both Hoima and Masindi Districts.

Tribes seen: Banyoro 46 (56.8 %), Alur 10 (12.3 %), Batooro 8 (9.9 %), Baganda 4 (4.9 %), Banyankole/Bakiga 4 (4.9 %), Bagungu 5 (6.2 %), others 4 (4.9 %).
Total 81 (100%).

Clinical Observations/Diagnosis: Hypertension 9 (11.l1 %), peptic ulcer disease 9 (11.11 %), respiratory tract infections 4 (4.9 %), pelvic inflammatory disease 4 (4.9 %), AIDS 3 (3.7 %), congenital heart disease 2 (2.5 %). No plausible cause established, i.e. normal echocardiography parameters 29 (35.7 %), others e.g. liver cirrhosis, rheumatoid arthritis etc. 23 (28.3 %), Total impression were 83 as some 2 patients had more than one diagnosis e.g. P.U.D. with hypertension.

EMF: No patients with EMF according to our criteria were seen.

C. Arua Hospital:

Location: 520 km North of Kampala
Date: 13-14/8/97 (travelled by air).
Total number of patients seen: 27.
Males: 11 (42 %)
Females: 15 (58 %)
Sex not recorded: 1
Age range: between 3-72 years.
Length of stay/residence in Arua: between 2-72 years.

Main tribes seen: Lugbara 20 (74 %), Kakwa 2 (7 %), Madi 4 (15 %), others 1 (4 %), total = 27 (100 %).

Clinical Observations/Diagnosis: Peptic ulcer disease 2 (8 %), Chest infections 5 (19 %), Hypertension 4 (15 %), Rheumatic heart disease 3 (12 %), EMF 2 (8 %) Diabetes 2 (8 %) others 4 (15 %) No plausible cause but normal echocardiographic parameters 5 (19 %), total 27 (100 %). N.B. some patients had more than one diagnosis suspected.

EMF: Characteristics of EMF Patients: both were males aged 5 and 12 years. One was a Lugbara and the other a Kakwa by tribe. Both had biventrivular EMF and both had a pericardial effusion. Both patients came from Yumbe (further up country near the banks of the river Nile where Schistosomiasis is endemic).

Laboratory results: The total Eosinophile count was 430 and 963 in cases and average 612 in controls. One EMF patient had Schistosomiasis Mansoni. Parasites found in stool or urine of controls stood at 12%.

D. Maracha Hospital:

Location: 30 km East of Arua town.
Missionary Hospital:
Catchment areas extends from Arua into the Sudan and the Democratic Republic of Congo.
Date: 15 August 1997
Total number of patients reviewed: 32
Males: 8 (25 %)
Females: 24 (75.0 %)
Sex not recorded: 1 (2.0 %).
Age range: between 5-61 years.
Length of stay in area: between 2 months to 61 years.

Tribes seen: 6: Lugbara 22 (69 %), Madi 2 (6 %), Kakwa 2 (6 %), Alur 6 (10 %), Sudanese (refugees) 6 (10 %), Rwandese 3 (5 %), others 7 (11.7%).

Clinical Observations/Diagnosis: Congenital heart disease (PDA, VSD) 2 (6%), liver disease 5 (16%), asthma 2 (6%), hypertension 5 (16%), rheumatic heart disease 2 (6%), peptic ulcer disease 8 (25%), others 3 (9%), No plausible cause but normal echocardiographic parameters 8 (9%), total 32(100%). Some had more than 1 diagnosis.

Laboratory results: Average eosinophile count was 481. Parasites found in stool or urine of control groups stood at 14%.

4 DISCUSSION

As in previous observations from Kampala this study confirmed the clustering of EMF cases in the area of Kayunga. However, the design of this study did not give an answer why EMF is so frequently occurring there.

In areas where other patients with EMF were diagnosed (West Nile) the eating habits especially considering cassava are apparently similar.

The lack of EMF evidence in Hoima coincides with an environment in which cassava production at a local level is rather limited and the population prefers a mixed staple diet of plantain/matoke, cassava and sweet potato. Both in Hoima and Arua Districts the population practice the same cassava processing methods, i.e. fermentation, which is less common in Kayunga (Mukono District). This might be due to the varieties of locally produced cassava.

Although the number of EMF patients in this study is limited it appears to confirm earlier observations that EMF patients eat considerable less animal protein than control groups (Rutakingirwa et al. 1999). 45% of all EMF patients in this study eat meat less than once a month or never, whereas this was reported only in 11% of non-EMF patients. In contrast to our previous findings there was no difference in the total number of eosinophiles of cases and controls. We speculate that this is due to the fact that in this study no new EMF patients were discovered. All lived since some time with their cardiac condition. The average time of sickness was 47 months with a minimum of 4 months and a maximum of 120 months.

Another confounding factor in this study may include the effect of language on the specificity with which a radio announcement calling for people with specific symptoms could be broadcast. The existence of such a confounding factor is supported by the wide range of ailments observed

during the visits to Arua and Maracha hospitals relative to those observed at Hoima and Kayunga following similar announcements. For example in the Lugbara language, spoken in Arua and Maracha, there is only one word for describing chest, shoulders and abdomen altogether.

5 CONCLUSIONS

The clustering of EMF cases in the region of Kayunga remains enigmatic. Generally, it is agreed that EMF patients eat an unbalanced diet with considerable less animal protein. The previously observed association of eosinophila and EMF was not confirmed in this study. It appears that this is due to the fact that none of these EMF patients was newly discovered.

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Water Infrastructure Development: A Key Adaptation Strategy to Impacts of Expected Climate Change and Variability in Africa

Jonathan I. Matondo

Abstract: The global green house gas emissions due to anthropogenic activities have increased since pre-industrial times with a rate of about 70 % between 1970 and 2004. There are also reports that the atmospheric concentrations of CO_2 (397ppm) and CH_4 (1774ppb) in year 2005 exceed by far the natural range over the last 650,000 years. Fossil fuel use is the major contributor of global CO_2, followed by land-use change. The major effect of the increase of anthropogenic green house gas emissions in the atmosphere is global warming. It has been established that climate change in the next 100 years will be due to anthropogenic activities. It has also been reported that 1995-2010 are the warmest years in the history of instrumentation (since 1850) and the global surface temperature rise is attributed to the green house gases effect. GCMS forecast a 10 to 20 % drop in rainfall in Northwestern and Southern Africa by 2070 and river water levels are expected to drop below 50 %.

Water infrastructure is defined as a stock of facilities and installations needed to develop and manage water resources, including delivery, supply and distribution of water to its users as well as for the collection, removal, treatment and disposal of sewage and wastewater. The major function of water storage and distribution facilities is to change the temporal and spatial availability of water in order to make it available when and where needed.

Today there are 800,000 dams world wide, out of which 45,000 are large dams with heights of more than 15 meters. In the African continent there are at least 1272 large dams, whose main purpose is irrigation, water supply and hydropower generation. Africa has only 2.7% of the world's dams but almost half of this is in the Republic of South Africa. Dams and reservoirs have a significant contribution to socio-economic development given the fact that water is a catalyst for economic development and therefore has been regarded as an economic good. The relationship between dam indicators and economic development indicators show that countries with High economic Income (HI) have the reservoir volume per capita (m^3/capita), greater than in countries with Low economic Income (LI) which is 2700m^3/capita and 470m^3/capita respectively. The reservoir volume per capita for sub-Saharan Africa is about 543m^3/capita.

Africa has less than 3 % stored water potential hence the very low water security especially for food and energy security. This resultant low stored water poverty index for Africa is a strong, indicator that water resources are not fully developed to act as a catalyst and engine for development and social equity. Thus, there is a need for Africa to develop water storage and distribution infrastructure to mitigate the impact of climate change, improve food and energy security to meet the MDGs and further advance the economic development agenda.

Keywords: Water infrastructure development, climate change, reservoir volume per capita, dams

Zusammenfassung: Die globalen Green House Gas Emissionen haben sich aufgrund menschlicher Aktivitäten seit Beginn des Industriezeitalters allein im Verlauf des Zeitraums von 1970 bis 2004 um etwa 70 % vermehrt. So sind die 2005 in der Atmosphäre gemessenen Kohlendioxid-Gehalte von etwa 397 ppm und die Methan-Gehalte von etwa 1774 ppb die vermutlich höchsten Werte im Verlauf der vergangenen 650000 Jahre. Der Verbrauch fossiler Brennstoff ist der größte Verursacher des erhöhten CO_2-Gehalts, gefolgt von intensivierter Landwirtschaft. Die größte Auswirkung haben die vermehrten Green House Gas Emissionen auf das globale Klima, das sich bei weiterem Anstieg der Emissionen in den nächsten einhundert Jahren signifikant erwärmen wird. Seitdem weltweit zuverlässige Temperaturmessungen vorgenommen werden, also etwa seit 1850, waren die Jahre von 1995 – 2010 die mit Abstand wärmsten, wie sich aus diesen Messungen klar ergeben hat. GCMS hält dementsprechend einen 10 bis 20-prozentigen Niederschlagsverlust im nordwestlichen wie auch im südlichen Afrika bis zum Jahr 2070 für recht wahrscheinlich. Im Verlauf des gleichen Zeitraums werden sich die Wasserstände der Flüsse in diesen Regionen vermutlich um etwa 50 % reduzieren.

Unter der Infrastruktur des Wassers versteht man alle Arten möglicher Installationen, die benötigt werden, um Wasser-Ressourcen nachhaltig zu entwickeln, ihre unbegrenzte Auslieferung und gerechte Verteilung zu gewährleisten, sowie für die Behandlung, Entfernung und Verteilung von Abwässern zu sorgen. Eine der wichtigsten Funktionen der Wasservorsorge besteht darin, Wasser sowohl zeitlich wie auch räumlich verfügbar zu machen, wo und zu welchem Zeitpunkt auch immer es gerade gebraucht wird.

Gegenwärtig gibt es weltweit etwa 800000 Staudämme, von denen ungefähr 45000 als große Dämme mit einer Staudammhöhe von mindestens 15 m gelten. In Afrika gibt es insgesamt mindestens 1272 große Staudämme, die vor allem zur Bewässerung, als Trinkwasserreservoirs und zur hydroelektrischen Energiegewinnung dienen. Afrika hat insgesamt nur einen Anteil von etwa 2,7 % aller Staudämme auf der Erde, und von diesen befindet sich knapp die Hälfte in Südafrika. Staudämme und Reservoirs spielen eine wichtige Rolle in der sozioökonomischen Entwicklung eines Landes. Es hat sich erwiesen, dass die Länder mit einem durchschnittlich vergleichsweise hohen pro Kopf-Einkommen auch ein erheblich größeres Wasservolumen pro Kopf in ihren Reservoirs aufweisen. Dieses beträgt in Ländern mit hohem Einkommen etwa 2700 m^3, in Ländern mit niedrigem Einkommen nur 470 m^3. Das Reservoir-Volumen pro Kopf in Afrika südlich der Sahara beträgt etwa 543 m^3.

Afrika staut nur etwa 3 % seines gesamten Wasserpotentials, vermutlich der wichtigste Grund für die bislang unzureichende Versorgung mit Wasser im Ernährungs- und Energiesektor. Daraus lässt sich ableiten, dass die durchaus vorhandenen Wasser-Ressourcen noch nicht hinreichend genutzt werden, um als Katalysator zukünftig zur ökonomischen Entwicklung und sozialen Gerechtigkeit beizutragen. Es besteht also die Notwendigkeit, das Potential des vorhandenen Wassers möglichst intensiv zu nutzen, um eine Infrastruktur zu erschaffen, die den Einfluss des Klimawandels und die Defizite im Ernährungs- und Energiesektor dahingehend verändern, dass die avisierten Millenium Development Goals (MDG) erreichbar werden.

Schlüsselwörter: Wasserinfrastrukturentwicklung, Klimawandel, Reservoirwasservolunen pro Kopf, Staudamm

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1 Climate and Water Resources in Africa

Africa's climatic zones are largely controlled by the continent's location astride the equator and its almost symmetrical extension into the Northern and Southern Hemispheres. Thus, except where altitude exerts a moderating influence on temperature or precipitation (permanently snowcapped peaks are found near the equator), Africa may be divided into six climatic regions. Areas near the equator and on the windward shores of South Eastern Madagascar have a tropical rain forest climate, with heavy rain and high temperatures throughout the year. North and south of the rain forest are belts of tropical savanna climate, with high temperatures all year and a seasonal distribution of rain during the summer season. The savanna grades pole-ward in both hemispheres into a region of semiarid steppe (with limited summer rain) and then into the arid conditions of the extensive Sahara (north) and the Kalahari (south). Belts of semiarid steppe with limited winter rain occur on the poleward sides of the desert regions. At the northern and southern extremities of the continent are narrow belts of Mediterranean-type climate with subtropical temperatures and a concentration of rainfall mostly in the autumn and winter months. (htt://www.infoplease.com/ce6/world/A0856492.html (2/2/2008)).

Africa has the greatest number of rivers and surface water bodies that cross or form international boundaries. Table 1 shows 10 largest surface-water bodies in sub-Saharan Africa with their corresponding basin countries and basin area. The 10 river basins in Table 1 (and Lake Chad) have a total drainage area greater than 14.8 million km^2, and they affect 36 sub-Sahara African countries and Egypt. Africa has 62 international river basins shared by two or more countries. Drainage basins with more than five basin countries are: Chad, Volta, Zambezi, Niger, Congo and the Nile. Africa has more than 160 lakes with a surface area greater than 27 km^2, most of which are located around the equatorial region and sub-humid East African highlands within the Rift Valley. Ground water represents 15% of Africa's water resource with major aquifers found in arid regions of north, Central, and southern Africa. Ground water is a very important source of drinking water supply and is used by more that 75 % of the population (World Bank 1995). Fig. 1 shows the drainage basins of Africa. It should be pointed out here that these rivers flow through several climatic regions and therefore depict high flow variability at certain points. Since rivers know no political boundaries, the management of their waters is challenging and complex. It is also important to note that few of the trans-boundary river basins shown in Table 1 are effectively jointly managed.

2 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) refers to climate change as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. These changes can be caused by dynamic processes on earth, external forces including variations in sunlight intensity, and more recently by human activities. There are three categories of climate change and these are: long-term, short-term and fluctuations. In 1941 Milankovitch proposed a theory that identified the main cause of the Pleistocene ice ages (long-term climate changes) as periodic changes in the distribution of incoming solar radiation resulting from variations in the earth's orbital geometry that is the tilt, precision of equinoxes and eccentricity. The earth is tilted on its rotational axis at an angle of 23.4^o relative to a perpendicular to the orbital plane to the earth. This angle of inclination has fluctuated between 22^o and 24.5^o with an average periodicity of 41 thousand years. As the angle of tilt increases, the amount of solar energy received at high latitudes over the summer season increases. The axis of rotation of the earth wobbles because of the gravitational pull of the sun and moon on the equatorial bulge on the earth. This wobble affects the timing of the solstices and equinoxes in relation to the extreme earth sun distances. This phenomenon is known as precision of the equinoxes and affects the

solar intensity of the seasons. The earth's orbit has varied from being near circular to markedly elliptical with a mean periodicity of about 9508 thousand years. These changes modulate effects of precision of the equinoxes. With maximum eccentricity, differences in solar radiation receipt of about 30% may occur between perihelion and aphelion. However, climate change due to the natural forcing is gradual and this allows for the natural environment, including human beings, to adapt to the changes, as it has been experienced in the past.

Table 1: The largest surface-water bodies in sub-Saharan Africa (IPCC 2001)

Basin Name	No of countries	Basin Area (1000 km^2)	Basin countries
Congo	9	3,720	Congo, Tanzania, Cameroon, Burundi, Rwanda, Zambia, DRC,
Nile	10	3,031	Sudan, Ethiopia, Egypt, Uganda, Tanzania, Kenya, Rwanda, Burundi, RDC, Eritrea
Niger	9	2,200	Mali, Nigeria, Niger, Guinea, Cameroon, Burkina Faso, Benin, Cote d'Ivory, Chad
Lake Chad	6	1,910	Chad, Niger, Central African Republic, Nigeria, Sudan, Camroon
Zambezi	8	1,385	Zambia, Angola, Zimbabwe, Mozambique, Malawi, Botswana, Tanzania, Namibia
Orange	4	950	South Africa, Namibia, Botswana, Lesotho
Okavango	4	529	Botswana, Angola, Namibia, Zimbabwe
Limpopo	4	385	South Africa, Botswana, Mozambique, Zimbabwe
Volta	6	379	Burkina Faso, Chana, Togo, Cote d'Ivory, Benin, Mali
Senegal	4	353	Mali, Mauritania, Senegal, Guinea

Climate changes occurring over time scales shorter than those associated with the orbital forcing frequencies are defined as short-term. Climate fluctuations on time scales of less than 100 years are usually considered as climatic variability.

It has been considered that the major potential mechanism of climate change over the next few hundred years will be anthropogenic green house gas warming up. A number of gases that occur naturally in the atmosphere in small quantities are known as "greenhouse gases". Water vapour (H_2O), carbon dioxide (CO_2), ozone, methane (CH_4), and nitrous oxide (N_2O) trap solar energy in much the same way as do the glass panels of a greenhouse or a closed automobile. This natural greenhouse gases effect has kept the earth's atmosphere some 30^o Celsius hotter than it would otherwise be, making it possible for humans and other living things to exist on earth.

Human activities, however, are now raising the concentrations of these gases in the atmosphere and thus increasing their ability to trap energy. Carbon dioxide levels have risen from 280 ppm by volume since before the Industrial Revolution to about 360 ppm by 1990 (IPCC 2001). Man-made carbon dioxide which, is the most important contributor to the enhanced greenhouse gases effect, comes mainly from the use of coal, oil, and natural gas. It is also released by the destruction of forests and other natural sinks and reservoirs that absorb carbon dioxide from the air.

Fig. 1: International River Basins of Africa.
(source:http://www.transboundarywaters.orst.edu/publications/register/tables/IRB_africa.html 2/22/2008)

The global green house gas emissions due to anthropogenic activities have increased since pre-industrial times with and increase of about 70 % between 1970 and 2004 (IPCC 2007). The IPCC (2007) also reports that the atmospheric concentrations of CO_2 (397 ppm) and CH_4 (1774 ppb) in year 2005 exceed by far the natural range over the last 650,000 years. Fossil fuel use is the major contributor of global CO_2, followed by land-use change. The major effect of the increase of anthropogenic green house gas emissions in the atmosphere is global warming.

It has been established that climate change in the next 100 years will be due to anthropogenic activities (IPCC 2001). It has also been reported that 1995-2006 are the warmest years in the history of instrumentation (since 1850) and the global surface temperature rise is attributed to the green house gases effect (IPCC 2007).

According to the IPCC (2007), if countries around the world do not reduce emissions of greenhouse gases by the end of this century:

- Temperatures globally are expected to increase 2 to 5 degree Celsius, depending on population and economic growth.

- Global average sea level has risen since 1961 at a rate of 1.8 mm per year and since 1993 at 3.1 mm per year with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Therefore, using the current rate, the sea level is expected to rise to 31 cm by the end of the century.

- Mortality and illness will have risen as the intensity and duration of heat waves increased and as the tropical habitat of mosquitoes that carry malaria and fever creep northward.

- Precipitation has increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. In summary precipitation is expected to increase in high latitudes and decrease in most subtropical land regions. This will significantly reduce food crop yields in developing countries as a whole.

- The frequency of extreme events (droughts, heat waves, cyclones, floods) is expected to increase. In north Atlantic an increase in intense tropical cyclone activity has been observed since 1970. Heat waves have become more frequent over most land areas and the frequency of heavy precipitation and thus floods has increased over most areas.

The number and size of glacial lakes has increased due to changes in snow, ice and frozen ground, thus increasing ground instability in mountain and other permafrost regions, and led to changes in some Artic and Antarctic ecosystems. The IPCC (2007) reports that some hydrological systems have also been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and thus effects on the thermal structure and water quality of warming rivers and lakes. In terrestrial ecosystems, earlier timing of spring events and poleward and upward shifts in plant and animals ranges are more likely linked to the recent warming. In some marine and freshwater systems, shifts in ranges and changes in algal, plankton and fish abundance are also associated with rising water temperatures, as well as related to changes in ice cover, salinity, oxygen levels and circulation.

The impacts of expected climate change globally and regionally may be summarized as follows. Global warming will affect the entire planet, noticeably warming the world ocean and causing it to expand. Expansion of the upper layer of the ocean and melting of land-locked glaciers may be sufficient to cause inundation of low-lying areas and some coastal flooding. The warming will be greater at high latitudes and less in the tropics. The differential warming effect will alter the traditional patterns of winds and ocean currents.

Overall precipitation will increase on a worldwide scale, but some regions will experience more precipitation than in the past while others will experience less. All regions will not be affected in precisely the same way. Global warming could dramatically alter regional climates.

Ecosystems contain the Earth’s entire reservoir of genetic and species diversity. Ecosystems have historically provided services that are essential to the smooth functioning of human societies. Changes in patterns of temperature and precipitation will affect many natural

ecosystems. The composition and geographical distribution of many ecosystems will shift asindividuals species respond to the impacts of climate change. Biological diversity may be reduced in some areas as a result of climate change. Some ecosystems may not achieve a new equilibrium for several centuries.

Forests, fisheries and regions of rain-fed agriculture may experience significant changes in their annual yields. The fertility, robustness, and species composition of various ecosystems may change dramatically. Human and animal health may be adversely affected by changes in the range and strength of disease vectors and pests.

The frequency, duration and severity of extreme weather events may change significantly on a regional basis. Changes in the availability of water, food, and energy may combine with episodes of extreme weather in ways which cause critical habitats to shrink or move geographically. In cases where rare or endangered species are close to the limit of their genetic tolerances, shifts in climate and habitat may increase the risk of species extinction.

Changes in the availability of food and water, combined with extreme weather events may stimulate significant flows of environmental refugees.

3 Climate Change and Variability in Africa

Humans have adapted to patterns of climate variability through land-use systems that minimize risk, with agricultural calendars that are closely tuned to typical conditions and choices of crops and animal husbandry that best reflect prevailing conditions. Rapid changes in this variability may severely disrupt production systems and livelihoods. Inter-annual variability of the African climate is determined by several factors. Nicholson and Entekhapi, (1986) report that the El Niño-Southern Oscillation (ENSO) is the most dominant perturbation responsible for inter annual climate variability over eastern and southern Africa. According to Nicholson and Kim, (1997), the typical rainfall anomaly associated with ENSO is a dipole rainfall pattern: Therefore, Eastern Africa is in phase with warm ENSO episodes, while southern Africa is negatively correlated with these events. The 1997–1998 ENSO event resulted in extreme wet conditions over eastern Africa and it is also suspected that the La Niña could have been the cause of the devastating floods in Mozambique in 2000. Modeling exercises indicate that climate change may increase the frequency of ENSO warm phases by increasing the warm pool in the tropical western Pacific or by reducing the efficiency of heat loss (IPCC, 2007). Ward (1998) reported that in the Sahel and similar regions of West Africa, the problem is more complex and ENSO appears to influence year-to-year variations and reduces rainfall. Its influence appears to be greater within long dry intervals in the Sahel, but it is not the dominant factor controlling rainfall in this region

Over northern Africa, the North Atlantic Oscillation (NAO) is a key factor that is responsible for inter annual variability of the climate (Lamb 1978). According to Stockton and Allali (1992), the northward displacement of the Azores high-pressure cell is a subject of study because of its association with a drought cycle in Morocco that is related to the dipole between the positioning of the Azores high-pressure cell and the Iceland low-pressure cell. These severe droughts seem to manifest themselves in Morocco in periodicities varying between 2 and 13 years.

Across western Africa, year-to-year changes in seasonal climatic conditions are determined primarily by the Atlantic Ocean, although the rest of the world’s oceans also play important roles. Low-lying islands and coastal regions receive significant amounts of rainfall from tropical cyclone activity, which is sensitive to inter annual variability of SST conditions over adjacent ocean basins.

The climate of Africa also exhibits high inter decadal variability. Rainfall variability in the Sahel derives from factors such as SST and atmospheric dynamics and is modulated by land surface effects related to soil moisture, vegetation cover, dust, and so forth (IPCC 2007). Modeling evidence also suggests that orographic control plays a significant role in promoting climate teleconnections between global SST anomalies and West African inter annual climate variability (Semazzi & Sun 1997).

Besides ENSO, the NAO, and West African climate anomaly patterns, other continental-scale and sub continental climate anomalies play significant roles in determining inter annual and longer climate variability time scales (Nicholson et al. 2000). For instance, the decade 1950–1959 was characterized by above-normal precipitation over most of Africa, although rainfall deficiencies prevailed over the near-equatorial region. Later, during the period 1960–1969, this rainfall anomaly pattern dramatically reversed in sign, with rainfall deficits observed for most of Africa while the equatorial region experienced widespread abundance of rainfall. Lamb and Peppler (1992) contend that these two time periods also coincide with a reversal in the sign of the Sahelian rainfall anomalies. More recently, the pattern has been one of increased aridity throughout most of the continent. Mean rainfall decreased by 20–49 % in the Sahel between the periods 1931–1960 and 1968–1997 and generally 5–10 % across the rest of the continent. Figure 2 shows the runoff hydrographs for Niger and Blue Nile rivers and the water levels of Lake Victoria from 1900 to 1997. It can be seen from Figure 2 that the levels in Lake Victoria have been decreasing since 1960 and worst levels were recorded in 2006. The Blue Nile is also depicting a decreasing trend since 1930. The Niger River is showing a remarkable decrease in the flows since 1950. In fact a decline in the average discharge in the range of 40-60 % has been observed since the early 1970s. The above phenomenon is in support of the decrease in rainfall as explained above.

Water is a renewable resource through the hydrologic cycle, but is unevenly distributed in time and space. In the past 30 years, Africa has experienced at least one major episode in each decade. In Eastern Africa there were serious droughts in 1973-74, 1984-85, 1987, 1992-94, and in 1999-2000. The last drought in the Sahelian persisted for decades, from 1972-73 to 1983-84 and in West Africa in 1982-83, 1993-94 etc. Southern Africa where weather patterns recently have been erratic has experienced sever droughts as recorded in 1967–73, 1981-83, 1986/87, 1991/92, 1993/94, 2001/02, 2003, 2005/06), and in Mozambique in 2007. Floods have also ravaged the continent such as the flood of 1999-2000 in Nigeria, South Africa and Mozambique. East Africa has also experienced floods in 2003, 2006 and 2012. Floods occurred in Southern Africa in 2008.

3.1 Impact of Climate Change and Variability

Chartres (2009) contends that, as the world awakens to the harsh realities of climate change and food insecurity, much of it apparently remains oblivious to a looming global water crisis, which climate change will aggravate by making rainfall more erratic in many regions. Climate change and variability is going to have an effect on rainfall, river flows and the environment and therefore, will affect the socio-economic development in Africa. Following below is an explanation of the impact of climate change and variability in the context of water resources, social economy and the environment.

3.2 Impact on Water Resources

The major impact of climate change and variability on the water sector of Africa will be through the changes in the hydrological cycle, the balance of temperature, and rainfall. Over the past 50

years the average temperature on the Earth has risen at the fastest rate in recorded history with the 10 hottest years on record occurring since 1990 (Zabarenko 2005).

Adrianne (2003) reported that the average GCMS forecast a 10 to 20 per cent drop in rainfall in Northwestern and Southern Africa by 2070 and river water levels are expected to drop below 50 per cent. Higher temperatures are expected to increase evaporation losses, coupled with a decrease in precipitation in arid and semi-arid regions of Africa which will exacerbate the water scarcity in these regions. The above phenomenon will therefore, reduce the flows of major rivers and the water levels in man-made and natural lakes in Africa (160 lakes).

Apart from the Zambezi and Congo Rivers, most major African rivers (Nile, Niger, Senegal, Senqu/Orange, Rufiji) traverse semi-arid to arid lands on their way to the coast. It has been established that, of the world's major rivers, the Nile has the lowest specific discharge (i.e., flow per unit catchment area), even if only the part of the catchment that receives precipitation is considered (Reibsame et al. 1995). In North Africa the Maghreb region is characterized by erratic and variable rainfall, with a high rate of evapotranspiration (almost 80 %). It is also expected that the Maghreb region will have water scarcity by 2025, especially in Tunisia and Libya (IPCC 2007). Evaporation losses are expected to be high due to temperature increase and therefore, runoff is likely to be further reduced in all the rivers in Africa.

Talling and Lemoalle, (1998) ascertain that all African river basins have a poor hydrological performance because most of the lakes in Africa have a delicate balance between precipitation and runoff; all the large lakes show less than 10 % runoff-to-precipitation ratio and important water basins like Lake Chad and the Okavango Delta have no outflow because evaporation exceeds the precipitation runoff balance. Lake Chad's boundary was in Niger, Nigeria Cameroon and Chad in 1963. Currently Lake Chad has disappeared in Niger and Nigeria and its boundaries are now in Chad and Cameroon only and its size currently is less than 5,000 km^2. In the savanna regions, the incidence of seasonal flow cessation may be on the increase, as shown by some streams in Zimbabwe (IPCC, 2007). Table 2 shows estimates of ranges of percentage changes in precipitation, potential evaporation, and runoff in African river basins due to climate change.

It can be seen from Table 2 that there is a negative change in both runoff and precipitation in most of the river basins with the exception of Niger, Nile and Congo basins. Expected high temperature rise associated with climate change will cause greater water loss through evaporation thus placing additional stress on water regardless of changes in rainfall. It has been estimated that the number of countries in Africa experiencing water stress will rise to 18 and will affect 600 million people by 2025 (World bank, 1995).

As mentioned earlier, groundwater currently represents 15 % of Africa's water resources and is used by about 70 % of the population, mainly North Africa. Decreased rainfall will reduce the groundwater recharge and therefore reduce groundwater resource. The implication of this in coastal areas is to shift the salinity interface inland. The expected sea level rise will cause salt water intrusion further inland thus affecting fresh groundwater resources in coastal areas of Africa.

3.3 Social, Economic and Environmental Consequences

Climate change has already dramatically altered the hydrological cycle and these changes signal a looming water supply crisis (http/www.sciencemag.org/cgi/content/full/319/5863/573). Africa is expected to lose 4.1 % of its cropland by 2039 and 18.1 % is likely to have disappeared by the end of the century. Cropland loss is likely to occur at a much faster rate in some parts of Africa,

with northern and eastern Africa losing up to 15 % of their current crop area within the next 30 years (IRIN 2008). It was reported (IRIN 2005) that climate change could force people in drought prone areas of southern Africa to abandon agriculture permanently in the next 50 years.

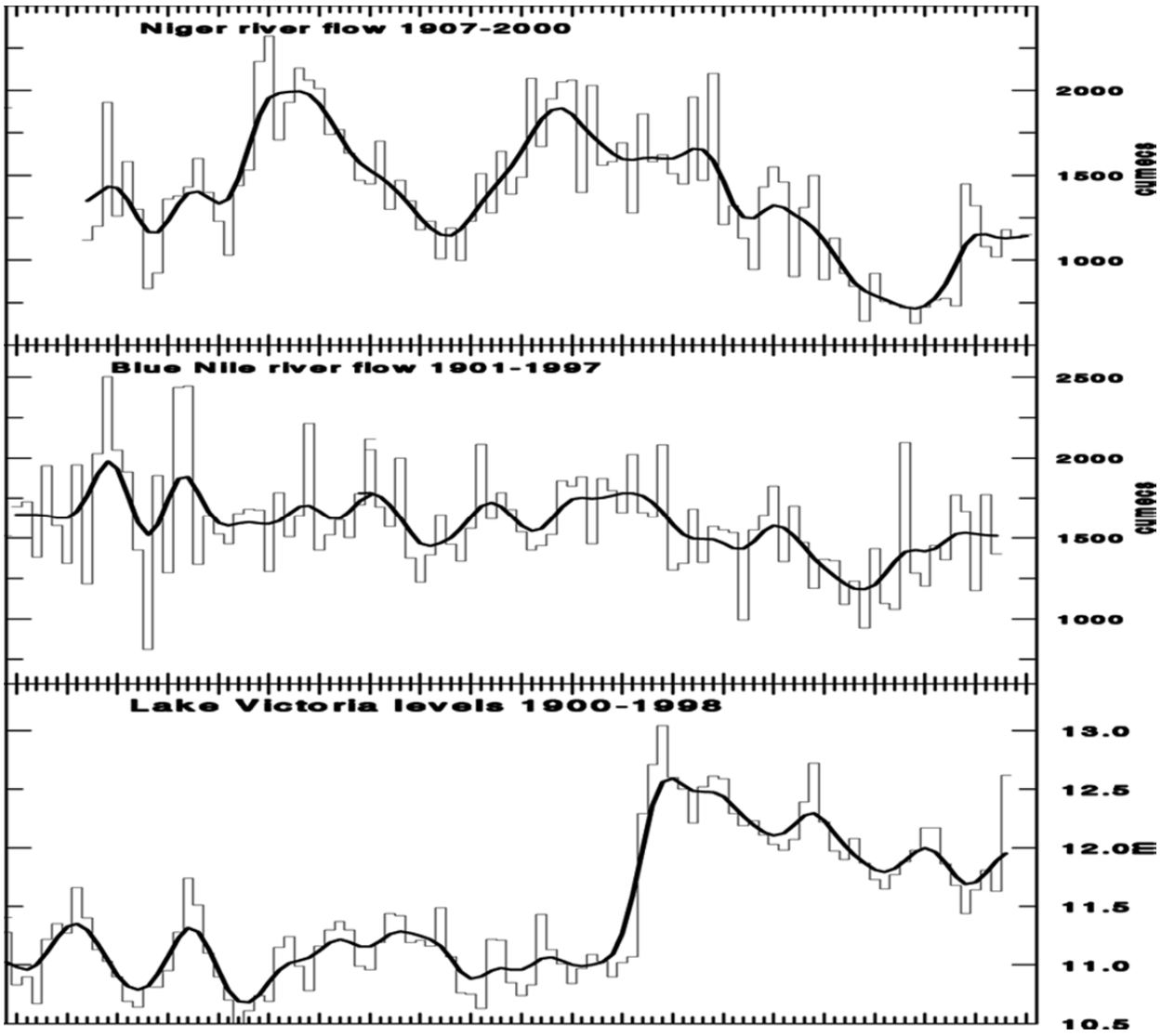

Fig. 2: Observed water level variability in Niger, Blue Nile and Lake Victoria (Conway and Hulme 1993)

To quote IPCC (2007): "Agriculture is not only a vital source of food in Africa; it also is the prevailing way of life". It is estimated that 70 % of the population lives on faming, and 40 percent of all exports are earned from agricultural products. One third of the national income in Africa is generated by agriculture. The poorest members of society are those who are most dependent on agriculture for jobs and income. It has been established that the poor from developing countries south of the Sahara on average spend 60-80 % of their total income on food (IPCC 2007). In the Maghreb region, agriculture is dominated by non-irrigated small-scale farmers who can not produce enough to feed the growing populations. Increasingly frequent droughts in North Africa will force governments to import more food thus placing their economies under severe strain. Climate variability which will lead to less food production which is going to contribute to poverty and social economic hardships to people in drought prone areas in Africa.

Dunham (see Reuters 2008) reported that some nations of southern Africa (Angola, Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland, Zambia and Zimbabwe) could loose about 30 % of their main staple food, maize, by 2030. African countries will have an expected crop yield reduction ranging from 10-20 % by 2020 (SciDev.Net, 2008). The dry spell in 2007 inMorocco left the country with a grain crop estimate of 2 million tons compared to 9.3 million tons in 2006. Grain stocks globally were precariously low and therefore the famine regions in Africa did not have the reserves to draw on. The implication of reduced food supplies is an increase in the price of food commodities, which affect the landless laborers and thus cause great economic hardship. According to WRI (1998) the food consumption in Africa as a whole exceeded domestic production by 50 %, in the drought-prone mid-1980s and by more than 30 % in the mid 1990s. In southern, central, eastern Africa more than 40 % of the population is undernourished. West Africa has the largest of the total population than any of the sub-regions, but it has the fewest undernourished people and by contrast East Africa has more than twice as many undernourished people. In early 2006 the World Food Programme needed US $ 5.2 million to fight hunger for children in Africa. About 20 million people in the Horn of Africa region were faced with the threat of famine (Toronto Star, March 8, 2006). The above statistics is expected to increase in future. Many countries in drought prone regions of Africa are receiving food aid. For example even Swaziland has been receiving food aid since 2001

Table 2: Estimates of range of changes (in percent) in precipitation, potential evaporation, and runoff in African rivers (IPCC 2001; Matondo et al. 2004; IPCC, 2007)

Basin name	**Change in precipitation (%)**	**Change in potential evaporation (%)**	**Change in runoff (%)**
Nile	10	10	0
Niger	10	10	10
Volta	0	4 to -5	0 to -15
Schebeli	-5 to 18	10 to 15	-10 to 40
Congo	10	10 to 18	10 to 15
Ogooue	-2 to 20	10	-20 to 25
Rufiji	-10 to 10	20	-10 to 20
Zambezi	-10 to -20	10 to 25	-30 to -40
Limpopo	-5 to -15	5 to 20	-25 to –35
Orange	-5 to 5	4 to 10	-10 to 10
Pangani			-6 to -9
Ruvu			-10
Rivers in Swaziland	10		-5 to 5

Hydropower generation on hydropower stations along major rivers in Africa is going to be affected by the low flow in rivers and low levels in water storage facilities thus affecting industry and domestic use of electricity. GNP per capita in Sub-Saharan Africa over the past ten years has averaged around US $ 493, which is slightly lower than that of US $ 536 in 1975-1984(Winterbottom 1997). Therefore climate change and variability is expected to cause a further reduction in the GNP in most countries in Africa. Thus the climate change and variability is going to impact negatively on the economy of most African countries.

The effect of decreased precipitation and the ever increasing population pressure on the environment is that areas considered now dry humid, semi-arid and arid will become semi-arid, arid and desert respectively. Those areas that will undergo desertification will trigger refugees into areas that will be considered relatively better. The Sahel is a 3.5 million km^2 band of semi-arid land stretching along the southern margin of the Sahara Desert and comprises nations that consist of entirely drylands such as Namibia, Botswana, Eritrea, etc. These are at risk of further

environmental degradation. In Nigeria about 2160 km^2 is being converted into desert each year thus forcing farmers and herdsmen to move to cities (Nduru 2007). Some three quarters of sub-Saharan Africa's agricultural drylands are now degraded to some degree. Desertification as explained by UNEP (1997) has reduced the potential vegetation productivity of more than one quarter of the continent's land area. It is expected that this percentage is going to increase in future. The estimated death of about 250,000 people in the Sahel region due to the drought of 1968-1973 has demonstrated the tragic human toll of desertification. Figure 3 shows the effects of drought on the environment in East and Southern Africa.

Fig. 3: Effects of drought on the environment in East Africa (Oludhe 2005) and crop field once fertile land turned barren in Southern Africa (IRIN 2008)

Too much or too little water is not good for the environment. Floods cause extensive damage to crops, infrastructure (roads, bridges, buildings etc.), human suffering and deaths, degradation of agricultural lands through the loss of the top soil by the erosive power of the moving water. Droughts in 1991-1992, 1997-1998, 2006-2007, and floods in 1998, 1999-2000, 2007, 2008 etc. affected livelihoods and economies and heightened renewed interest in the impact of climatic hazards. Dilley and Heyman (1995) note that for national and international agencies the costs of climatic hazards may result into a shift in expenditure from reducing vulnerability to simply coping with immediate threats. Many people in African drought prone areas are now already depending on food aid.

Climate change and variability is expected to cause an increase in the frequency of extreme events (droughts and floods). Therefore, the development of water infrastructure is apparent in order to deal with the impacts of climate change and variability in Africa.

3.4 Water Infrastructure Development

Water infrastructure is defined as a stock of facilities and installations needed to develop and manage water resources, including delivery, supply and distribution of water to its users as well as for the collection, removal of storm water, treatment and disposal of sewage and wastewater (UN General Assembly 2003).

Water is a renewable resource through the hydrologic cycle, which starts with solar energy heating the ocean waters and any other body of water on land thus changing it to the gaseous state. In the atmosphere it condenses and is forming clouds, which give rise to precipitation. This renewable resource world wide is estimated at approximately 40,000 km^3 per year (www.iwhr.com/download/li080905-Berga.doc, July 29, 2010). However, only around 9,000

Km^3 out of 40,000 Km^3 per year are accessible. Naturally water is unevenly distributed in time and space depending on the climatic variations, latitude, season of the year and topographical features.

Water has always played a central role in human societies, but in order to sustain that role, it needs to be harnessed and managed sustainably to increase its productive impact and reduce the risk of destruction, while protecting aquatic ecosystems, which are crucial for the environment. This can only be achieved through the development of an adequate hydraulic infrastructure in accordance with legal institutional frameworks for water management.

The major function of water storage and distribution facilities is to change the temporal and spatial availability of water in order to make it available when and where ever needed. The water that is stored and regulated by dams and reservoirs provides an irreplaceable water resource and benefit to water supply, irrigation, hydropower generation, flood control, river navigation, recreation, tourism, environment, etc. Reservoirs regulate around 40 % of the water for irrigation and play a significant role in drought and flood mitigation and one of the purposes of 20 % of the world's reservoirs is to reduce the major socio-economic impacts of flooding. The main purpose of reservoirs and distribution facilities in the world are: 38 % for irrigation, 18 % for hydropower generation, 14 % for water supply (domestic and industrial use), 14 % for flood mitigation, 8 % for recreation and 8 % for the rest (navigation, aquiculture, etc.).

3.5 Water Infrastructure Development in the World

History tells us that most of the great ancient civilizations grew up around a water source (Egypt – the Nile, Assyria-Babylon – the Tigris and Euphrates, China – the Yellow River, etc.). It is also evident that civilization grew and prospered if the regulation and management of the water systems was efficient and systematic. When this order broke down, these systems fell into despair and the civilizations withered often away too.

Most dams were constructed in the last century for power generation in temperate countries and also for power and irrigation purposes in various arid and semi-arid countries. Small dams were constructed at the end of the 20^{th} century in Europe and Northern America due to the high demand for power by industries. Panhwar (www.panhwar.com/Adobe/Article35.pd, July 29, 2010) contends that dam construction up 1950 was small because earth moving machinery such as bulldozers, scrappers, drag-lines, front-end-loaders, dumpers, pile and sheet hammers, heavy cranes and large concrete mixtures were unavailable. These developments started in the first quarter of the last century and an early peak of this technology had reached in late 1930s, but WW II delayed further development. There were improvements in construction and earth-moving machinery immediately after WW II. A boom in dam construction all over the world occurred. The industrialized countries were not only interested in selling their equipment but also their technologies and almost every highly developed country contributed funds for the construction of dams. Very large finances were advanced which mostly returned to developed countries through their sale of equipment, fee for consultants and contractors.

Today there are 800,000 dams world wide, out of which 45,000 are large dams with heights of more than 15 meters (http://www.dams.org/news_events/press317.htm 1/9/2009). Table 2 shows the number of dams in different regions in the world.

It can be seen from Table 2 that Asia has the most water infrastructure development (64.18%) followed by North America (15.46%) and Europe (8.97%). Africa has only 2.67% of the world water infrastructures, most of which are in South Africa (539).

Table 2: Number of large dams in different regions of the world

Region	**Number of dams**	**% of total**
North America	7368	15.46
Central A. & Caribbean	644	1.39
Central/Eastern Europe	1203	2.52
Europe	4277	8.97
Asia	30587	64.18
South America	979	2.05
Oceania	577	1.21
Middle East	753	1.58
Africa	1272	2.67
Total	47660	100.00

3.5 Water Infrastructure Development in Africa

3.5.1 Need for Water Infrastructure Development in Africa

Water is naturally unevenly distributed in time and space. The major objective of water resources infrastructure development as explained earlier is to change the natural temporal and spatial availability of water to make it available when and where ever needed. The objective of Integrated Water Resources Management (IWRM) is to allocate the available water resources among competing and conflicting uses in the most beneficial and optimal manner. The above objectives can not be implemented effectively without the existence of water infrastructures (storage, distribution, urban and rural water supply systems, waste water treatment and disposal facilities, water harvesting systems, etc.). Water is the major catalyst for economic development and affects almost all sectors of the human endeavor. In fact the achievement of the Millennium Development Goals (MDGs) is hinged at the availability of dependable water supplies. Africa has less than 5 % of stored water potential hence the very low water security especially for food, energy security and poverty alleviation. This resultant low stored water poverty index for Africa is a strong indicator that water resources are not fully developed to act as a catalyst and engine for development and social equity.

In the African continent there are at least 1272 large dams, whose main purposes are irrigation, water supply and hydropower generation. South Africa has the most dams in Africa (539), followed by Zimbabwe (213), Algeria (107), Morocco (92), Tunisia (72), Nigeria (45), Cote d'Ivoire (22), Angola (15), Democratic Republic of Congo and Kenya 14 dams each, Namibia (13), Libya (12), Madagascar (10), Cameroon and Mauritius 9 dams each, Burkina Faso, Ethiopia and Mozambique 8 dams each, Lesotho 7, Egypt and Swaziland 6 dams each, Ghana 5, Sudan and Zambia 4 dams each, Botswana and Malawi 3 dams each. The rest of African countries have 2 dams with the exception of Gabon, Liberia and Uganda which have one dam each. It can bee seen from Table 2 that, Africa has only 2.67 % of the world's dams, but almost half of these are in the Republic of South Africa.

3.5.2 Africa's Dam Projects on the Drawing Board

Currently there are more than 70 dam projects along the major rivers and their tributaries in the African continent that are on the drawing board. Table 3 shows an estimate of the number of dams on the drawing board and corresponding river basins in African countries in alphabetical order.

It is however argued that if all the dams on the drawing table were built, Africa would see its external debt increase by billions of dollars and that hundreds of thousands of people would become dam-refugees, and upstream/downstream environmental impacts (inundation of upstream areas and ecological deterioration of the river system downstream etc.) would affect millions more. It is advocated that African governments should work together to resolve the issues that are affecting societies in the vicinities of dam projects by the implementation of strategies that reduce the adverse environmental and socio-economic impacts. It is also advocated that people who are affected by the building of dams should benefit the wealth accruing from such projects. In summary people should be able to share the economy that is created by the dams, and have access to the opportunities they create.

It is unfortunate that as Africa is gearing towards water storage infrastructure development, more hindrances are on the pathway which developed countries did not have. It is however, very important to build dams following good principles such as some of those enshrined in the World Commission on Dams (WCD) report to ensure sustainability and directly contribute to poverty reduction. In fact water resources development should be carried out with the aim of conservation of the environment in a sustainable way, which does not compromise the future generations.

3.5.3 Dams and Economic Development

Dams and reservoirs have a significant contribution to socio-economic development given the fact that water is a catalyst for economic development and therefore has been regarded as an economic good. Therefore, the appropriate indicator of dam contribution to socio-economic development is that proposed by Berga (www.iwhr.com/download/li080905-Berga.doc, July 29, 2010) which is the volume of the reservoir per capita (m^3 per capita). This is calculated as the total capacity of the reservoirs divided by the population of the country and is a more specific indicator of the stock of infrastructures developed effectively to regulate water resources and of the actual availability of water regulated for different uses (Berga 2010).

Berga (2010, op. cit.) established that the relationship between dam indicators and development indictors show that in countries with High economic Income (HI) the reservoir volume per capita (m^3/capita) is greater than in countries with Low economic Income (LI). In numerical terms for the HI economies the mean value of the volume of reservoir per capita is about 2700 m^3/capita, which is 5 times higher than the LI value (470 m^3/capita). Table 4 shows the regional population, reservoir storage and reservoir volume per capita. It can be seen from Table 4 that developed countries such as North America, Oceania, South America and Europe have high reservoir volume per capita (which ranges from 1486 to 5660 m3/capita) compared to Su-Saharan Africa (543 m^3/capita).

Therefore, according to Berga (2010, op. cit.) the stock of dams and fundamentally the reservoir volume per capita that a country has is generally closely linked to its socio-economic development, and that these infrastructures are essentially for a country's development. The developed countries have a large and varied stock of dams and hydropower infrastructures. Berga (op. cit.) concludes that it is vital for the socio-economic development of emergent and developing countries to plan for the construction of new infrastructures, to reach the adequate stock of energy and water infrastructures, in order to have available sufficient supplies of water and energy

Table 3: Africa's dam projects on the drawing table

Country	Number of dams	River basin
Angola	8	Kwanza
Benin/Niger	1	Mekiona
Benin/Togo	1	Mono
Cameroon	3	Sanaga, and Ntem
DRC	4	Congo
Ethiopia	6	Gogeb, Blue Nile, Nesh, Kesem and Awash
Gambia	1	Gambia
Ghana	1	Black Volta
Kenya	2	Samda and Mara
Lesotho	2	Phuthiatsana and Orange
Malawi	2	Lake Malawi
Mali	1	Bam
Morocco	5	Mbulouya
Mozambique	2	Zambezi and Oliphants
Namibia	1	Okavango
Namibia/Angola	1	Cunene
Niger	1	Niger
Nigeria	2	Benue and Kaduna
Republic of Congo	2	Lefini and Kouilou
Rwanda/Tanzania/Burundi	1	Kagera
Senegal/Mali	1	Senegal
Senegal/Guinea	2	Gambia and Konkoure
South Africa/Namibia	2	Orange
South Africa	2	Thukela and Berg
Sudan	2	Nile
Tanzania	2	Rufiji and Rumakali
Uganda	6	Nile, Karuma, Kalagala, Ayago, Murchson, Masindi,
Zambia	9	Zambezi
Zimbabwe	4	Zambezi, Tokwe and Bubu
Total	**76**	

Table 4: Population, reservoir storage and reservoir volume per capita by region (Source: White, 2005)

Region	Population (2004) in millions	Total reservoir storage (km^3)	Reservoir volume per capita (m^3/person)
Asia	3574	1262	353
Europe	729	1083	1486
Middle E. and N. Africa	435	392	901
Su-Saharan Africa	714	388	543
North America	326	1845	5660
Central A. and Carib.	177	148	836
South America	367	891	2428
Oceania	31	107	3452
World	6353	6116	963

3.5.4 Adaptation Strategies to the Impact of Expected Climate Change and Variability

3.5.4.1 Broader Review of Adaptation Strategies

Adaptation refers to adjustment made in natural or human systems in response to actual or expected climate stimuli or their effects in order to moderate harm or make use of beneficial opportunities (Zaki-Eldeen 2007).The time horizon of the change that might occur (increased or reduced precipitation) is similar to the time required for planning, approval, funding, construction, and economic life of water resources projects (dams, irrigation canals, drainage systems etc. (Shaake 1989)). Therefore, adaptation strategies should make sense regardless of the direction and magnitude of change. Miller (1989) contends that "adaptation strategies should be directed at developing robust water resources systems as well as techniques to incorporate climate change uncertainties into the long-term planning." Water resources adaptation options that are being proposed in order to deal with the effects of expected climate change and variability in the sector of water resources for Africa are as follows (Strzepek et al. 1996, Matondo et al. 2001, IPCC 2007):

Modification of the existing infrastructure

- Supply adaptation (installing canal linings, changing location of water intakes, using closed conduits instead of open channels, integrating separate reservoirs into a single system, using artificial recharge to reduce evaporation);
- Possible modifications if there is increased flows due to climate change (raising dam wall height, increased canal size, desilting reservoirs to increase storage);
- Construction of new infrastructure (reservoirs, hydro power schemes, delivery systems, inter-basin transfers);
- Alternative management of existing water supply systems (change operating rules, use conjunctive surface/groundwater supply, change priority of releases, physically integrate reservoir operation system, co-ordinate supply/demand)

Demand adaptation strategies

Conservation and improved efficiency

- Domestic (low-flow toilets, low-flow showers, re-use of cooking water, more efficient appliance use leak repair, commercial car washing where recycling takes place, rainwater collection for non-potable uses)
- Agricultural (night time irrigation, lining canals, closed conduits, improvements in measurements to find losses and apply water efficiently, drainage re-use, use of wastewater effluent, better control and management of supply network.
- Industrial (re-use of acceptable water quality, recycling)

Technological change

- Domestic (water efficient toilets, water efficient appliances, landscape changes, dual supply systems, recycled water for non-potable uses)

- Agricultural (low water use crops, high value per water use crops, drip, micro-spray, low-energy, precision application irrigation systems, salt tolerant crops that can use drain water, drainage water mixing stations)
- Industrial (dry cleaning technologies, closed cycle and/or air cooling, plant design with reuse and recycling of water imbedded, shift the type of products manufactured)
- Energy (additional reservoirs and hydropower stations, low head run of river hydropower, more efficient hydropower turbines)

Market/price-driven transfers to other activities

- Using water price to shift water use between sectors

The review of some of the above adaptation approaches are given in IPCC (2007). Not all the above proposed adaptation options will apply to all African regions.

3.5.4.2 Specific Adaptation Strategies for Africa

Proposed adaptation options to deal with the impact of expected climate change and variability on water resources in Africa have been grouped into two categories namely: short term and long term adaptation options. The explanations are presented in sections 3.5.4.3 and 3.5.4.4 below.

3.5.4.3 Short-term Adaptation Options Strategies

(i) Public awareness

The impact of climate change is felt by everyone hence everyone is aware of them. However, it is very crucial to raise awareness of the fact that the cause of the extreme weather related events is due to the climate change phenomenon and the need to adapt to it. This also involves dissemination of information on the interpretation of the impact of the phenomenon packaged in a way that suites the target audience. For example, if studies indicate that the rain season is delaying by a month, the farmer can use such information to adapt the cropping pattern. In most cases where floods have swept away and resulted in a large number of casualties it is normally due to the fact that the inhabitants have seen many floods, which came and left them as they were without knowing that the upcoming flood is of a far larger magnitude than earlier occurrences due to a result of climate change.

(ii) Efficient water use

Given the fact that water is going to be a scarce resource it is proposed that African countries should put in place measures that will reduce water consumption at all levels. This is only possible through efficient water utilization using water demand management at all levels. The effectiveness of efficient water use as an adaptation strategy is by reducing wasteful water use, cutting leaks in water supply systems and losses in irrigation systems (by using efficient water application methods and reducing evaporation through the application of mulches), and by reducing exaggerated household water use and pollution (which frees up more clean water). Aggressive water conservation programs

can obviate the need for dams and other diversion infrastructure as has happened in Bogota, Columbia, in California, and in Boston, Massachusetts. Efficient water use approaches at the household and farm level are available in the literature (Pereira *et al*. 2002, Falkenmark *et al*., 2007, Gleick *et al*. 2007). This adaptation option does not require much funding but it requires the education of the people from household to farm level on efficient water utilization (this could work very well in conjunction with the implementation of IWRM). Water pricing has also been used as a means of encouraging efficient water use. This is because people have the tendency to use less water as the price goes up. However, water pricing will not work in most countries where irrigation water is still free.

(iii) Wastewater recycling in urban areas whose wastewater is about 75 % of the supplied water can be a source of water. Wastewater treatment and reuse is an obvious possible solution to cope with the ever increasing water demand especially in addressing drought situations, which are exacerbated by climate change. It has been argued that potable water as a product of recycling is psychologically not acceptable by the public. The question is why would people be subjected to such a psychological trauma when some fresh water is being used for other activities such as irrigation, industrial activities, etc. The strategy that is proposed here is to treat wastewater to a level that is intended for a specific use such as water quality requirement for irrigation of vegetables that are eaten raw (e.g. tomatoes and lattice) is higher than those that are cooked before eating. The worst acceptable quality of recycled wastewater in irrigation is for plants that are grown as fodder. Various guidelines and standards for the use of recycled water already exist in a number of developed countries worldwide.

Therefore, African countries should encourage the recycling of wastewater especially in urban areas. This is because developing and managing water supply and wastewater infrastructure in an integrated way will have a number of advantages. Wastewater from the cities of Mbabane and Manzini in Swaziland is treated and the effluent is directed into natural rivers where it is used for domestic, industrial and irrigation purposes downstream

(iv) Strengthening of early warning centers

According to Elasha *et al.* (2006) early warning systems have been identified as a prerequisite for adaptation to climate change and variability, particularly to predict and prevent the effects of floods, droughts and tropical cyclones as well as for indicating the planting dates to coincide with the beginning of the rainy season. Important progress is being made in relation to the possibilities of using the El Nino Southern Oscillation (ENSO) and to a lesser extent, the North Atlantic Oscillation (NAO) as forecasting tools. It is argued that if farmers can adapt to current year to year variability through the use of advanced information on the futures season's climate and institutional systems are in place to respond to short-term changes (early warning systems), then communities will be in a position to adapt to longer-term changes (Oludhe, 2005). Drought monitoring centers have been established in Eastern, Southern and Western African Regions (Nairobi, Harare and Cote de Ivory). Therefore the need to strengthen these centers is apparent.

(v) Implementation of Integrated Water Resources Management

IWRM takes into consideration all the sectors of the human endeavor, land use and the environment. The benefits of integrating the various aspects of water resources management have been identified by many researchers, policy makers and water managers (Grigg 1996). According to Malano (1999) there are four major principles in IWRM and these are:

- Sectoral (and sub-sectoral) integration that takes into account competing and conflicts among various users.
- Geographical integration
- Economic, social and environmental integration that take into account of social, and environmental costs and benefits and
- Administrative integration that coordinates water resources planning and management responsibilities and activities at all levels of government.

Integrated Water Resources Management should be carried out from the local, national and regional levels. However, river basin and regional cooperation is a pre-requisite for successful implementation of IWRM.

(vi) Rainwater harvesting.

Rainwater harvesting is rainwater that is captured from the roofs of buildings on residential property. Harvested rainwater can be used for domestic and irrigation purposes. Rainwater harvesting is a technology used for collecting rainwater from rooftops, land surface or rock catchments and storing it using simple techniques such as jars and pots as well as more complex techniques such as underground storage tanks, small dams and large dams.

Rainwater harvesting is an intervention that enables development and human well-being without undermining ecosystem services. Rainwater harvesting is a local intervention that improves equity, gender balance and strengthens social capital in a community. It also regulates and supports the ecosystem by reducing soil erosion, improving groundwater and spring supplies and increasing diversity among flora and fauna. In urban areas, it reduces the pressure on surface and groundwater supplies (http://www.unep.org/Themes/Freshwater/PDF?Rainwater_Harvesting_090310b.pdf September 1, 2009). Rainwater harvesting in arid and semi-arid regions of Africa can be a source of water for domestic, livestock and irrigation and therefore, it can lead to increased crop production and thus food security. Therefore, this strategy should be implemented and is suitable to all African regions where precipitation falls.

(vii) Groundwater development

Groundwater development should be carried out in all African countries with favorable aquifers (especially in North Africa). The Nubian Sandstone Aquifer, which lies under the desert sand of Libya, Egypt, Chad and Sudan contains 120,000 km^3 of fossil water. Libya started utilizing this resource since 1991 (UNESCO 2002). This is going to be a great source of water for domestic and irrigation supplies in the future for North, Central and West African regions

3.5.4.4 Long-term Adaptation Measures

(i) Water resources development and inter-basin transfers

Africa has less than 5 % stored water potential hence the very low water security especially for food and energy security. This resultant low stored water poverty index for Africa is a strong, indicator that water resources are not fully developed to act as a catalyst and engine for development and social equity. Developed countries have generally a higher stored water per capita amount than developing countries. Thus, there is a need for Africa to develop water storage infrastructure to mitigate the impact of climate change, improve food and energy security to meet the MDGs and further advance the economic development agenda. It is unfortunate that as Africa is gearing towards water storage infrastructure development, more hindrances are on the pathway, which the developed countries did not have. It is however, very important to build dams following good principles such as some of those enshrined in the World Commission on Dams (WCD) report to ensure sustainability and directly contribute to poverty reduction.

(ii) Building desalination plants

The major challenge in Africa is the availability of fresh water resources. There is however an enormous amount of water in various forms such clouds, sea water, deep ground saline brackish water and wastewater. The cost of purifying the water to potable water is prohibitive. Desalination using solar energy could be a solution in those areas with access to the sea and the unquestionable availability of solar energy in Africa.

3.5.5 The Role of Water Infrastructure in Adaptation to Impacts of Climate Change

Available observational evidence as analyzed and summarized by the Intergovernmental Panel on Climate Change indicates that many human systems are sensitive to climate change and some are vulnerable. The human systems that are sensitive to climate change include mainly water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries), human settlements, energy, and industry; insurance and other financial services; and human health. The vulnerability of these systems varies with geographic location, time, and social, economic, and environmental conditions.

Projected adverse impacts based on models and other studies include:

(i) Decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics.

(ii) A widespread increase in the risk of flooding for many human settlements from both increased heavy precipitation events and sea-level rise.

Projected changes in climate extremes could have major consequences. The vulnerability of human societies and natural systems to climate extremes is demonstrated by the damage, hardship, and death caused by events such as droughts, floods, heat waves, avalanches, and windstorms. Some of these events are projected to increase in frequency and/or severity during the 21st Century due to changes in the mean and/or variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming. The impacts of future changes in climate extremes are expected to fall disproportionately on the poor.

Adrianne (2003) reported that the average GCMS forecast a 10 to 20 per cent drop in rainfall in Northwestern and Southern Africa by 2070 and river water levels are expected to drop below 50 per cent. According to Nyong (2005), every record has showed that climate change is happening,

as it has been observed in past records and established by predictive models. Nyong (2005) also reported that by the 2080s, climate change is expected to place an additional 80-120 million people at risk of hunger; 70 to 80 per cent of these are expected to be in Africa. Reuters (September 5, 2005) reported that about 50 million more people, most of them in Africa, could be at risk of hunger by 2050 due to climate change and reduced crop yields.

It has been pointed out earlier that the major function of water storage and distribution infrastructure is to change the temporal and spatial availability of water in order to make it available when and where ever needed. It has also been established that water is the major catalyst for economic development and plays a central role in human societies. Each body of water is a delicately balanced component of the landscape in a continuous interaction with the surrounding air and land. Therefore, water is intimately related to all man's activities in the landscape and whatever occurs on the land and in the air also affects water (Kindler 1992).

It has been explained earlier that adaptation strategies to the expected impacts of climate change and variability are: Rain water harvesting; efficient water use (water recycling and re-use); water transfers; groundwater development; IWRM; early warning systems, etc. It can also be viewed that, IWRM encompasses rain water harvesting, efficient water use, water transfers, groundwater development, etc.

IWRM has emerged from the perception that water is an integral part of the ecosystem, a natural resource, and a social and economic good (United Nations 1992). The definition of IWRM is the incorporation of the socio human factors, the economic issues and the ecological system, which means that, the society will continue to benefit from the utilization of the water resources while maintaining the environment and the resource base to meet the needs of the future generations. The four major principles in IWRM can be summarized as sectoral, geographical, socio-economic, environmental and administrative integration (Matondo 2002). The major issue here is the allocation of water among sectors, geographical areas (local, national, regional etc.), and the environment as a legitimate user of water. This is only possible through a good water storage and distribution infrastructure that is when there is a control on the flowing rivers. **In summary it can be stated here that the implementation of adaptation strategies to the expected impact of climate change and variability can not be implemented effectively without a good water infrastructures in any country** (storage by dams, groundwater development, desalination plants, conveyance systems, efficient water use, wastewater treatment and re-use, water transfers, etc.).

The current water storage per capita for Africa south of the Sahara is estimated at 543m^3/capita while that of the world is 963m^3/capita and the average for developed countries is 2700m^3/capita (see Table 4). Therefore, the water storage capacity (m^3/capita) for developed countries is five times that of sub-Saharan Africa. Berga (op. cit. 2010) contends that the stock of dams and thus the reservoir volume per capita that a country has, is closely linked to its socio-economic development, and that these infrastructures are essential for a country's development and for the alleviation of the impacts due to climate change.

Africa has the greatest number of rivers and surface water bodies that cross or form international boundaries (61 international river basins). However, the current water storage capacity is only 543 m^3/capita. Africa is endowed with water resources with only about 5 % taped hydropower potential and yet the continent is facing serious energy shortage. The currently planned hydroelectric dam at Inga in the Congo River, which will generate twice the power generating capacity of the current record holder, the Three Gorges Dam in China, is a move in the right direction (Wachter 2007).

Most rivers in Africa flow full during the summer or rainy months while most of them dry up during winter or dry season. Therefore, it is very difficulty to implement adaptation strategies to the impacts of climate change in Africa because most rivers are wild that is they are uncontrolled. Such river basins experience drought and flood related problems during drought and rainy years and the frequency of those is expected to increase under climate change.

Therefore each African country needs adequate infrastructures to regulate the flow of its rivers and create water storage to meet reasonable requirements for water of suitable quantity and quality for its population and economy on a sustainable manner. The water infrastructure is also needed for inter-basin transfers to move water from regions of excess to regions of scarcity.Artificial reservoirs play a major important role in semi-arid and arid regions where natural precipitation is erratic or is often only seasonal. The water is then stored only during wet periods while it would otherwise flow into oceans, and is therefore not available during dry periods.

There is a great need, therefore, to facilitate and support accelerated water infrastructure development in Africa in order to promote socio-economic development and thus be well prepared to deal with the expected impacts of climate change (droughts and floods). Such efforts will also facilitate the implementation of the adaptation strategies to the impacts of expected climate change. This is because most of the adaptation strategies that have been presented are hinged on water availability.

4 Summary and Conclusions

Africa has six climate types namely tropical rainforest climate near the equator and tropical savanna climate north and south of the tropical rain forest. The tropical savanna grades pole-ward in both hemispheres into a region of semiarid steppe. Narrow belts of Mediterranean type of climate are found in the northern and southern extremities of the continent.

Africa has 160 larger lakes and 61 international rivers shared by two or more countries. The largest basins are Congo, Nile, Zambezi, Niger and Volta. The rivers in Africa flow through several climatic regions before entering the oceans (Indian, and Atlantic Ocean) and the Mediterranean Sea and therefore, depict high flow variability at certain points. Groundwater is also another source of water for 75 % of the population of Africa (most of them in North Africa) (Elasha *et al*. 2006).

Historical record show a warming up of approximately 0.7^{o} C over most of Africa during the 20^{th} century, an increase of rainfall in east central Africa and a decrease over large portion of the Sahel region. Actually, mean rainfall decreased by 20 to 49 % in the Sahel region between the period 1931-1960 and 1968-1997 and generally 5-10 % across the rest of the continent. The continent has also experienced severe droughts and floods during the 20^{th} century. A decrease in the average discharge in most rivers in Africa has also been observed. The surface area of Lake Chad has decrease from 50,000 km^2 in 1963 to 5000 km^2 to date and has affected millions of people whose livelihoods depended on it.

The projected temperature increase due to anthropogenic activities across Africa rages from 2^{o} C to 5^{o} C for low and high climate change scenarios respectively, in the next 100 years. Studies using General Circulation models predict a decrease in rainfall ranging from 10-20 % and a decrease in runoff ranging from 10-40 % in major river basins in Africa. Studies using General Circulation Models (GCMs) forecast a 10 % rainfall and runoff increase for the Niger and Congo basins while the forecast for the Nile basin is a 10 % rainfall increase and no runoff change. The expected temperature increase under climate change is going to cause high evaporation rates.

Therefore it is anticipated that runoff in the above basins could be low. Low precipitation is going to affect groundwater recharge and therefore groundwater resource. The expected sea level rise is going to cause sea water intrusion and this will affect groundwater and surface water in coastal areas of Africa. Big cities along the coast of Africa are also vulnerable to expected sea level rise.

The economy of most African countries is driven by agriculture, which contributes about 50 % of the total export value. Agriculture is mostly rain-fed and subsistence in nature. There will be less rainfall in drier areas in Africa under climate change. Therefore agriculture in Africa is highly vulnerable to climate change and variability and knowing that 70 % of the population depends on farming, it is the poor that are going to be affected most. The expected low flow in rivers is going to affect hydropower generation and thus the economy of African countries.

The increase on pressure to the environment due population increase and climate change and variability effects will compound the problem of desertification. The areas that are now dry-humid, semiarid and arid will become semiarid, arid and desert respectively. People in drought prone areas will abandon agriculture and move to cities. The number of people depending on food aid will increase in the future. The continent has been ravaged by droughts and floods and the expected increase in frequency of these extreme events is going to have a negative effect on human beings, infrastructure and the environment. This will have a negative impact on the economy of African countries.

Adaptation strategies to climate change and variability are: efficient water use (at domestic and farm level), wastewater recycling, rainwater harvesting, ground water utilization, implementation of integrated water resources management (IWRM), water resources development and inter-basin transfers and construction of desalination plants. However, desalination is expensive and is only going to be possible to countries that have access to the sea and will be the last resort after exhausting all alternative sources of water.

Africa has the lowest reservoir volume per capita (m^3/capita) which is estimated to be 470 m^3/capita, compared to 2700 m^3/capita, for developed countries. African countries should embark on water infrastructure development while following closely the ICOLD environmental policy, which focuses on the safety, social and environmental aspects of dams. African countries should aim at balancing the need for the development of water infrastructure with the conservation of the environment in a sustainable way without compromising the future generations.

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Evaluation of Geoscience Education at African Universities

Thomas Schlüter

Abstract: Due to decades of political instability, periods of economic stagnation and reduction of life expectancy because of the AIDS epidemic, the geoscience education in Africa is currently in a crisis which has led to deficiencies in basic training of geology/geosciences graduates and postgraduates, and furthermore inequalities in teaching resources and research facilities, including staffing, fieldwork, library equipment and student attitude. This report presents in tabular form a short overview on the current situation of geoscience education of all African countries as indicated by the available websites of the respective universities, and as sometimes reported from other sources. Except for South Africa, where Earth science departments often rank quite highly in international databases, at the other end of the scale some smaller countries do not provide facilities at all for training and education in the geosciences (Cape Verde, Comoros, Djibouti, Equatorial Guinea, Gambia, Guinea Bissau, Sao Thomé & Principe, Seychelles). Countries like Morocco, Nigeria and Egypt have Earth science departments with few highly skilled people and are often poorly equipped. Civil wars have contributed to the deterioration of the Earth science departments in Burundi, Democratic Republic of Congo, Liberia, Rwanda, Sierra Leone and Somalia where rehabilitation appears to be extremely difficult.

Key words: Africa, Geoscience education, university ranking, university websites.

Zusammenfassung: Nach Jahrzehnten politischer Instabilität, ökonomischen Niedergangs und verminderter Lebenserwartung in Afrika ist auch die geowissenschaftliche Ausbildung an den Universitäten des Kontinents in eine ernste Krise geraten, die sich sowohl im graduierten wie auch im postgraduierten Bereich auswirkt. Das betrifft die menschlichen Ressourcen in der Lehre wie auch die Möglichkeiten hinsichtlich landesspezifischer Forschung. Probleme bezogen auf den akademischen Nachwuchs und die in der akademischen Ausbildung in den Geowissenschaften unumgängliche Feldarbeit sind fast überall an Afrikas Universitäten spürbar. Nicht zuletzt hat sich auch das Verhalten der Studenten seit der frühen postkolonialen Phase gewandelt. Der vorliegende Bericht fasst die gegenwärtige Situation geowissenschaftlicher Ausbildung an Afrikas Universitäten tabellarisch zusammen, sofern Informationen von websites oder anderen Quellen zur Verfügung standen. Mit Ausnahme von Südafrika, wo geowissenschaftliche Institutionen traditionell einen hohen Stellenwert im akademischen Sektor aufweisen und im internationalen Ranking bisweilen auch auf vorderen Plätzen zu finden sind, gibt es am anderen Ende einige afrikanische Länder, in denen zur Zeit überhaupt keine Möglichkeit für eine geowissenschaftliche Ausbildung mehr vorhanden ist (Kapverden, Komoren, Dschibuti, Äquatorial-Guinea, Gambia, Guinea-Bissau, Sao Thomé & Principe, Seschellen). Verschiedene Länder wie beispielsweise Marokko, Nigeria und Ägypten weisen zwar zahlreiche geowissenschaftliche akademische Ausbildungsstätten auf, oftmals fehlt es hier jedoch an Spitzenkräften und der Ausstattung. Bürgerkriege haben in den vergangenen Jahren früher häufig gut funktionierende geowissenschaftliche Institutionen in Burundi, der Demokratischen Republik Kongo, Liberia, Ruanda, Sierra Leone und Somalia zum Erliegen gebracht. Ihre Rehabilitation erscheint zur Zeit noch ausgesprochen schwierig.

Schlüsselwörter: Afrika, geowissenschaftliche Ausbildung, Universitäts-Ranking, Universitäts-websites

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Introduction

Africa is richly endowed with geological resources and ranks first or second in terms of concentration of world mineral reserves of bauxite, chromite, cobalt, coltan (columbite-tantalite), diamond, gold, manganese, phosphate rock, platinum-group metals (PGM), titanium minerals (rutile and ilmenite), vanadium, vermiculite and zirconium. Africa`s contribution to the world economy in the production of oil, coal and gas is also very significant (Fig. 2). In this context it is hardly surprising that the geosciences are attracting greater attention from policy-makers and government officials. Yet the geoscience education system in many African countries is unable to rise to this challenge. After decades of instability, including military coups, civil wars, periods of economic stagnation and drastically reduced life expectancy due to the AIDS epidemic (Fig. 1), there are yawning inequalities across the continent in terms of teaching resources and research facilities. This affects staffing, curriculum development, fieldwork and the quality of libraries, with the knock-on effect of low numbers of graduates who are in turn handicapped by insufficient expertise.

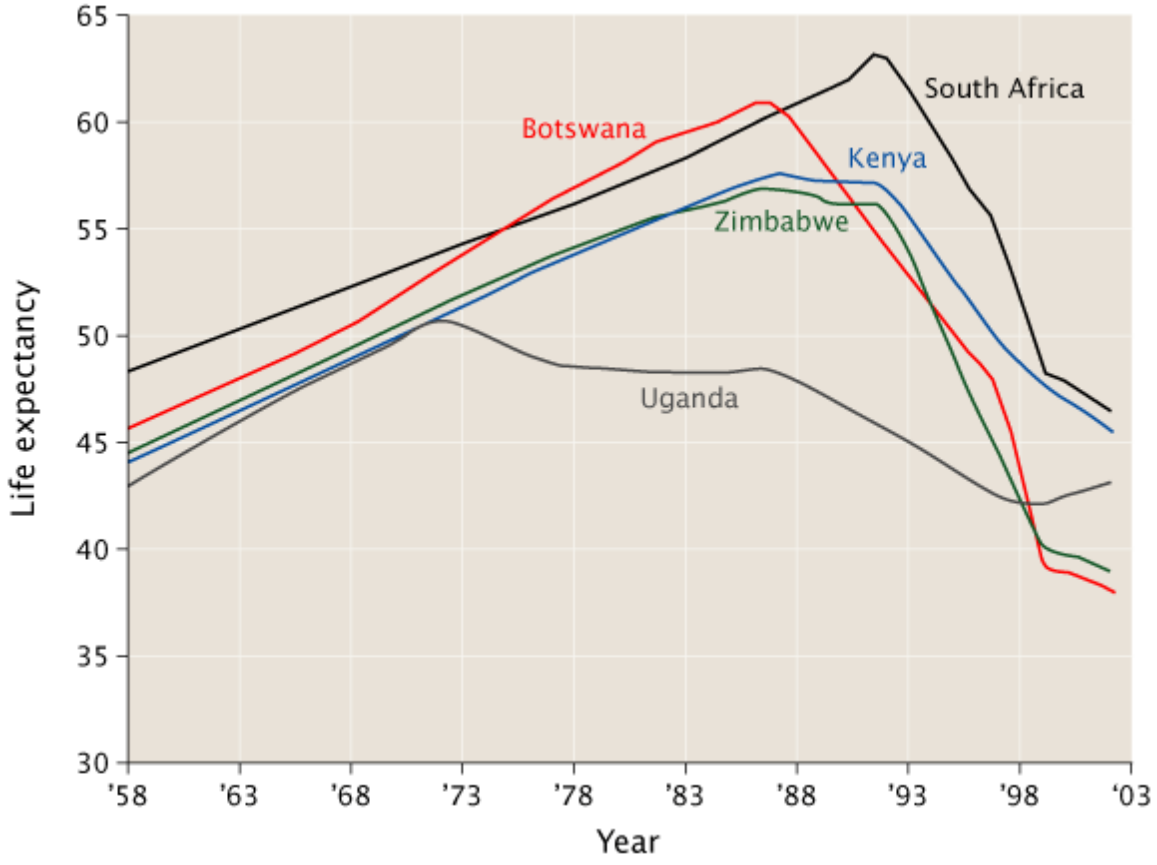

Fig. 1: Life expectancy in various African countries from 1958 to 2003. Note the sharp break around the mid 1980s to the early 1990s due to the AIDS epidemic. Since 2003 life expectancy is in most of these countries again steadily but slowly increasing. Source: UN data.

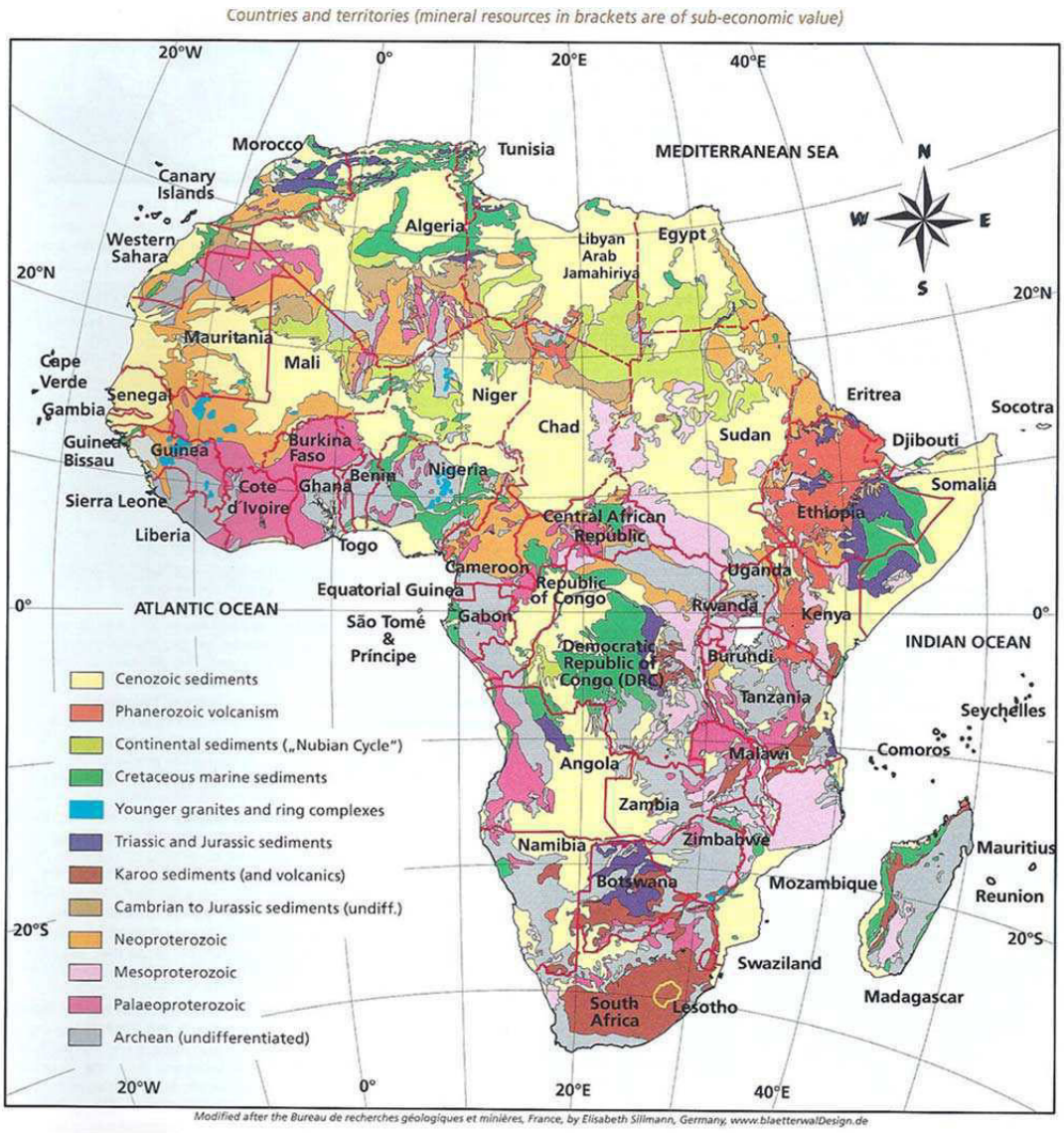

Fig. 2: Overview of the geology of African countries and territories (from Schlüter & Davies 2008). The following mineral resources are recorded: **Algeria:** Fe, Pb, Zn, Petr; **Angola:** D, Au, Ni, Cr, PGS, Fe, Mg, Cu, Ph; **Benin:** Au, Petr; **Botswana:** D, Cu, Ni, Au, PGS, Fe; **Burkina Faso:** Au, Ph; **Burundi:** Au, T; **Cameroon:** bx, Petr; **Democratic Republic of Congo (DRC):** Cu, Co, Zn, T, colt, Mg, D; **Republic of Congo:** Petr, Cu, Pb, Zn, Fe, Ph; **Egypt:** Petr, Ph; **Equatorial Guinea:** Petr; **Eritrea:** Au; **Ethiopia:** Au; **Gabon:** Petr, Mg, U; **Ghana:** Au, D, bx; **Guinea:** bx, D, Au, Fe, Ni, U; **Ivory Coast:** Au, D, Fe; **Kenya:** trona; **Lesotho:** D, U; **Liberia:** Fe, D; **Libya:** Petr; **Madagascar:** Cr, gas; **Malawi:** coal; **Mali:** Au; **Mauritania:** Fe, Cu, Ph; **Morocco:** Ph, Pb, Zn, Cu; **Mozambique:** Au, coal; **Namibia:** D, Au, Ag, Cu, Pb, Zn, Au, gem; **Niger:** U, Au, coal; **Nigeria:** Petr, Au, T, coal; **Rwanda:** T, colt, Au; **Senegal:** Au, Ph; **Sierra Leone:** bx, D, Au; **South Africa:** Au, PGS, D, coal, Fe, Mg, Cr, gem, U, Va, Pb, Zn, Ph; **Sudan and South Sudan:** Petr, gas; **Swaziland:** Fe, Au, D, coal; **Tanzania:** Au, D, gem, coal, gas, Ph; **Togo:** Ph; **Tunisia:** Ph, gas; **Uganda:** Au, Cu, Co, T; **Western Sahara:** Ph; **Zambia:** Cu, Co, Pb, T, Zn, coal, gem; **Zimbabwe:** Cr, Au, Ni, PGS, D, coal.

Abbreviations: Au: gold; Ag: silver; Pb: lead; Cu: copper; Co: cobalt; Zn: zinc; PGS: platinum group minerals; U: uranium; Fe: iron; Mg: manganese; Cr: chromium; Va: vanadium; Ni: nickel; Ph: phosphate; D: diamonds; colt: coltan; Petr: petroleum; bx: bauxite; coal: coal; gas: natural gas; gem: gemstones; trona: trona.

Methodology

This paper gives a survey on the current teaching and education facilities in the Earth sciences of all African countries. It is largely based on the original websites of those African universities where Geology/Geosciences and closely related disciplines (mostly in Geography or Environmental Sciences Departments) are currently taught (see Fig at the end of the text). The information from where and under which spelling to achieve these websites was obtained from various secondary website sources, among which Braintrack, Wikipedia, Commonwealth University Pathfinder, and the French Geosciences Guide for Africa (for all of them see the references) are the most important. However, it has to be noted that all of their inventories were incomplete and sometimes are giving totally wrong statements and information when emphasized only on the Geosciences.

But even my own research on Geoscience education in Africa as here presented is by far not yet completed and it may be possible to find sometimes hidden websites of the respective Departments of Geology/Geosciences, which I was not yet able to trace. It has also to be stated that the quality of the respectively quoted websites is often not very good. In many cases basic information on the subject itself is missing, not alone on substantial topics like course outlines, course descriptions, institutional and personnel capacities. The webmasters of the respective departments, faculties or universities appear sometimes not to be very professional, and much has still to be done in future. Unfortunately, in some cases a website of the respective department or even of its university was not at all available – this being a great professional failure, which needs immediate action and improvement!

Another source of information – largely in the historical context – was the "Directory of Geoscience Departments in Universities in Developing Countries", published already in 1983 by Tan & Kumar as a comprehensive booklet and then printed with financial assistance of UNESCO. Geoscience departments and their educational capabilities in Africa are there presented in a 17-page chapter, and it is obvious that many problems arising from missing communication between the universities and the two authors of this publication already existed at the same time (similarly as today). Apparently the development of Geoscience education has often taken rather different ways, leading in extreme cases either to a now flowering institution or in the worst case to an almost complete deterioration of the respective department – due to various reasons, but mostly because of civil wars and related events in the respective African countries.

A special issue of a previous volume of the renowned Journal of African Earth Sciences (1999, No. 28, 4) was devoted to "Earth Science Education in Africa", and comprises summarizing articles on the subject in the following countries: Botswana, Cameroon, Eritrea, Kenya, Morocco, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe. These published papers were the outcome of a workshop on Earth Science Education in Africa held as a part of the 17th Colloquium of African Geology in Harare, Zimbabwe, and some of their statements and conclusions are also here incorporated.

Some words on ranking: There are a number of different rankings of the world universities available in the internet, but due to my knowledge and investigations, there is only one dealing exclusively with Geology/Geosciences, but limited only to Geosciences Departments in Germany (M. Trauth, Potsdam, pers. Comm.) Quality assessment in Earth Science education – specifically for Africa – was, however, also discussed by Rollinson (1999), who argues that different definitions of quality will apply in different societal contexts in Africa, and that these may be used to shape the relevance of Geoscience education.

CONTINENT RANK	UNIVERSITY	COUNTRY	WORLD RANK
1	University of Cape Town	RSA	324
2	University of Pretoria	RSA	507
3	Stellenbosch University	RSA	540
4	University of the Witwatersrand	RSA	699
5	University of Kwazulu Natal	RSA	727
6	Rhodes University	RSA	1,083
7	University of the Western Cape	RSA	1,156
8	Cairo University	Egypt	1,219
9	University of South Africa	RSA	1,221
10	Makerere University	Uganda	1,256
11	American University in Cairo	Egypt	1,357
12	University of Johannesburg	RSA	1,395
13	Kwame Nkrumah University of Science & Technology	Ghana	1,559
14	Nelson Mandela Metropolitan University	RSA	1,586
15	Mansoura University	Egypt	1,716
16	Ain Shams University	Egypt	1,819
17	Université Cheikh Anta Diop de Dakar	Senegal	2,065
18	University of Khartoum	Sudan	2,112
19	North West University	RSA	2,123
20	Université Mentouri de Constantine	Algeria	2,142

Fig. 3: The 20 best universities of Africa, according to the ranking standards of webometrics. In 2013. Their respective place in world ranking of universities is also indicated. Note that 11 (including all from 1 to 7) are located in South Africa.

Very popular among the many available rankings are for instance those of 4INTERNATIONAL COLLEGES & UNIVERSITIES (below in Table 2 abbreviated as ICU), and the Webometrics Ranking of World Universities (abbreviated as W), which both give a ranking of the top 100 universities in Africa, but sometimes differ significantly in their results. However, it has to be noted that both directories do not indicate clearly their assessment and evaluation criteria. It appears that their ranking is merely based on the web popularity of the respective universities. This might be methodologically correct for a university as a whole and single unit, but has nothing to do with reality of certain disciplines.

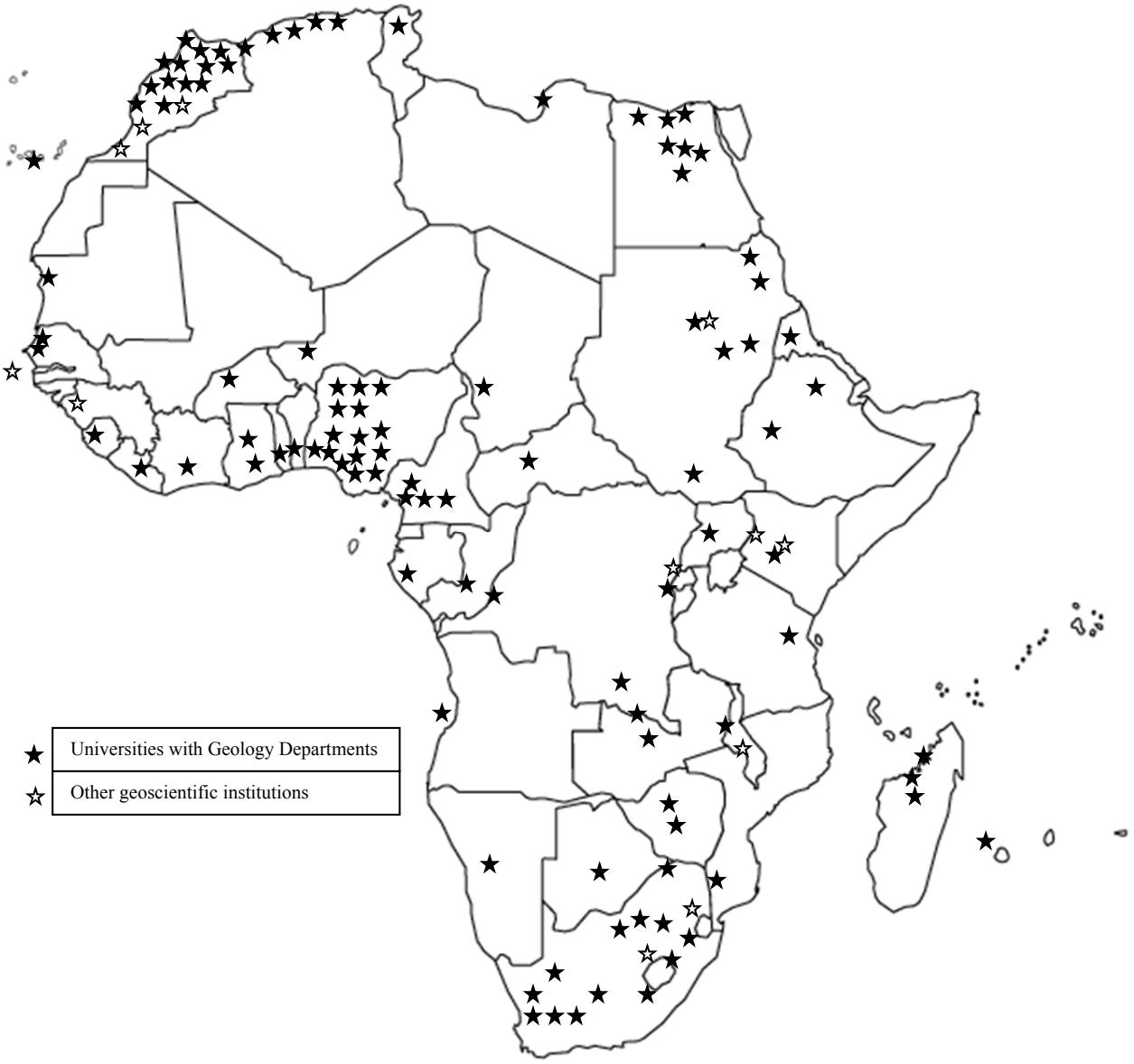

Fig. 4. Location of Geology/Geoscience departments and other geoscientific institutions of each African country as mentioned in the text and Tables 1 and 2 (after Schlüter, 2008).

However, the ranks of the respective universities have here been added as part of the departmental information, which of course may not always be applied for the respective department. Nevertheless, a general trend also applicable for the respective Geosciences/Geology Department is often recognizable. To achieve a true goal of ranking of Geology/Geosciences Departments and their programmes, however, some other, more

Table 1. The African nations and other territories in alphabetical order, their area size, approximate population (2012), number of universities and number of Geosciences departments of each country.

Country	Area Size	Population	Universities	Geosciences Departments
Algeria	2,381,741km^2	34,000,000	>10	5
Angola	1,246,700km^2	13,500,000	1	1
Benin	112,620km^2	8,000,000	1	1
Botswana	581,730km^2	2,000,000	1	1
Burkina Faso	274,200km^2	14,500,000	1	1
Burundi	27,830km^2	8,000,000	1	1
Cameroon	475440km^2	17000000	>12	5
Canary Islands	7,500km^2	2,050,000	1	1
Cape Verde	4,033km^2	500,000	1	0
C. African Rep	622,984km^2	5,000,000	1	1
Chad	1,284,000km^2	10,000,000	1	0
Comoros	2,033km^2	900,000	0	0
Congo D R	2,345,410km^2	65,000,000	2	2
Congo R	342,000km^2	4,400,000	1	1
Djibouti	23,200km^2	900,000	0	0
Egypt	997,739km^2	84,000,000	>20	7
Equat. Guinea	28,057km^2	700,000	0	0
Eritrea	121,320km^2	5,500,000	1	1
Ethiopia	1,127,127km^2	80,000,000	>12	2
Gabon	267,667km^2	2,000,000	2	1
The Gambia	11,300km^2	2,000,000	1	0
Ghana	238,540km^2	25,000,000	5	2
Guinea	245,857km^2	10,500,000	1	0
Guinea Bissau	36,125km^2	2,000,000	0	0
Ivory Coast	322,463km^2	19,000,000	2	1
Kenya	582,650km^2	38,000,000	>25	3
Lesotho	30,355km^2	2,900,000	1	0
Liberia	111,369km^2	3,500,000	2	1
Libya	1,759,540km^2	6,800,000	3	1
Madagascar	587,041km^2	21,000,000	3	3
Malawi	118,484km^2	12,000,000	2	2
Mali	1,241,232km^2	12,500,000	1	0
Mauritania	1,030,700km^2	3,800,000	1	1
Mauritius	2,040km^2	1,250,000	1	0
Morocco	458,730km^2	34,000,000	>20	16
Mozambique	801,590km^2	21,500,000	2	1
Namibia	824,292km^2	2,500,000	2	1
Niger	1,267,000km^2	13,000,000	1	1
Nigeria	923,768km^2	150,000,000	>22	15
Reunion	2,512km^2	800,000	1	1
Rwanda	26,338km^2	9,500,000	5	0
Sao Thomé & Pr.	1,001km^2	180,000	0	0
Senegal	196,722km^2	13,000,000	2	2

Seychelles	455km^2	100,000	0	0
Sierra Leone	71,740km^2	6,500,000	2	1
Somalia	637,657km^2	11,000,000	0	0
South Africa	1,219,000km^2	50,000,000	>20	14
Sudan, S Sudan	2,505,813km^2	40,000,000	>30	6
Swaziland	17,364km^2	1,200,000	1	1
Tanzania	945,087km^2	39,500,000	7	1
Togo	56,785km^2	6,300,000	1	1
Tunisia	163,610km^2	10,700,000	5	1
Uganda	236,040km^2	29,800,000	>20	1
Western Sahara	266,000km^2	350,000	0	0
Zambia	742,618km^2	12,200,000	2	2
Zimbabwe	390,757km^2	12,500,000	3	2

substantial criteria should be considered. The report here presented is therefore attempting togive a short overview on degrees obtainable in the respective departments, and summarizes with a „yes“ or „no“ if websites of the departments are available that give information on course outlines and institutional and personnel capacities. A short overview of the current Geoscience education and training opportunities of all African countries and territories is also presented in my book “Geological Atlas of Africa” (Schlüter 2008).

For some general information on each African country or territory the area size, approximate population size as known in 2012, approximate number of universities and the current ranking according to the above mentioned web institutions (ICU and W – see references) is also here included (Table 1).

A future evaluation should also consider the number of students, number of graduates, postgraduates and doctorates obtained in each geosciences department, and the number of publications that were published by its staff members, respectively, over a period of the last one or two years. All these criteria would probably contribute to a much better and more justified ranking of the respective geosciences departments.

Results

The results of this survey are shown in Table 1 and 2 below. Some additional details on course outlines, institutional and personal capacities are given by Schlüter (2010, unpublished).

Conclusions and Discussion

Africa has currently (2013) a population of slightly more than 1000 Million people, distributed over 54 countries and 6 other territories. Altogether there are about 115 university departments and other geoscientific institutions on the continent that offer undergraduate and often postgraduate courses in Geology/Geosciences, corresponding to roughly one Geology/Geosciences Department per about 10 Million people. The distribution of these departments is, however, quite uneven. Classic mining countries like South Africa yield for a population of about 50 million people at least 14 universities, where undergraduate and postgraduate courses in Geology/Geosciences are offered, whereas some of the smaller countries do not provide at all an education with geoscientific background (e.g. Comoros, Equatorial Guinea, Guinea-Bissau, Mauritius, Sâo Thomé & Principe, Seychelles). Traditionally, countries like Morocco, Nigeria and Egypt have quite a number of Geology/Geosciences Departments (at

least 16, 15 and 7, respectively), and it appears that many of these departments often are still well equipped with personnel capacities and human resources, but due to their lack of institutional capacities their efficiency in teaching and research is currently rather poor.

Table 2: Names and locations of geoscientific institutions in each African nation and territory in alphabetical order; ICU: Ranking according to „Top 100 Universities in Africa by Web Popularity"; W: „Webometrics Ranking of World Universities"; Degrees: B. Sc. Bachelor of Science; M. Sc. Master of Science; Lic. Licence; M Maitrise; DEUA Diplome Etudes Universitaires; DESS Diplome Etudes Superieurs Specialises; DEUG Diplome Etudes Universitaires Générales; WS: Website of the institution available (Yes) or not (No).

Country	Name of Institution and Location	ICU	W	Degrees	WS
Algeria	1. Univ. Abou Bekr Belkaid, Tlemcen	48	27	DEUA	Yes
	2. Univ. Batna, Batna	56	45	Lic., M.	Yes
	3. Univ. Houari Boumedienne, Alger	66	75	Ing.	Yes
	4. Univ. Mentouri, Constantine	59	36	Ing.	Yes
	5. Univ. Technologie, Oran	68	84	Lic.	No
Angola	1. Univ. Agostinho Neto, Luanda	0	0	Lic.	No
Benin	1. Univ. Abomey-Calavi, Cotonou	0	0	Lic.,M.,DESS	Yes
Botswana	1. Univ. Botswana, Gaborone	18	32	B.Sc., M.Sc.	Yes
Burkina Faso	1. Univ. Ouagadougou, Ouagadougou	37	27	Lic., M.	Yes
Burundi	1. Univ. Burundi, Bujumbura	0	0	Lic., M.	Yes
Cameroon	1. Univ. Bamenda, Bamenda	0	0	B.Sc.	No
	2. Univ. Buea, Buea	0	0	B.Sc., M.Sc.	No
	3. Univ. Dschang, Dschang	0	0	B.Sc., M.Sc.	Yes
	4. Univ. Douala, Douala	0	0	Lic.,M.	Yes
	5. Univ. Ngaoundere, Ngaoundere	0	0	Lic.	Yes
	6. Univ. Yaounde 1, Yaounde	0	0	B.Sc.,M.Sc.	No
Canary Islands	1. Univ. Las Palmas, Gran Canaria	0	0	B.Sc.,M.Sc.	Yes
Cape Verde	1. Univ. Jean Piaget, Praia	0	0	?	Yes
C. African R.	1. Univ. Bangui, Bangui	0	0	Lic.,M	Yes
Chad	1. Univ. N`Djamena, N`Djamena	0	0	Lic.,M.	Yes
Congo D. R.	1. Univ. Kinshasa, Kinshasa	0	0	Lic.,M?	Yes
	2. Univ. Lubumbashi, Lubumbashi	0	0	Lic.,M?	Yes
Congo, R.	1. Univ. Marien Ngouabi, Brazzaville	0	0	Lic.,M?	No
Egypt	1. Univ. Ain Shams, Cairo Abbasia	34	18	B.Sc.,M.Sc.	Yes
	2. Univ. Alexandria, Alexandria	20	0	B.Sc.,M.Sc.	Yes
	3. Univ. Cairo, Giza, Cairo	8	10	B.Sc.,M.Sc.	Yes
	4. Univ. Mansoura, Western Nile Delta	10	17	B.Sc.,M.Sc.	Yes
	5. Univ. Minia, Cairo South	63	0	B.Sc.,M.Sc.?	Yes
	6. Univ. Tanta, SE Alexandria	43	89	B.Sc.,M.Sc.	Yes
	7. Univ. Zagazig, Zagazig City	32	47	B.Sc.,M.Sc.	Yes
Eritrea	1. Univ. Asmara, Asmara	0	0	B.Sc.	Yes
Ethiopia	1. Univ. Addis Ababa, Addis Ababa	25	24	B.Sc.,M.Sc.	Yes
	2. Univ. Mekelle, Mekelle	0	0	B.Sc.	Yes
Gabon	1. Univ. Masuku, Franceville	0	0	Lic.,M.	No
Ghana	1. Univ. Ghana, Accra	17	39	B.Sc.,M.Sc.	No
	2. Univ. Mines & Technology, Tarkwa	0	0	B.Sc.,M.Sc.?	Yes
Ivory Coast	1. Univ. Cocody, Abidjan	0	0	Lic.,M.?	Yes
Kenya	1. Univ. Nairobi, Nairobi	16	26	B.Sc.,M.Sc.	Yes
	2. Univ. Jomo Kenyatta, Nairobi	55	80	B.Sc.,M.Sc.	No

	3. Univ. Moi, Eldoret	70	74	B.Sc.,M.Sc.	No
Lesotho	1. Univ. Lesotho, Roma	0	0	B.Sc.,M.Sc.?	Yes
Liberia	1. Univ. Liberia, Monrovia	0	0	B.Sc.,M.Sc.?	Yes
Libya	1. Univ. Garyounis, Benghazi	67	82	B.Sc.,M.Sc.	Yes
Madagascar	1. Univ. Antananarivo, Antananarivo	0	0	Lic.,M.	Yes
	2. Univ. Mahajanga, Mahajanga	0	0	Lic.,M.?	No
Malawi	1. Univ. Malawi, Zomba	92	65	B.Sc.	Yes
	2. Univ. Mzuzu, Mzuzu	0	0	?	No
Mauritania	1. Univ. Nouakchott	99	81	DEUG	Yes
Mauritius	1. Univ. Mauritius	0	0	B.Sc.Env.	Yes
Morocco	1. Ecole Nat. Industriie Minerale, Rabat	0	0	Ing.,M.	Yes
	2. Univ. Cadi Ayyad, Marrakech	15	20	Lic.,M.	No
	3. Univ. Chouaib Doukali, El Jadida	0	0	Lic.,M.	No
	4. Univ. Mohammed 1, Oujda	0	0	Lic.,M.	Yes
	5. Univ. Mohammed 5, Agdal, Rabat	82	73	Lic.,M.	No
	6. Univ. Hassan 2 Ain-Chock, Casablanca	80	0	Lic.,M.	No
	7. Univ. Sidi Mohammed ben Abdellah, Fes	90	0	Lic.,M.	No
	8. Univ. Moulay Ismail, Meknes	0	0	Lic.,M.	No
	9. Univ. Ibn Zohr, Agadir	94	0	Lic.,M.	No
	10. Univ. Ibn Tofail, Kenitra	0	96	Lic.,M.	No
	11. Univ. Abdelmalek Essaadi, Tetouan	0	0	Lic.,M.	No
	12. Univ. Hassan 2, Mohammedia	91	78	Lic.,M.	No
	13. Univ. Hassan 1, Settat	0	0	Lic.,M.	No
	14. School of Mines, Marrakech	0	0	Dipl.Appl.G.	No
	15. Cherifian Scientific Institute, Rabat	0	0	?	No
Mocambique	1. Univ. Eduardo Mondlane, Maputo	14	48	Lic.,Dipl.	Yes
Namibia	1. Univ. Namibia, Windhoek	52	29	B.Sc.,M.Sc.	Yes
Niger	1. Univ. Abdou Moumouni, Niamey	0	0	Lic.,M.?	Yes
Nigeria	1. Univ. Ahmadou Bello, Zaria, Kaduna	0	0	B.Sc.,M.Sc.	No
	2. Univ. Delta State, Abraka	0	0	B.Sc.,M.Sc.?	Yes
	3. Federal Univ. Technology, Minna	0	0	?	Yes
	4. Federal Univ. Technology, Yola	0	0	?	Yes
	5. Univ. Obafemi Awolowo, Ile Ife	35	61	B.Sc.,M.Sc.	Yes
	6. Univ. River States, Port Harcourt	0	0	Certificate	Yes
	7. Univ. Ado-Ekiti, Ekiti State	0	0	B.Sc.,M.Sc.	Yes
	8. Univ. Calabar, Calabar	0	0	B.Sc.,M.Sc.	Yes
	9. Univ. Ibadan, Ibadan	45	0	B.Sc.,M.Sc.	Yes
	10. Univ. Univ. Maiduguri, Maiduguri	0	0	B.Sc.,M.Sc.	Yes
	11. Univ. Nigeria, Nsukka	0	99	B.Sc.,M.Sc.	Yes
	12. Univ. Jos, Jos	0	66	B.Sc.,M.Sc.	Yes
	13. Univ. Ilorin, Ilorin	37	0	B.Sc.,M.Sc.	No
	14. Univ. Port Harcourt, Port Harcourt	0	0	B.Sc.,M.Sc.	No
	15. Univ. Lagos, Lagos	31	68	B.Sc.,M.Sc.	No
Reunion	1. Univ. La Reunion, Saint Denis	19	0	Lic.,M.	Yes
Rwanda	1. Nat. Univ. Rwanda, Butare	26	0	B.Sc.?	Yes
Senegal	1. Univ. Cheikh Anta Diop, Dakar	24	14	Lic.,M.	Yes
Sierra Leone	1. Univ. Sierra Leone Fourah Bay, Freetown	0	0	B.Sc.,M.Sc.?	Yes
South Africa	1. Univ. Nelson Mandela, Port Elizabeth	36	16	B.Sc.,M.Sc.	Yes
	2. Rhodes Univ., Grahamstown	7	6	B.Sc.,M.Sc.	Yes
	3. Stellenbosch Univ., Stellenbosch	3	2	B.Sc.,M.Sc.	Yes
	4. Tshwane Univ. Technology, Gauteng	57	69	B.Sc.,M.Sc.	Yes

	5. Univ. Cape Town, Cape Town	1	1	B.Sc.,M.Sc.	Yes
	6. Univ. Fort Hare, Fort Hare	0	72	B.Sc.,M.Sc.	Yes
	7. Univ. Free State, Bloemfontein	12	39	B.Sc.,M.Sc.	Yes
	8. Univ. Johannesburg, Johannesburg	13	9	B.Sc.,M.Sc.	Yes
	9. Univ. KwaZulu-Natal, Durban	6	5	B.Sc.,M.Sc.	No
	10. Univ. Limpopo, Sovenga	88	0	B.Sc.	Yes
	11. Univ. Pretoria (Tuks), Pretoria	2	3	B.Sc.,M.Sc.	Yes
	12. Univ. Western Cape, Belville	11	7	B.Sc.,M.Sc.	Yes
	13. Univ. Witwatersrand, Johannesburg	4	4	B.Sc.,M.Sc.	Yes
	14. Univ. Venda, Thohoyandou, Limpopo	100	0	B.Sc.,M.Sc.	Yes
Sudan	1. Univ. Africa, Khartoum	0	0	B.Sc.	No
	2. Univ. Dongola, Dongola	0	0	B.Sc.	No
	3. Univ. Khartoum, Khartoum	46	15	B.Sc.,M.Sc.	Yes
	4. Univ. Neelain, Khartoum	0	0	B.Sc.	No
	5. Univ. Red Sea, Port Sudan	0	0	B.Sc.	No
South Sudan	1. Univ. Juba, Juba	0	0	B.Sc,,M.Sc.?	No
Swaziland	1. Univ. Swaziland, Kwaluseni	0	0	B.Sc.,M.Sc.	Yes
Tanzania	1. Univ. Dar es Salaam, Dar es Salaam	22	22	B.Sc.,M.Sc.	Yes
Togo	1. Univ. Lome, Lome	0	0	Lic.,M.?	Yes
Tunisia	1. Univ. Carthago, Tunis	0	0	Lic.,M.?	No
Uganda	1. Makerere Univ., Kampala	30	13	B.Sc.,M.Sc.	Yes
Zambia	1. Univ. Zambia, Lusaka	23	0	B.Sc.,M.Sc.	No
	2. Copperbelt Univ., Kitwe	0	0	B.Sc.?	No
Zimbabwe	1. Africa Univ., Mutare	0	0	B.Sc.	No
	2. Univ. Zimbabwe, Harare	0	30	B.Sc.,M.Sc.	Yes

The AIDS epidemic has since the mid-1980s contributed especially in sub-Saharan Africa to the loss of an unknown but significant number of staff in the geoscientific academic institutions of the continent. How many potential students in the geosciences due to an infection with HIV/AIDS paid with their life is impossible even to estimate.

Civil wars have also contributed to the deterioration of many Geology/Geosciences Departments, for instance in Burundi, Rwanda, Liberia, Sierra Leone and Somalia (some of these were previously of high standard), and rehabilitation of their academic institutions is still in an initial phase. Only in some countries of southern Africa (South Africa, Botswana, Namibia) the current status of geological/geoscientific education appears to be sufficient for competition with other comparable institutions in the Developed World. Isolated examples of comparatively high standard geological/geoscientific education have also to be noted from East Africa (Kenya, Tanzania, Uganda, Mozambique and Ethiopia), and from the Maghreb States in North Africa (Algeria, Morocco and Tunisia), whereas the standard in most countries of West (except Ghana), Southwest and Central Africa is apparently rather low.

What generally can be concluded and should in future be discussed from the inventory shown in Tables 1 and 2 (see also Gaines et al., 2009)?

- There is an urgent need for a dedicated website of each Geoscience department in Africa, for publishing its programmes in graduate and postgraduate courses, thus outreaching the highest number of potential newcomers and customers.

- Well-designed websites can also contribute to the formation of regional or continental networks with the strong mandate of breaking the isolation of African Earth science researchers and stimulating collaborative and cross-disciplinary research.

- Some of the problems facing Geoscience education and research may be solved through such networks, for instance when these involve Africans in international research projects like IGCP.

- Other outreach activities in African Geoscience departments should raise the public profile of the Earth sciences and make them especially more attractive for the youth.

- There is a need for staff/researcher/technician exchange on a regional basis that may also be monitored via well-designed websites and email addresses of the respective Geoscience departments.

- In contrast to the past Geoscience education examples in Earth science-related courses should use African examples that are embedded in the regional context. In this regard the continent is richly endowed with huge geological heritage sites having a high pedagogical and outreach value.

- Also in this context African geoscientists should work towards the identification and promotion of geological heritage as an important pedagogical and outreach tool.

- Last, but not least – Geoscience education in Africa should also focus on developing Earth-related indigenous knowledge (research example: geophagia).

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The Role of African Languages in the Namibian Education System and their Potential for Edutainment

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Abstract: The concept of edutainment as a combination of education and entertainment is investigated in how far it could be utilised for development projects supporting basic education in sub-Saharan Africa. In particular, the then GTZ-funded *Upgrading African Languages* (AfriLa) project in Namibia was chosen as an example how the development of textbooks in African languages for literacy and numeracy in the lower primary phase in Namibia could integrate elements of edutainment in order to make learning part of an educative communication process. Elements of edutainment in textbooks will mainly be based on visual literacy, and thus, they are enriching the learning process through the medium of entertainment in order to achieve learning outcomes in a learner-centred way.

Key Words: Edutainment, African Languages (Namibia), Multilingualism, Mother-tongue education, Reading Culture, Learner-centred Education, Visual Literacy, Textbook Development

Zusammenfassung: Die Verbindung von Lernen und Unterhaltung steht hinter dem im angelsächsischen Raum verwendeten Begriff *Edutainment.* Das didaktische Potenzial einer solchen Verbindung wurde im Rahmen eines von der GTZ geförderten Grundbildungsprojekts in Namibia erprobt. Die Entwicklung von Lehrbüchern in afrikanischen Muttersprachen für die unteren Klassenstufen der Grundschule integrierte Elemente von *Edutainment*, um den Erwerb der Grundfertigkeiten im Lesen und Rechnen durch visuelle Mittel zu unterstützen. Lernen in der Muttersprache wurde dadurch zu einem kommunikativen Prozess, der nicht nur Schüler-zentriert ausgerichtet wurde, sondern auch visuell-semiotisches Lernen – „visual literacy – in die afrikanischen Muttersprachen integrierte.

Schlüsselwörter: Edutainment, afrikanische Sprachen (Namibia), Vielsprachigkeit, muttersprachliche Ausbildung, Lesekultur, Schüler-zentrierte Ausbildung, visuell-semiotisches Lernen.

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1 Framework

1.1 Education is Key to Development

After the first conference on *Education for All* in Jomtien in 1990 German technical and financial contributions to the development of primary education increased significantly. The motivation behind this increase can be summarised by James D. Wolfensohn: “All agree that the single most important key to development and to poverty alleviation is education.” In these few words Wolfensohn captures the numerous research findings which indicate a clear relationship between education, in particular primary education, and economic, social and cultural development.

Because of its key role in the fight against poverty, Primary Education became also one of the 8 international development Goals to be achieved by 2015. Consequently, it is an important reference for the German development policy.

1.2 Multilingualism is the Rule and not the Exception

Contrary to conventional wisdom monolingual nations worldwide are in the minority. 80%, the overwhelming majority of all nations are multilingual, including the United Kingdom, France, Spain, Germany and, to a lesser extent, Portugal – the former colonial powers in Africa. Multilingual societies are the norm. Monolingual societies are the exceptions. Universal Primary Education (UPE) takes place first and foremost in multilingual societies. Literacy and numeracy for all should, therefore, not be a privilege of monolingual societies.

1.3 Education is Communication

The World Education Forum, Dakar 2000, not only reconfirmed the key role of primary education but recognised the direct link between EFA and teaching in the mother tongue or in a language familiar to the child. This vital link can be found again in a communication from the EU Commission (2002) to the Council and the European Parliament on education and training and poverty: The language of learning (in particular the mother tongue) plays a key role in access to education and its quality. Both institutions recognise education as synonymous with communication as stated by UNESCO years ago: “Education is organised and sustained communication designed to bring about learning”.

Under the particular historical circumstances in many multilingual societies, Primary Education for All is first and foremost a question of introducing communication in the classroom. This means introducing or enhancing the teaching and learning of literacy, numeracy and life skills (sciences) as well as all other subjects in the respective language of these societies.

In this context it has to be stated that *introducing communication in the classroom* has a far more basic meaning than in the way it is used in this conference where the word EDUTAINMENT is meant as a combination of education and entertainment, and refers to entertainment that educates or *educative communication* that also entertains. However, I believe there are many areas where edutainment can be mutually utilised to improve the quality of education in the wider context of education and development.

At the end of my presentation I will touch on possible areas where synergy could be possible and try to give a few examples within the context of a basic education development project.

2 Background to the Upgrading African Languages Project (AfriLa)

In Namibia, the use of African languages in primary education is constrained by insufficient implementation guidelines, inadequate teaching methods, outdated teaching and learning materials and old-fashioned teacher training concepts. These deficits limit the effective use of the mother tongue in the teaching of school beginners in the Lower Primary phase. In order to improve mother tongue education and to strengthen the implementation of *The Language Policy for Schools in Namibia* (Ministry of Basic Education, Sports and Culture 2003), in particular for grades 1 to 4, the *Upgrading African Languages Project* (AfriLa) had been supporting the Ministry of Education (MoE) with the development and production of appropriate mother tongue teaching and learning materials for the subjects First Language (literacy), Mathematics (numeracy) and Environmental Studies from November 2000 until July 2007 as part of the GTZ supported Basic Education Programme (BEP) Namibia.

The target groups were mainly children of the formerly disadvantaged smaller language groups, in particular learners of the Rukwangali, Rumanyo, Thimbukushu and Silozi language areas of the Kavango and Caprivi Education Regions as well as the Otjiherero and Khoekhoegowab language groups found in the Kunene, Erongo, Otjozondjupa, Omaheke, Khomas, Hardap and Karas Education Regions. The intermediaries were the teachers at primary schools, and it was for them that the training measures in textbook development and mother tongue instruction were intended.

There were four intersecting major results for the AfriLa Project:

1. Basic principles and guidelines for the Language Policy are in place;
2. The promotion of African languages and multilingualism;
3. Teacher proficiency and competency in teaching African languages is improved;
4. A range of teaching materials for grades 1- 4 is available.

3 The Mother Tongue Materials Development Process

3.1 Historical Background

In Namibia as in many parts of Africa, the challenge is great for most children because they do not experience their languages in print and do not have such experiences with print at home before formal schooling begins. Many studies have been conducted into what leads to success in reading and writing, and one of the strongest contributing factors that leads to ease at learning to read and write is when children grow up in a *literate* and print-rich environment. However, they do have abundant oral language practices. They live in homes and communities where an oral culture prevails: oral language is used as people go about their daily activities and written language rarely if at all has any regular functional value. This factor impacts significantly on literacy learning and teaching. The reading culture in Namibian society with regard to young African language speaking children is essentially offered in a foreign language (English, German or Afrikaans) and does little to persuade young children that reading could be of any significance to their lives.

This context were described in detail by Marie Chatry-Komarek:

> For teachers and parents it is similarly crucial to be informed about the link between language, culture and education, as well as about the status of most African languages. (…) These languages have been systematically downgraded and they need to be valued by their own users in order to become effective languages of instruction. [73]

[73] See Marie Chatry-Komarek. *Literacy at Stake.* Windhoek: Gamsberg Macmillan 2003, pp. 43/44.

This indicates the importance of enabling a culture of reading and writing by providing role modelled behaviour, using videos and other interactive materials to assist people to build up conceptual understandings and insights inherent to literate behaviour. In this context supplementary reading materials were developed by the AfriLa Project aimed at creating a reading culture and a print-rich environment for all learners, but especially for the African languages.

One of the goals of the AfriLa Project is to enable children to be taught effectively in their mother tongues so that they become more successful learners. The task has been interpreted as one which acknowledges the link between the need to upgrade teacher training and have available appropriate teaching and learning materials for the lower primary classroom.

Education Officers for African Languages at the National Institute for Educational Development (NIED) described existing mother tongue learning materials as largely culturally inappropriate or irrelevant in Namibia, and linguistically and conceptually compromised. Their central message was that it is a fundamentally disempowering experience to have mother tongue materials that are *never more* than translations from English. This is a critical issue for materials in African languages throughout the continent.

It is important not to denigrate the practice of developing translations for multilingual situations as it continues to be essential in many ways. At the same time, for sustainable development, role players need to be included at all points in the textbook development process, from conception to production. The AfriLa approach acknowledged that African language speakers have to be empowered to produce learning materials and that a way for this to happen is through a *well-scaffolded mentoring process*. As all members of the Regional Languages Working Groups were well-trained Lower Primary teachers or Language Education Officers, but not specialists in textbook writing, an initial training in textbook development was conducted. This was a capacity-building process and a training programme for emerging authors with the assumption that each language group would produce its own literacy textbook.

3.2 Guiding Principles

When the materials were conceptualised, the following guiding principles were accepted:

- It is a fact beyond doubt that first encounters with written language are most powerful when these are ones that take place initially in the mother tongue and demonstrate to children the usefulness of print in the lives of people around them. Children develop phonic knowledge, they learn to recognize and decode words, and they develop hand-eye coordination and slowly come to form conventional writing and confident reading.
- Learner-centred education for literacy assumes the foundational principle of beginning with what the learners know and building on this, both at the level of adult and child education.
- Effective early literacy learning should be contextualised, culturally adequate, active and personally meaningful.
- We learn to read by reading and to write by writing thus the need to develop appropriate reading materials, such as supplementary readers that contribute to a literate and print-rich environment and support emergent, early, transitional and confident/conventional reading and writing in the Lower Primary phase.

A principle of *learner-centred education* is to build on what children already know and can do:

> [The] learner's prior knowledge and experience about the issue under study and their interpretations have to be considered. As learners we are more likely to make connections with what is at hand if we can relate it to our experiential and environmental framework. New learning is a process where previous knowledge interacts with the phenomena and ideas with which we come into contact. This also means that the contextual aspect of learning goes beyond the classroom and that the context has an impact on our learning.[74]

3.2 Visual Materials, Layout and Design Issues

Let's Read and Write in _____ is a set of literacy course books for the Lower Primary Phase offering young Namibian learners also a wide range of visual materials to reflect their own, a wider Namibian as well as an imaginary world of images through different media and styles. It was, therefore, decided to include illustrations by different illustrators.

For the *Go for Environmental Studies* and *Maths with the Boffins* course books photographic and computer generated visual materials were used in order to maximise on visual literacy development throughout the three core subjects in the Lower Primary phase supported by the AfriLa Project.

For the literacy course book it was, however, realised that there is in fact a debilitating shortage of skilled illustrators for children's materials in Namibia, and that while the cooperating publishing houses do the best that they can under the circumstances sometimes cannot meet visual needs and artistic standards. Moreover, similar to the situation that prevails in South Africa, most illustrators in Namibia are middle class and 'white'. As training of illustrators is a long term process a decision had to be taken to have material illustrated by carefully selected South African illustrators in order to have the greatest chance to maximise on this opportunity to invest in a visually appropriate book.

The Namibian publishing process also quickly becomes overstretched because of the paucity of skills in the area of design and layout. Ideally, the book would have been designed to at least some extent by the time the artwork was commissioned. The challenge was for the individual illustrators to approximate and imagine what space they had to use. This is difficult under 'normal' circumstances, but far more difficult when there are six languages involved, and the English (which the English speaking illustrators need to interpret into appropriate visuals) is the shortest text. As a consequence it has to be seriously stated that there is an urgent need for African language speakers to empower themselves in the children's literacy domain at the level of illustration and graphic design as well as writing in African languages. Only then will it be possible to have a reading culture that is sustainable and will flourish in the long run.

4 African Languages in Education and Edutainment

Up to now, I have concentrated on the scope of work and the objectives of the GTZ supported Basic Education Programme: *Upgrading African Languages* (AfriLa). I would now like to present a few ideas how Edutainment could be utilised for developmental goals within the

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[74] H. Pomuti. Learner-Centred Education and Democratic Teaching: Constructing Common Understanding of Learner Centred Education, in: Sguazzin, T and van Graan, M (eds.). *Education Reform and Innovation in Namibia: How Best can Changes in Classroom Practice be Implemented and Supported.* Proceedings from the 1998 NIED Educational Conference. 1998, p. 14.

education sector and how African languages can and should be used for Edutainment in various media forms as they are instrumental in basic education as well as in educating parents and communities with regard to developing a free and informed opinion and to achieving poverty alleviation through education.

Edutainment wants to educate and to entertain or to put it differently, edutainment wants to enlighten people through the medium of entertainment in order to achieve educationally motivated behavioural changes.

In Namibia, like in many other African countries African languages are the medium of communication in rural societies. Children are going to schools in rural areas where the official languages is often not understood by their parents and the communities at large.

In 2002, Namibia passed an *Education Act* that stipulated the establishment of School Boards which are seen as crucial for overall school development. Parents and communities are charged to play a vital role in the development and management of schools. It is not unsual that parents cannot converse in the official language at School Board meetings. The respective local language must then be used, but regulations concerning the running and the responsibilities of School Boards are mainly available only in English.

Matters to be handled by School Boards range from managing the School Development Fund, the appointment of teachers, disciplinary issues like misconduct of teachers (absenteeism, alcoholism, teenage pregnancies) and HIV and AIDS.

Edutainment in its various forms could be utilised to educate and further empower School Board members. Awareness campaigns could be conducted through newspaper cartoons (Popya), radio plays, theatre for development and TV plays all using the respective African language of the community. Namibia has radio and TV programmes in almost all 13 national languages and already a couple of community radio stations.

Further educational issues that could be transported through Edutainment are:

- the usefulness of Mother Tongue Education (MTE): awareness campaign for parents
- curriculum reform: focus on literacy, numeracy and life skills in the Lower Primary phase of basic education which is not fully understood by parents as they are often illiterate themselves
- adult literacy campaigns
- HIV and AIDS

Textbooks and supplementary readers like the ones produced by the AfriLa Project use various forms of illustrations in order to develop a comprehensive degree of visual literacy through picture stories, cartoons and fantasy. Edutainment should therefore be a vital part of learning as well as it is focussed on what the curriculum wants the learners to achieve, but also as part of the Arts as a subject which aims to promote the balanced growth, socialisation and development of the creative ability of a learner as well as cultural awareness and appreciation.

Comic books and multimedia communication initiatives like *Sara* produced for Southern and Eastern Africa by UNICEF in collaboration with Maskew Miller Longman should be further developed and made available in African languages as they are not only dealing with educational issues through the medium of entertainment but also as they are contributing to the creation of a literate environment.

The list could be prolonged, issues to be tackled through forms of Edutainment are plenty. I am convinced that Edutainment can effectively be utilised to address educational issues as long as there is dialogue between the practioners of Edutainment and Education Ministries. One should,

however, also assure that classroom learning and textbooks offer hidden forms of edutainment which will make learning delightful and at the same time learner-centred. Edutainment for Edutainment's sake will not work as too much is at stake in order to achieve education for all that is a prerequisite for a knowledge based society which is Namibia's vision for 2030.

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Broad Curriculum Framework for Skills Development: Tomorrow's Curriculum Today

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Abstract: Social and economic change in the 21st century is demanding totally different skills from learners in order to meet the challenges of a knowledge-based society. This will require a broad curriculum framework that is *future-oriented* as opposed to a curriculum that is still *past-oriented*. However, a true paradigm shift in curriculum has yet to happen for many school systems and especially in sub-Saharan Africa. Labour market changes are asking for school leavers with flexible enquiring minds and critical thinking skills capable of adapting to new demands and being able to continuously learn from own initiative. Tomorrow`s curriculum today therefore requires of the education systems in general and the curriculum in particular shifting emphasis from imparting knowledge to imparting learning competencies that would enable learners to cope with the rapidly changing world. Taking Swaziland as an example, the country will have to define its goals of education for the future an what kind of individual it wants to develop to meet the demands of the future. The broad curriculum will be the framework through which the national development strategies for shared growth and empowerment as outlined in Swaziland`s *Vision 2022* will be delivered.

Key Words: Knowledge-based Society, Curriculum Development, Skills Development, Labour Market Demands, Trainability, Swaziland, Core Skills, Basic Competencies, Lifelong Learning

Zusammenfassung: Die sozialen und ökonomischen Veränderungen des 21. Jahrhunderts verlangen von Schulabgängern neue Fähigkeiten und Fertigkeiten, um die Anforderungen einer auf Information basierenden Gesellschaft zu erfüllen. Schulische Rahmenpläne müssen daher zukunftsorientiert sein und dürfen nicht nur das Wissen der Vergangenheit reproduzieren. Ein derartiger Paradigmenwechsel hat aber in den meisten Bildungssystemen in Afrika noch nicht stattgefunden. Die Lehrpläne für die Zukunft sollten daher Schulabgänger für die Arbeitsplätze der Zukunft vorbereiten. Im Vordergrund steht dabei der eigenständige Umgang mit Wissen und dessen Anwendung, kritisches Denken und die Anpassung an neue Problemfelder. Das zukunftsorientierte Curriculum vermittelt daher nicht mehr nur reines Wissen, sondern Fähigkeiten und Fertigkeiten, die es dem Schulabgänger ermöglichen, sich auf die ständig verändernden Anforderungen der Zukunft einzustellen. Am Beispiel von Swaziland werden Bildungsziele mit übergeordneten Entwicklungszielen des Landes in Beziehung gesetzt.

Schlüsselwörter: Wissensorientierte Gesellschaft, schulische Rahmenpläne, Arbeitsmarktanforderungen, Bildungsziele, Swasiland

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Introduction

One also has to think beyond *education for all* and give equal attention to the area of learning and at the foundation of the teaching-learning process is the *curriculum*. But which curriculum? Our children and grandchildren will need to know totally different things and in totally different ways than we know today or as today's written curricula describe. There has been long-standing and widespread agreement that a transformation of education through curriculum as well as other means is needed in order to meet the demands of social change in the 21st century (Delors, 1998).

Practically all education systems are presently going through some kind of curriculum reform, even in the education systems where learners do relatively well in international or regional comparisons, and curriculum development has become a common feature of education and training sector improvement programmes. There are several obvious reasons why curriculum reform is at the core of education development programmes:

First, the information age has brought technology to schools and with these technologies people have access to all information they need faster and easier than ever before. Previous curricula that were based on covering essential knowledge are becoming outdated as present day learners need new skills in coping with the challenges of an information society. Many Ministries of Education have realised that the old fact-based curricula need to be replaced by new ones that emphasise better the development of thinking skills, interpersonal skills and creativity than simply mastering pieces of past knowledge to be assessed in centralised examinations.

Second, the restructuring of the world economic and political orders since 1989 called for new content and methods of schooling, among many other societal changes. The process of democratisation in many parts of the world and also in Africa, the expansion of market economies, and mobilisation of peoples and individuals have all raised questions of what learners should be taught in schools and what they should know and be able to do after they have attended school.

Finally, increasing evidence from empirical research on learning in schools and international comparison studies such as PISA or SAQMEC is showing that learners attain often much less in schools than is generally expected by the education authorities and the public at large. For example, when students' conceptual understanding of mathematical and scientific knowledge has been investigated, the findings often conclude that many students have serious misconceptions about the knowledge domain that has been taught by their teachers. In other words, students do not always learn what teachers expect them to learn but they create their own knowledge structures instead.

It is already over forty years since Alvin Toffler in *Future Shock* coined the phrase "Education in the Future Tense" and proposed a strategy of *futureness* as opposed to yesterday's curriculum today. Yet, formal education which should be the generator of new knowledge and new ways of knowing is still in a reactive rather than proactive mode in relation to social and economic change. Despite numerous revisions and modifications, the curricula of the early 21st century are in a transitional phase and still too similar to those of forty years ago in the face of tomorrow's challenges, and a true paradigm shift in curriculum has yet to happen.

Some of the key social and economic changes that represent new challenges to the curriculum are sets of contradictions. To name but a few: the impact of technology on the labour market heightens certain needs for education to prepare for work at the same time as increasing redundancy; the accelerating rate of change of knowledge and ways of knowing exist in a

contradictory relationship to the emergence of uniform standardisation of knowledge; scientific-technological monoculturalism contrasts to the recognition of cultural diversity. Although education is changing, there is nothing like the radical transformation one would expect to match the changes in society, especially if curricula are to be future-oriented:

> *Educational transformations are always the result and the symptom of the social transformations in terms of which they are to be explained. For a people to feel at any given moment the need to change its educational system, it is necessary that new ideas and needs have emerged for which the old system is no longer adequate.* (Durkheim, 1969)

Preparation for work in a knowledge-based society – and lifelong learning

The influence of changes in the labour market illustrates how labour market demands supercede idealistic or educational lobbies. During the nineteenth century, the spread of primary education was a hard-fought process. In Europe, liberal reformers and charity organisations took initiatives both to stop the exploitation of children and to spread primary education, and eventually labour acts banning or limiting children's work in industry and agriculture were passed after much controversy. However, it was not until the demand for child labour was reduced through improved mechanisation in industry and agriculture that primary education substantially increased in Europe.

As labour market demands for child labour dwindled in Europe through the twentieth century, the length of compulsory schooling increased accordingly, up to 16 years of age. In the early part of the century it was still possible for schools to give manual skills training which was marketable: school could to some extent prepare directly for work. As technological developments accelerated in the second half of the last century it became increasingly impossible for school curricula to include direct training for work, and by the end of the century a few systems had already extended the length of compulsory schooling to 18 years of age (Grade 12). Curricula were moving to a more general education rather than perpetuating a sharp division between the academic and vocational. The trends are continuing: more countries are moving to 12 years of schooling being made available to all and those already there to 12 years being compulsory for all. At the same time as technology develops more and more, opportunities for work in the traditional sense diminish, and schooling has to, and can only, develop *trainability* for ever-changing demands for new skills.

What does this mean in the context of Swaziland and how could *trainability* be made a key feature of a broad curriculum framework for skills development? According to the World Bank study on the *Education System in Swaziland*:

> a striking weakness in Swaziland's curricula is the dearth of blueprints that clearly link children's education experiences with the broader country development strategy and sector strategy, spell out the rationale, philosophy, objectives, scope, sequence, balance, vertical and horizontal articulation, pedagogy, assessment and the nature of outputs at each phase - lower, middle, higher primary, junior and senior secondary. Because curricula do not clearly characterize the nature of output from each phase in terms of the knowledge, skills and competencies to be acquired, it is very difficult to judge their effectiveness and relevance to higher levels of the system, national, global and labor market demands. (Marope, p.38)

However, Swaziland has a broad national development framework in the form of the PRSAP which should orient the conceptualization of a broad curriculum framework[75]:

> *In order to inculcate the culture of entrepreneurship among the young Swazi population, the system of education in all schools in the country will have to change. The focus of the school curriculum should be on skills development and business management rather than on white-collar jobs.* (PRSAP, Volume 2, p. 35)

As the World Bank study on the *Education System in Swaziland* further points out, "examples of PRSAP actions with direct curricula implications include growth acceleration, productivity growth especially in agriculture, social equity imperatives, efforts to re-attract FDIs and to promote science and technology" (Marope, p. 38). The box below is adapted from the World Bank study and gives examples of key changes in global labour markets and workplaces which are already evident in Swaziland:

Labour market and workplace changes already evident in Swaziland		
Labour market changes	Changes in the work place	Impact on individuals' lives
• Diminishing pure blue-collar jobs as they get replaced by automation • More skill intensive industries and jobs • Skill biased employment creation • Creation of unskilled and semi-skilled jobs dependent on the availability of highly skilled labour force • Shrinking job opportunities along expanding work opportunities • Occupational identities getting blurred • Life-long careers diminishing	• Flat structures • Small task groupings instead of specialized departments • Demand for a range of skills and not just credentials • Directly facing clients and handling human relations • Directly facing problems and designing solutions rather than routine tasks • Improvising fit-for-purpose and responding to diversity rather than mass production • Demand to learn on the job	• Transformation into knowledge worker • Uncertain job security and steady upward mobility • Multiple jobs at any one time • Multiple careers in a life time • Coping with rapid change and uncertainty • Work-study mismatch and constant need for up-skilling and re-tooling • Blurred professional identity • Precarious income • Varying networks instead of single employer

The changes in the labour market and at the workplace summarised above demand a range of skills exemplified in the box below, most of which are not well covered in the current school curricula in Swaziland, and should therefore be outlined as core skills and basic competencies in a broad curriculum framework:

[75] A generic model with common elements for the design and structure of a broad curriculum framework is presented for discussion in **Annex 1**. The model is adapted from Module 3: Curriculum Design. *Curriculum Developers Resource Pack*. IBE UNESCO. (www.ibe.unesco.org).

Core Skills	Basic Competencies
Learning to learn	*Setting goals, solving problems, evaluating and reflecting on completed processes; working effectively, independently and in groups; increasingly taking responsibility for their own learning and work*
Personal skills	*Make informed choices, decisions and judgements; evaluate beliefs and opinions; take initiative, act creatively, produce, innovate, self management, time management etc.*
Social skills	*show respect, tolerance, trustworthiness, honesty; co-operate and team work, accept encouragement and positive criticism, show appreciation, adaptability to heterogeneous groups, etc.*
Cognitive skills	*explore, investigate, enquire, recognise, contextualize, hypothesize, interpret, weigh up alternatives, analyse, synthesize, evaluate, think critically, think creatively, create knowledge etc.*
Communication skills	*talk fluently, write, elicit, explain, discuss, convince, demonstrate, present, act out, dramatize, draw, show, display, report; be clear, concise, expressive, meaningful, etc.*
Numeracy skills	*estimate, approximate, measure, calculate, tabulate, draw graphs, charts, diagrammes, shapes, figures; use instruments; be accurate, logical, solve problems, present information; use mathematical language, etc.*
Information and Communication Technology skills	*choose appropriate communication solutions; utilise hardware and software; evaluate information; transform information to knowledge; follow ethical practice; interact considerately; communicate clearly, etc.*

The constituency arguing for education first and foremost as preparation for the labour market is pushing towards the need for higher-level thinking skills to be developed, developing so-called good problem solvers (OECD 2004a; OECD 2004b) and the pressure on the curriculum is particularly increasing in mathematics, science and technology to adequately prepare learners to function well in a knowledge-based society. Thus, the goal for education and training is to provide for a strong general education base in science and technology, a flexible delivery of a flexible curriculum, combined with new teaching methodologies. A knowledge-based society is asking for school leavers with flexible enquiring minds and critical thinking skills, capable of adapting to new situations and demands and continuously learning from own initiative. This new situation requires of the education systems in general and the curriculum in particular to shift the emphasis from imparting knowledge in the form of large quantities of information to imparting learning competencies that would enable learners to cope with and take advantage of the rapidly changing world.

This paradigm shift is linked to emerging trends in education which have a particular relevance for the broad curriculum framework and can be presented as follows:

From	To
Teaching	Learning
Transfer of facts	Learners are constructing knowledge
Memorisations of information	Analysis, synthesis, evaluation, application of information
Concentration on acquisition of knowledge	Concentration on development of knowledge, skills, values and attitudes
Rote learning	Applied learning and learning in context
Categorised knowledge (traditional subject)	Integrated knowledge (broader learning areas such as Languages, Mathematics, Natural Sciences, Social Sciences, Technology, Commerce, Creative Arts, Ethics and Religious Education, Physical Education)
Schooling	Lifelong learning
Focus on inputs	Focus on outcomes and processes
Didactic teaching	Participatory activity-centred approaches and interactive methodology
Assumption that there is one "learning style"	Recognition that there are "preferred learning styles"

However, this shift towards skills development does not necessarily mean permanent employment or the elimination of unemployment. As technological development increases and takes over more and more functions it will bring increasing leisure time. The work ethic by which an individual has judged their worth, including their self-esteem (the personal problems associated with being unemployed), no longer applies in affluent societies where there is not enough work in the conventional sense. One can no longer delineate a life in career terms of the time one is employed and the time one is unemployed, or retired. Even the term leisure as the opposite of work becomes redundant. A life needs to be delineated in different terms if it is to have new meaning. The work ethic will no longer be a valid justification of curriculum goals and aims, or of working methods in the classroom, or of work at all.

The challenge ahead for schooling in technologically developed countries is to prepare young people not primarily for work, but to use time creatively, because they have time as never before. Being able and ready to work will remain part of this, but will no longer be a main justification for education. In developing countries, on the other hand, education will primarily have to prepare for work in the conventional sense for some time to come since they will be performing outsourced lower-tech jobs, but must also include preparation for high-tech since that is also the global demand. The technology divide between and within countries has long been identified, and in developing countries is widening between the elite and the majority.

Supranational stakeholders and movement towards standardisation

It is the modern sector constituency which is a main driving force in formal education, and has been at least since the Sputnik and Apollo space missions. What is new is that from national governments being endogenous generators of change, the modern sector constituency has become an exogenous generator of change through supra-national bodies such as the OECD or SADC. PISA or SAQMEC are becoming a powerful instrument in the standardization of curricula even though that is not their declared aim. PISA results hit national headlines and unsatisfactory results are taken almost as national disasters even by countries that do quite well. Country after country declares that it will develop the best educational system in the world, the most competitive, and will score better on PISA results. Such results are being appropriated politically in a way which the scope and nature of PISA, TIMSS or other such assessments obviously do not give reasonable grounds for, but the political rhetoric corresponds to OECD politics and its priorities of science, technology and market liberalism. It is very revealing, for example, that issues of identity, awareness, aesthetic knowing, and positive values (reflected in literature, social sciences and arts) are not part of the OECD PISA or TIMSS. Nor does PISA interest itself in how well a system looks after the weakest, but at most, relative performance between the middle and higher achievers. The increasing standardisation of different national educational systems leading to mutual automatic recognition of school and post-school certification will however produce the mobile labour force envisaged for the modern sector, including those who are willing to do service-industry jobs which other more educated people are less willing to do.

Uniformity and diversity

With increased globalisation, the dilemma of uniformity and diversity has to be re-addressed. Historically speaking, uniformity is not new: the trivium and quadrivium[76] were an international curriculum in their time, but for an elite culture that considered itself homogenous. Much later, universal formal education has always had to confront the dilemma of uniformity and diversity even when pretending that it does not exist. PISA, TIMSS, SACMEQ in Africa, and other similar assessments, are not the only influences driving national curricula towards uniformity. The change of examinations in Africa from British, French and Portuguese to more diversified national examinations is now entering a second phase, where in order to measure oneself against global standards, mutual recognition of standards in the various co-operation regions is bringing back greater uniformity. This is having a backwash effect on curriculum content through generic textbooks developed by often European publishers, with illustrations and some examples adapted for each country. The inherent contradiction in this is of course that curricula should help build identity, but modern identity is multi-layered and complex: a lack of recognition of diversity is a major source of or factor in conflict.

National curricula which previously went into great detail of prescriptive content are becoming more open frameworks. In Europe, competencies, outcomes or standards are described and content is left to the next level be it regional, canton, district or school, depending on the country. The most recent trend in Scandinavia is not so much to write the curriculum for the teacher, but to develop a framework from which the school itself develops the curriculum. In Belgium, central authorities only negotiate common national outcomes from which the cantons develop their curricula. Schools and teachers would appear to be given more say in curriculum.

[76] In medieval universities, the **trivium** comprised the three subjects that were taught first: grammar, logic, and rhetoric. The word is a Latin term meaning "the three ways" or "the three roads" forming the foundation of a medieval liberal arts education. This study was preparatory for the quadrivium. The quadrivium includes geometry, arithmetic, astronomy, music. Combining the trivium and quadrivium results in the seven liberal arts of classical study.

However, this apparent opening up to locally-developed curricula stands in contrast to the pressures not only for content giving national identity (however that is defined) but also supra-national content from the backwash effect of assessments and political agreements.

Knowledge explosion and knowledge implosion

Another social change which ought to be impacting on curriculum is change in knowledge, not only the knowledge explosion, but also the changing nature of knowledge, new ways of knowing, and the acceleration of those changes. Uncertainties are growing about what knowledge and what ways of knowing are relevant. There are changes in the selection of content but as yet little evidence of work done in ways of knowing. In curricula, knowledge is imploding into competencies, skills or standards rather than a *micropaedia* of content, but it is still being classified in terms of a collection code with subject boundaries rather than an integration code (Bernstein, 1971). Some of these classifications have existed for centuries such as Language, Mathematics, and Natural Science. Others have emerged later such as History, Geography, Arts. There are some variations in the classifications today which reflect a hesitant beginning of integrative paradigms such as Language Arts; Social Studies; Natural Science, Technology and Environment; Orientation Studies; Craft, Design and Technology. But no national curriculum has as yet made a major paradigm shift in the existing academically-anchored classification of knowledge: vested power knowledge relations still dominate and these need to be analysed if a paradigm shift is to take place.

In the words of Nahas Angula, Hon. Prime Minister of the Republic of Namibia, this dilemma can also be observed with regard to the disregard towards African traditional knowledge systems:

> Africa's underdevelopment can partly be attributed to the fact that current paradigms of socio-economic development have totally ignored African knowledge systems. The current approach to the African development challenge is like climbing a tree from its branches. Such an approach has no organic roots in the culture and knowledge system of the African people. The people have therefore found it difficult to take ownership of this development process. As we all know development cannot come from outside. Development must come from within. Self-development is the only lasting development. Such development should start from the African knowledge systems. The challenge of African development is how to build bridges between African knowledge systems and the Western knowledge systems. In other words, we must start the development process by recognizing the importance of how our people mastered the environment in order to sustain themselves. We should then proceed with the programme of integrating our traditional knowledge systems into modern knowledge systems. This will enable our people to appreciate the strength and shortcomings of their traditional knowledge. Learning starts from what people already know to what they need to know in order to solve their problems.

Social change – curriculum change?

None of the above are new points: they have been made both separately and together many times over the last thirty to forty years. They, and many other issues not touched on here, all point towards the need for paradigm shift in epistemology, curriculum and learning and teaching. The theoretical underpinnings are accessible from various disciplines, i.a. learning theory, cognitive

psychology, and research into intelligences. A paradigm shift is occurring in practical teaching and learning, based on somewhat loosely connected ideas about what constructivism is (sometimes merely using the term as a label). A transformative paradigm shift in epistemology, classification and framing in curriculum has yet to take place. If teaching and learning is to be based on social constructivism, where is the critique of the way categories of knowledge are currently constructed in the curriculum? If understanding how things are interconnected in reality is what is needed for the future, where is the integrated curriculum, rather than themes struggling to integrate subjects? If it is the competencies currently grouped under subject headings that are important, what are they for if not to understand and shape ourselves in a reality which is not divided into subjects? The question that arises is why, when it is evident and there is widespread consensus that such a transformation is needed and the intellectual tools are available for the job, does it not happen as needed?

First, curricula in times of social change are at the fault lines of system transformation and system reproduction, where the tectonic plates of state and private provision, religious and idealist, purist and eclectic, elitist and mass education, break through today's surface of changing knowledge, uniformity and diversity and so on. Curricula have to find a new form: until now too radical a departure from what has been before, or insufficient change, have both rendered an educational system dysfunctional. Transformation in education has thus not always been rapid and disjunctive although it might go through such phases in special cases such as the cultural revolution in China. In general it has been closer to what Dalin calls systemic process change, which takes time (Dalin, 1978; Smith, 1989).

Giddens' concept of *structuration* and Archer's studies of morphogenesis in the emergence of educational systems in Europe are useful tools for analysis at the macro-level (Archer, 1984; 1985; Clark et al., 1990). Giddens describes *structuration* as the conditions governing system reproduction. A system is structured by the way the rules (overt and covert) and resources are organised, and is reproduced through the capability of agents to interact in the system. It is the system which has to transform itself. We can infer from this that for a system to be transformed, the rules, organisation of resources and interactions all have to change. If not, the former system will be at least partially reproduced in the process of transformation. The question thus is, "What changes need to be made to system rules and resources for the necessary curriculum transformation for tomorrow's curriculum today?"

Curriculum is at the heart of an educational system: how the system is intended to be structured, organised, managed and resourced is derived from the curriculum. The resources around and within a curriculum include knowledge, time, space, and human, material and financial resources, and it is the degree of structural change in how these resources are accessed, organised and used that will indicate to what extent the curriculum and education system are being transformed or reproduced. The question then arises of how and what is changed or conserved of the overt and covert system rules governing resources. If the curriculum is changed but the *structuration* of the system remains, transformation will not ensue, only revision. We will have yesterday's curriculum in today's, or at best today's curriculum with an ever shortening shelf-life.

A curriculum reflects the power-knowledge relations of the constituencies who were involved in the discussions around and in the curriculum development process. This is where the collection code of curricula has tended to be conservative rather than transformatory, since academic hierarchies have vested interests in their own subject areas, and all too often where academic expertise is innovative, political conservatism limits its scope. A paradigm shift would either presuppose or involve a shift in power-knowledge relations. Moves to include a much wider base of stakeholders by devolving curriculum development to school and community level ought to lead to a totally different type of curriculum, but as a national curriculum has not done so yet. It

remains to be seen to what extent the democratisation of access to information will change the monopoly of school and impact on the way curricula describe the organisation of knowledge. It is also worth noting that in several African countries, attempts are finally being made to combine community and school learning and Europe will have something to learn from that.

An additional perspective on the inflexibility of educational change can be given by applying Bourdieu's concept of cultural reproduction (Bourdieu, 1991). We inherit and embody our cultural habitus, a continuity of the past into the present, and as we interact we draw on the cultural capital which we have accumulated. Applied to curriculum, those who are empowered will tend to draw on the existing cultural capital of formal schooling and conserve and reproduce it through the curriculum. The crisis of education now is that new and different forms of cultural capital are needed to meet the social changes which confront us, not least given the growing influence of supranational constituencies such as the OECD.

The transformation of the classification of knowledge is bounded by *structuration*, the persistence of existing power-knowledge relationships, and cultural habitus. If we follow Bernstein's analysis, the transformation of the framing of knowledge is dependent to some extent on the curriculum but to a greater degree on the teacher. Although it is true that creative teachers can teach a conventional curriculum in unconventional ways to make learning relevant and meaningful (if they are allowed to), teachers generally are not sufficiently empowered to do so, and the transformation of the framing of knowledge is also constrained. Once again, mechanisms of cultural reproduction from the school culture or the teacher's pedagogical habitus lead to conservation rather than transformation. With the challenges that lie ahead, we should expect to see both new classification and new framing in curricula and teaching.

Implications

To sum up: the implication of the social and economic changes taking place is that a completely new type of curriculum is needed, founded on a deep paradigm shift. The social changes are so far-reaching that one would hardly expect to see the same classifications of knowledge, nor the same framing, as before. There needs to be a new epistemology, new classification, new framing and new discourse. In order to understand some of the obstacles to achieving this, insight into the processes of *structuration* and how power-knowledge relationships and cultural reproduction operate, can inform strategies for change of the nature and on the scale which is needed to meet the new challenges. There is not likely to be one global answer. As Fullan puts it: "Theories of pedagogy and theories of change must be integrated again and again in each action setting." (Fullan, 2001)

What sort of education makes it possible to keep the vast majority of humanity in inhumane living conditions, or to exterminate the whole earth in a few minutes? Whose education is that? What power-knowledge relations does that reflect? What reproduction of which pedagogical culture makes that possible? In what ways is it being reproduced in new transformations of the curriculum? Either policy makers, curriculum developers and teachers are complicit in creating the educational preconditions for this situation, or are indifferent to it, or it is a truly unintended consequence of policy, curriculum and teaching. In any case, the extremities of social change which education has made possible should cause us to reflect and act on unresolved, and ultimately fatal, system contradictions.

That such a transformation is also a moral imperative ought to be obvious. It is a widely held belief that education is a key influence in creating the sort of person that a society wants to see, and education is therefore a powerful influence in shaping society. Like any other nation, Swaziland has to define its goal and aims of education and what kind of individual it wants to

develop, and the broad curriculum will be the framework through which the national development strategies for shared growth and empowerment as outlined in the PRSAP and Swaziland's *Vision 2022* will be delivered.

These goals should include providing a foundation in a strong general education in literacy, numeracy, science and technology, generic competencies, and values. Transforming education through curriculum should therefore aim to develop an individual with a flexible, enquiring mind, critical thinking skills, the capacity to adapt to new situations and demands, and to learn continuously on one's own initiative. It should develop individual understanding, creativity, the ability to construct alternative solutions to problems, and to make independent, informed and responsible decisions in real-life situations.

We need tomorrow's curriculum today - or there will be no tomorrow for our grandchildren.

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Table 4: The Structure of a Curriculum Framework

Toffler, A. (1970). Future Shock. London: Random House. **Common Elements of a Curriculum Framework**	
Element	**Function or Purpose**
1. Introduction: Current Context ***EDUCATIONAL PHILOSOPHY as a reflection of national policies and development priorities***	describes the social and economic environment in which educational policy is made and in which teaching and learning occur
2. Educational Policy Statements ***EDUCATIONAL GOALS are the outcomes to be achieved by learners and connecting development needs to education***	describes the Government's goals for education, such as universal literacy and numeracy, the development of skills needed for economic prosperity and the creation of a stable and tolerant society
3. Statement of Broad Learning Objectives and Outcomes / standards for each level / cycle ***CURRICULUM OBJECTIVES specify the performance standards for the learners for whom the curriculum is designed***	describes what students should know and be able to do when they complete their school education. Outcomes should be expressed in a range of domains, including knowledge, understanding, skills and competencies, values and attitudes
4. Structure of the Education System	describes the school system within which the curriculum framework is to be applied. It should specify: • Number of years of schooling, including compulsory schooling • Stages (or cycles) of schooling and their durations • Number of weeks in the school years, hours / teaching periods in the school week
5. Structure of curriculum content, learning areas and subjects.	describes the organization of content within the framework and the extent to which schools and students can make choices. It might describe: • The pattern of Subjects or Learning Areas to be studied in each stage or cycle (such as core, elective and optional subjects) • A brief description of each Subject or Learning Area outlining the rationale for its inclusion in the curriculum and the contribution it makes to the achievement of the Learning Outcomes defined in Section 3. • The number of hours to be assigned to each subject or Learning Area in each stage or cycle.
6. Standards of resources required for implementation	describes standards as they apply to: • Teachers – qualifications, teaching load (number of classes per week) • Students – number per class in each subject • Materials – textbooks, computers, other equipment; facilities – classrooms, furniture, fittings.
7. Teaching methodology	describes the range of teaching approaches that might be employed in the implementation of the framework
8. Assessing and reporting student achievement	describes • the importance of assessing the extent to which students achieve the outcomes of each subject, and recommends or prescribes types of assessment strategies • how achievement will be certified