

Cooperation over Freshwater Resources in Africa

Work (very much) in Progress

Jillian Stallman

ENRE

April 24, 2024

Drought Pushes Millions Into ‘Acute Hunger’ in Southern Africa

The disaster, intensified by El Niño, is devastating communities across several countries, killing crops and livestock and sending food prices soaring.



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75



A farmer in Zimbabwe last month. Several countries have declared national emergencies. Tsvangirayi Mukwazhi/Associated Press



By [Somini Sengupta](#) and [Manuela Andreoni](#)

April 18, 2024

/ UTRIKES



En pappa hjälper sin undernärda son att gå. Bilden är tagen i Kenya där torka, vattenbrist och undernäring har blivit en dödlig kombination för många barn. Nu varnar Unicef att undernäring och vattenbrist riskerar miljoner barns liv på Afrikas horn. Foto: Brian Inganga/AP/TT

Antalet drabbade av torka på Afrikas horn nästan fördubblat

UPPDATERAD 23 AUGUSTI 2022 PUBLICERAD 23 AUGUSTI 2022

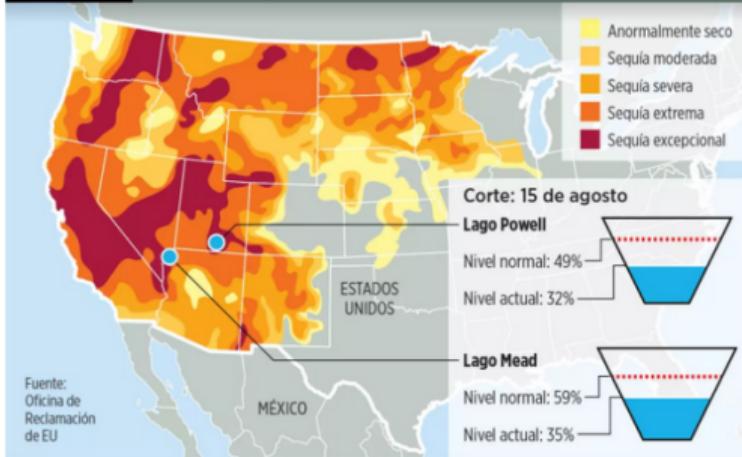
Afrikas horn har drabbats av svår torka och svält. Bara mellan februari och juli i år har antal mäniskor påverkade av torkan ökat från 9,5 miljoner till 16,2 miljoner, varnar Unicef. Detta kommer drabba barnen hårdast, säger Unicefs generaldirektör Catherine Russell i ett pressmeddelande.

FRONTERA SAN DIEGO-TIJUANA

Estados Unidos reducirá la entrega de agua a México

CRISIS

La sequía en EU ha mermado el nivel de almacenamiento en dos embalses del río Colorado, que suministran agua a siete estados de ese país y a Baja California, México, según un tratado de 1944.



La sequía en EU ha mermado el nivel de almacenamiento en dos embalses del río Colorado, que suministran agua a siete estados de ese país y a Baja California, México, según un tratado de 1944.
(Agencia Reforma)

Por Víctor Osorio
Agencia Reforma

Ago. 17, 2021 9:52 AM PT

ANUNCIO

MÁS

NOTICIAS

Acusan penalmente a parlamentario griego por pelea en el recinto

Abr. 24, 2024

NOTICIAS

Una explosión cerca de un barco apunta a nuevo ataque de rebeldes hutíes

Abr. 24, 2024



NOTICIAS
Cinco caballos militares se escapan por el centro de Londres, hieren a 4 personas y desatan el caos

Hace 1 hora



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新华网 > 新闻 > 正文

—2023—

08/28

埃及、埃塞俄比亚、苏丹三国就“复兴大坝”争端展开新一轮谈判



10:55:21

来源：新华网



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深度观察



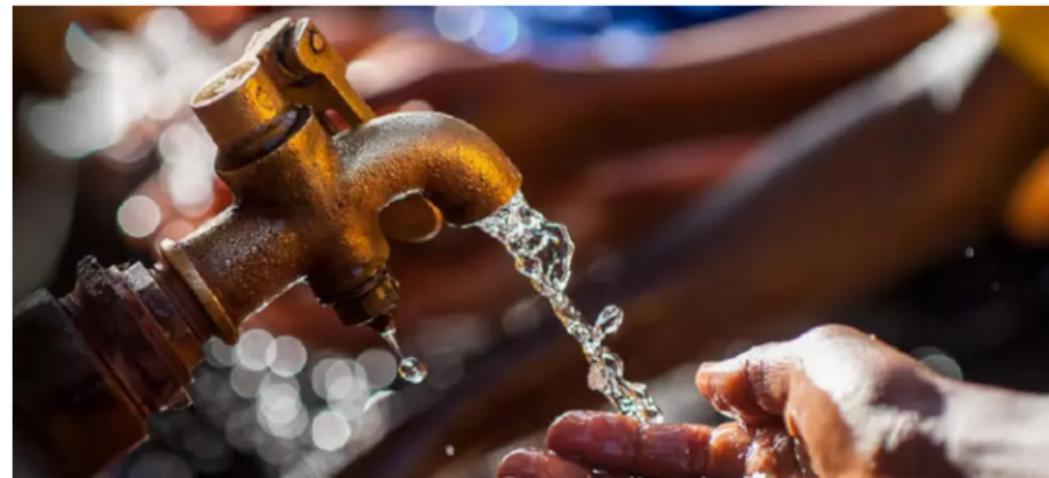
新华全媒头条 | 人文
经济视野下的武威观
察

ANALYSE

Les crises de l'eau menacent la paix dans le monde

À l'occasion de la journée mondiale de l'eau, ce 22 mars, l'ONU rappelle l'urgence de gérer cette ressource essentielle de façon durable et équitable. 2,2 milliards de personnes n'ont toujours pas accès à une distribution d'eau potable. Et pour ne rien arranger, le changement climatique perturbe gravement le cycle de l'eau sur Terre.

Publié le : 22/03/2024 - 05:09 Modifié le : 22/03/2024 - 11:34 9 mn



SENEGAL-HYDRAULIQUE / La commune de Balla confrontée à un problème d'eau, selon son maire

publié 15 avril 2024 à 11h37



Goudiry, 15 avr (APS) – Balla, une commune de 32 villages et hameaux du département Goudiry (est), est confrontée à un problème d'accès à l'eau, indique son maire Amadou Ba, dans un entretien accordé à l'APS.

PUB

populaire récent

Le site web de l'APS (Agence de Presse Sénégalaise) est visible sur le côté droit de l'écran, avec des préviews d'autres articles et des boutons pour 'populaire' et 'récent'.



وكالة تونس افريقيا للأنباء
Agence Tunis Afrique Presse

Arabic | English

CONNEXION CLIENT

S'ABONNER

ACCUEIL ▾ POLITIQUE ECONOMIE SOCIÉTÉ RÉGIONS CULTURE & ARTS

La situation hydrique actuelle demeure inquiétante malgré les récentes précipitations (Ridha Gabouj)

18/04/2024 13:15, TUNIS/Tunisie





VOTRE PARTENAIRE MÉDIA
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LE COURRIER
DE KINSHASA



LES DÉPÊCHES
DE BRAZZAVILLE

Environnement

Crues du fleuve Congo et ses affluents : une dizaine de provinces sous les eaux

Samedi 13 Janvier 2024 - 19:06

Abonnez-vous



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Kinshasa, Tshopo, Mongala, Équateur, Kongo central, Mai-Ndombe, Sud-Ubangi, Nord-Ubangi, Kasaï, Kasaï central, Sud-Kivu, la Lomami, la Tshuapa et le Kwilu sont les quatorze provinces les plus touchées. Lors de la 121^e réunion du Conseil des ministres le 12 janvier, le président de la République, Félix-Antoine Tshisekedi Tshilombo, a exprimé ses inquiétudes sur le risque des épidémies, même si le majestueux cours d'eau entame déjà sa phase de décrue.

Lire aussi :

Environnement
> Changement climatique: la vague de chaleur

ANTANANARIVO - La Jirama annonce le retour de l'approvisionnement en eau

Mialisoa Ida - Publié le 5 avril 2024

764 1

Telma BIZINESY' PACK

Inscrivez-vous
en 5 minutes !

CLIQUEZ ICI



Le ministre de l'Eau, de l'Assainissement et de l'Hygiène a visité la station de la Jirama à Mandroseza.

L'approvisionnement en eau à Antananarivo reviendra à la normale bientôt. Des pannes à la station

Kalemie : le boulevard Lumumba inondé, la traversée de cette artère principale se fait par pirogue

Publié le mar, 16/04/2024 - 14:14 | Modifié le mar, 16/04/2024 - 14:14

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Des pirogues facilitent la traversée des personnes et leurs biens. Ces routes sont inondées par des eaux du lac Tanganyika et de la rivière Lukuga. Kalemie, le 16 avril 2024

Radio Okapi/Ph. Paulin Munanga

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Dans la même catégorie



Haut-Katanga : la CNDH alerte sur les cas de torture dans les prisons

24/04/2024 - 12:50

Société, Actualité / Haut-Katanga, Prisons, conditions carcérales, CNDH, ministre de justice

SENEGAL-COLLECTIVITES-HYDRAULIQUE / Dagana : sept villages de la commune de Mbane confrontés à une pénurie d'eau

publié 23 avril 2024 à 14h51



FSG

AGENCE DE PRESSE SENEGALAISE

PUB

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A thumbnail image of the APS Hebdo magazine cover. The cover features a photo of people working in a forest, with the title "APS HEBDO" at the top and several articles listed below.

populaire

récent

commentaire

Tags

6



AFRIQUE-MONDE-SPORT / L'AIPS
célèbre son centenaire à Santa
Susana, lundi

SENEGAL-EDUCATION-HYDRAULIQUE / Kédougou : l'école élémentaire Bakary Dansokho sans eau courante depuis six ans (enseignant)

publié 22 avril 2024 à 12h58



MDS
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DE BRAZZAVILLE

Politique

Eau et électricité : le Sénat fustige la qualité des services

Lundi 5 Février 2024 - 16:09

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Ouvrant les travaux de la deuxième session ordinaire administrative de la chambre haute du Parlement, le 1^{er} février, son président, Pierre Ngolo, a déploré la situation de l'eau et de l'électricité, un véritable sujet de préoccupation de nos jours.

Lire aussi :

RePublique

Régions - 24/04/2024

Région Béni-Mellal-Khénifra: signature d'une convention de partenariat pour la collecte de données sur les ménages

M'diq: Salon des femmes rurales pour encourager les initiatives économiques

News : Driss Lachguar appelle à la révision de l'article 47 de la Constitution



Les pluies sont toujours les bienvenues

[Ne serait-ce que pour le moral](#)

Mehdi Ouassat
Jeudi 8 Février 2024



Le Maroc fait face à une pénurie sévère de ressources hydriques, accentuée par des conditions climatiques défavorables. Si les

AUTRES ARTICLES

[L'Agence Bayt Mai Al Qods organise la 4ème édition du modèle de simulation du sommet international](#)

Beni : la société civile déplore le manque d'eau potable à Mwangaza

Publié le sam, 13/04/2024 - 16:20 | Modifié le sam, 13/04/2024 - 16:21

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Haut-Katanga : la CNDH alerte sur les cas de torture dans les prisons

24/04/2024 - 12:50

Société, Actualité / Haut-Katanga, Prisons, conditions carcérales, CNDH, ministre de justice



Haut-Katanga et Lualaba : la BAD

Kongo-Central : la cité de Luozi privée d'eau potable depuis 3 mois

Publié le lun, 11/03/2024 - 05:48 | Modifié le lun, 11/03/2024 - 05:48

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Radio Okapi/Ph. John Bompengo

L'eau ne jaillit pas dans certains robinets à Kinshasa le 23/02/2015. Radio Okapi/Ph. John Bompengo

Dans la même catégorie



Haut-Katanga : la CNDH a les cas de torture dans le

24/04/2024 - 12:50

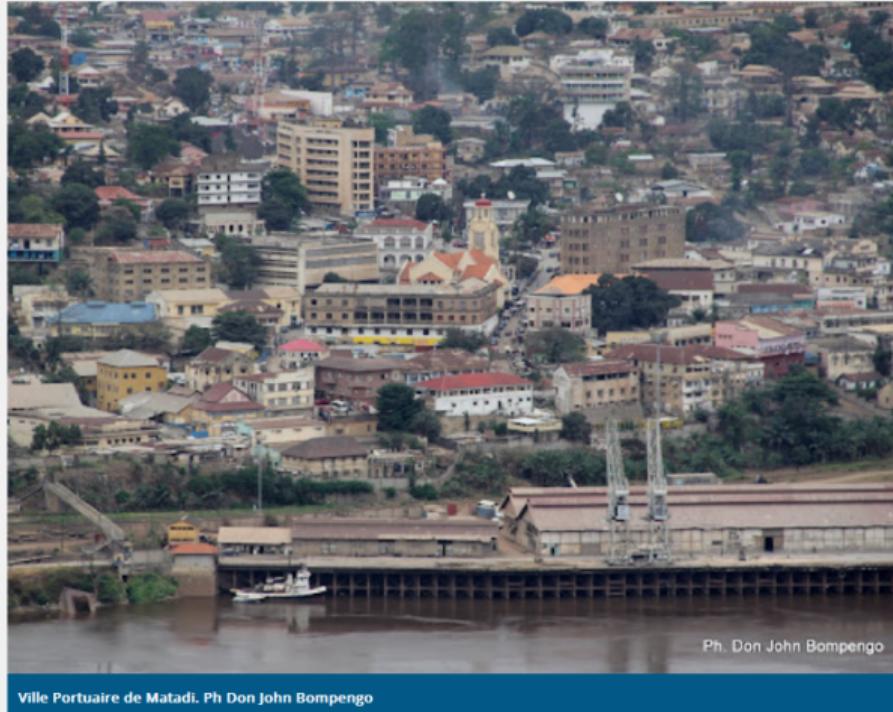
Société, Actualité / Haut-Katanga, conditions carcérales, CNDH, mini



Matadi : rétablissement de la desserte en eau potable après 5 jours de pénurie à Momo

Publié le mer, 17/04/2024 - 20:28 | Modifié le mer, 17/04/2024 - 20:28

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Beni : Sous-lieutenant Mbuyi Kalonji désigné porte-parole des FARDC du secteur opérationnel Sokola 1

24/04/2024 - 11:21

Sécurité, Actualité / FARDC, Sokola 1, Porte-parole, Nord-Kivu



Tanganyika : plusieurs quartiers de Kabalo inondés par les eaux du fleuve Congo

Publié le mar, 09/04/2024 - 18:17 | Modifié le mar, 09/04/2024 - 18:17

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Inondation à Kabalo.

Radio Okapi/Ph. Paulin Munanga

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Haut-Katanga : la CNDH alerte sur les cas de torture dans les prisons

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AMPITATAFIKA - Un millier de personnes exposées à l'inondation

Miora Raharisolo - Publié le 29 janvier 2024

1 836

0



Limited Time Offer: Jaw-Dropping
Car Deals Near You!

諳音哏最高成就！台灣「超神店名」釣出
吳彥祖本尊反應曝光：夠了哩

A Lump isn't the Only Sign of Breast
Cancer - See List

2024/04/23

小
家

台灣人多數都養寵物？鏟屎官揭狗狗「天真又單純」：小孩先緩緩

2023/05/15 15:49:20



A- A A+



À LIRE

20 avril 2024 |

Amboditsiry : Manifestation contre la pénurie incessante d'eau

⌚ Temps de lecture : 1 min.



Amboditsiry (aussi) en a ras-le-bol !

[Accueil](#) > Éditorial

Solution bidon

Sylvain Ranjalahy - Publié le 10 avril 2024

610 0

Telma BIZNESY' PACK Inscrivez-vous en 5 minutes ! CLIQUEZ ICI

Cent soixante-dix camions citerne pour ravitailler les quartiers victimes de « geneaucide » depuis plusieurs mois. On ne manque pas d'idées pour trouver des solutions aux problèmes quotidiens de la population. De qui se moque-t-on? Où va -t-on trouver tous ces camions citerne ? À moins de lancer un appel d'offres avec ce que cela suppose d'éventuelle entente entre le fournisseur et le client.

Avec tout l'argent que l'État a injecté pour résoudre le problème d'eau et d'électricité depuis plus de dix ans, on aurait pu construire trois barrages hydroélectriques et on n'en serait pas là aujourd'hui. Hélas, ce fut une longue galère dont on ignore le bout du tunnel. Pire, les problèmes s'aggravent d'un jour à l'autre. Les quartiers privés d'eau s'étendent de plus en plus. Ceux qui en étaient approvisionnés deux heures par semaine en sont complètement dépourvus aujourd'hui. Et à l'allure où les choses évoluent, il n'y a aucun espoir que la situation s'améliore.

L'impunité règne en maître et seuls les abonnés en bavent.

Congo-Brazzaville: dans la capitale, l'eau se fait de plus en plus rare au robinet

Bordée par le fleuve Congo et quelques-uns de ses affluents, Brazzaville, la capitale congolaise, vit paradoxalement une pénurie d'eau sans précédent. Plus rien ne coule au robinet depuis des jours, voire des mois, selon les zones d'habitation. Cette situation est difficile à vivre en cette période où les vagues de chaleur sont insupportables. Officiellement, aucune explication n'est donnée à ce sujet.

Publié le : 25/03/2024 - 07:01 | 2 mn

Écouter - 01:14



Une vue aérienne de Brazzaville et du fleuve Congo (Image d'illustration) Universal Images Group via Getty - Education Images

Tchad: l'accès à l'eau, l'une des principales préoccupations des électeurs à Abéché

Au Tchad, la campagne électorale bat son plein et l'eau est source de débat, notamment dans la ville d'Abéché, à l'Est du pays. Rare et donc coûteuse, l'eau est à l'origine de problèmes entre certains locataires et bailleurs.

Publié le : 21/04/2024 - 11:42 ⏱ 1 mn

Écouter - 01:17



Le problème de l'approvisionnement en eau est l'une des questions de la campagne électorale à Abéché au Tchad où la ressource est rare et chère (avril 2024). © Olivier Monodji / RFI

Las disputas por los recursos entre agricultores y pastores en Camerún conducen a un ataque sangriento: la vida como refugiado climático

Luchó todos los días por comprender cómo grupos que alguna vez fueron amigos ahora luchan entre sí; cómo vecinos cordiales se convirtieron en agresores, expulsándonos de nuestras casas y prendiendo fuego a todo.



Leocadia Bongben • 4 meses ago • ① enero 5, 2024

7 min read

CONFLICTO



IDPs men at the Maroua camp

Forum national de l'eau: les questions de l'eau et de l'assainissement au cœur des réflexions

Par **JK. Sidwaya** - 23 avril 2024

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SENEGAL-HYDRAULIQUE-COLLECTIVITES / Tivaouane : des quartiers privés d'eau durant des heures

publié 16 avril 2024 à 23h44



Tivaouane, 16 avr (APS) – Plusieurs quartiers de Tivaouane ont été privés d'eau durant des heures, ce mardi, entraînant des désagréments pour leurs habitants, en cette période de canicule, a constaté l'APS.

PUB

populaire récent



 6 FÉVRIER 2024

 10:09

 Commentaire(s)

Par



Yasin Denmamode

PARTAGER CET ARTICLE



QUESTIONS À...FARHAD AUMEER

«Que la météo se soit trompée ou pas, il y aurait eu la même quantité d'eau dans la capitale»



Farhad Aumeer, député travailliste

La circonscription n°2 (Port-Louis Sud - Port-Louis Centre) a été l'une des plus touchées par les inondations du 15 janvier. Le Dr Farhad Aumeer, député de la circonscription, est descendu sur le terrain dès le début. Il revient sur le calvaire que vivent ses mandants depuis...

Quel a été votre constat de la situation après les inondations et le passage de Belal ?

Motivation

Overview

Contribution to the Literature

Model

Data

Results

Next Steps

Water Management is a Global Concern

- The extent to which water is managed well touches many aspects of our lives, from the quotidian to the geopolitical
- Managing freshwater resources is hard, even for rich countries (common pool, up- or downstream externalities)
- These externalities are exacerbated when water crosses boundaries
- Half the world's population lives in transboundary water basins (De Stefano et al., 2017)

[Basins Map](#)

- Cooperation with formal agreements is hard to interpret (causality \Leftrightarrow)
- Cooperation with informal agreements is hard to document

- In Africa, both too much and too little can (still) be fatal (Persson et al., 2012)
- Agriculture accounts for 85% of water withdrawn in Africa (ReliefWeb, 2020); yet irrigation is very low ($\approx 7\%$ of ag. land (International Water Management Institute, 2024)).
- Climate change is affecting levels, variability, and onset of rains (Monerie et al., 2021)
- Water markets are often incomplete or informal themselves (e.g. tankers for drinking water) (Mapunda et al., 2018)
- Many arrangements over water resources are **informal** or **implicit** (Nemarundwe and Kozanayi, 2003)
- Expert opinion on basin-level management has been mixed

Too many cooks in the kitchen

Opposing / too many goals

Geopolitics (Wolf, 1999; Wolf et al., 2003)

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Research question(s):

How do communities share water in practice on (small) rivers?

What implications does their water-sharing have for on-the-ground outcomes (production, livelihoods)?

What factors are associated with "good" management (marginal utilities co-move, all else equal)?

(Eventually: How might climate change affect these *de facto* arrangements?)

Strategy:

- **Descriptive:** What's the relationship between rainfall, water availability on rivers, and outcomes for small rivers (i.e. with few towns to contract with)
- **Model:** Dictator Game: upstream town(s) can allow water to pass to downstream town(s) (or: Self-Enforcing Contracts game)
- **Empirics:** Examine Demographic Health Surveys (DHS); satellite lights; greenness. Compare as a function of precipitation and water flow over a broad space
- **Identification:** IV / DiD changing **costs** to sending water or **benefits** from cooperation (e.g. shift-share for outside option; tech improvements for irrigation; NGO RCTs)

Short-term Goal:

Trace out how rainfall → water flow → affects final outcomes (currently infant mortality) and how this varies according to the usual suspects (e.g. borders, language, ethnicity, conflict prevalence)

Medium/ Long-term Goals:

Add identification (shift-share for population growth? Policy roll-out? Forced displacements?) that changes costs or benefits of cooperation

Use this to parameterize how river allocation changes with precipitation affects final outcomes

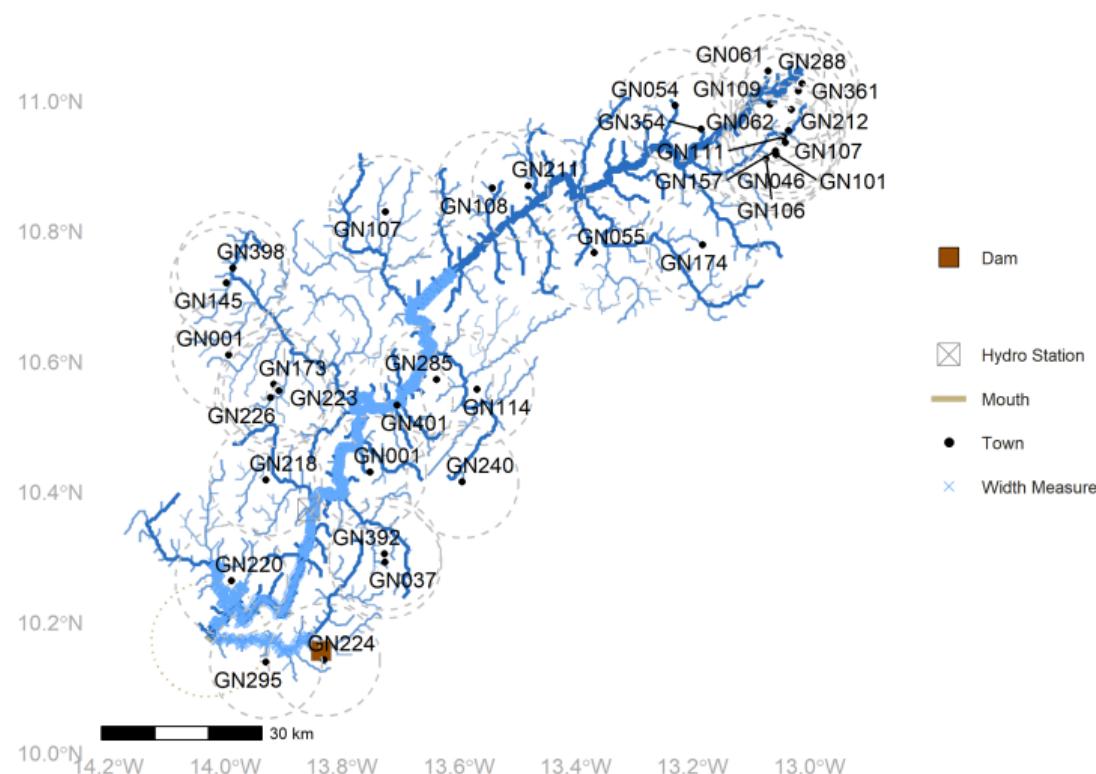
Consider climate change counterfactuals

DHS Towns Along a River in MDG



Labels give (Country+DHS cluster number) for DHS 2008.
Includes 937 width location(s), 4 town(s), 0 hydro station(s), 0 dam(s).
Source: DHS, GADM (2022), AWS (2023), HydroRIVERS (2023), ADHI (2020), GDAT (2023).

DHS Towns Along a River in GIN

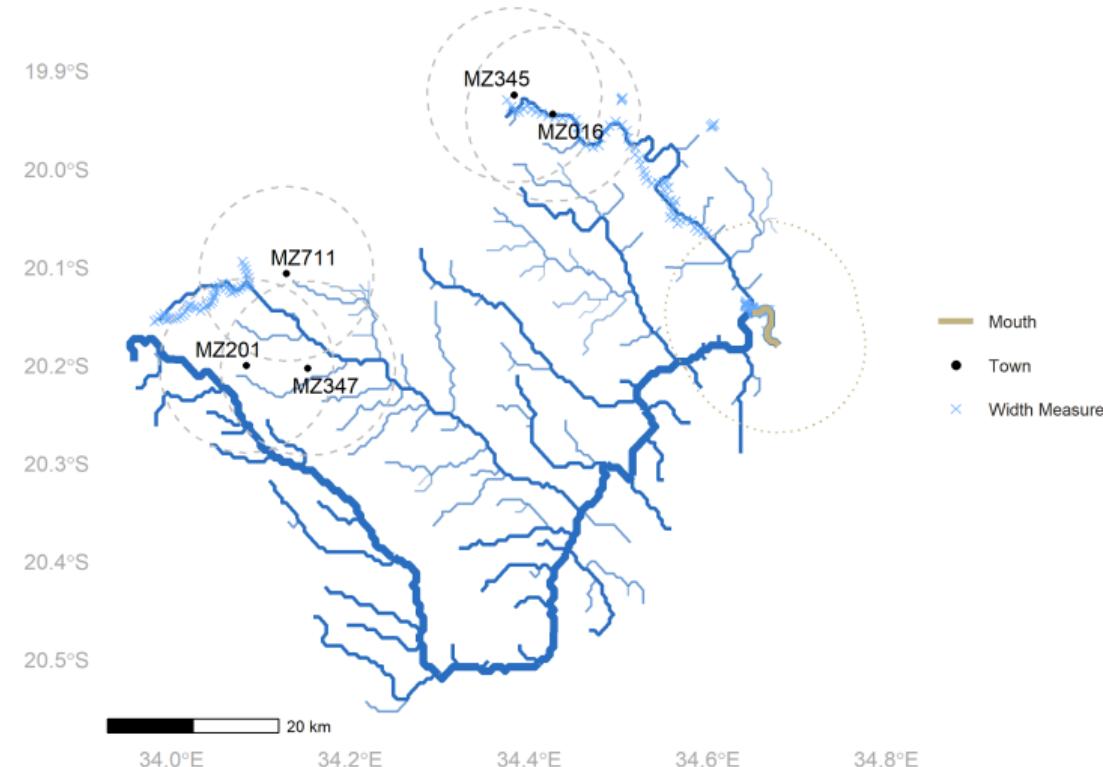


Labels give (Country+DHS cluster number) for DHS 1999.

Includes 806 width locations, 36 towns, 1 hydro stations, 2 dams.

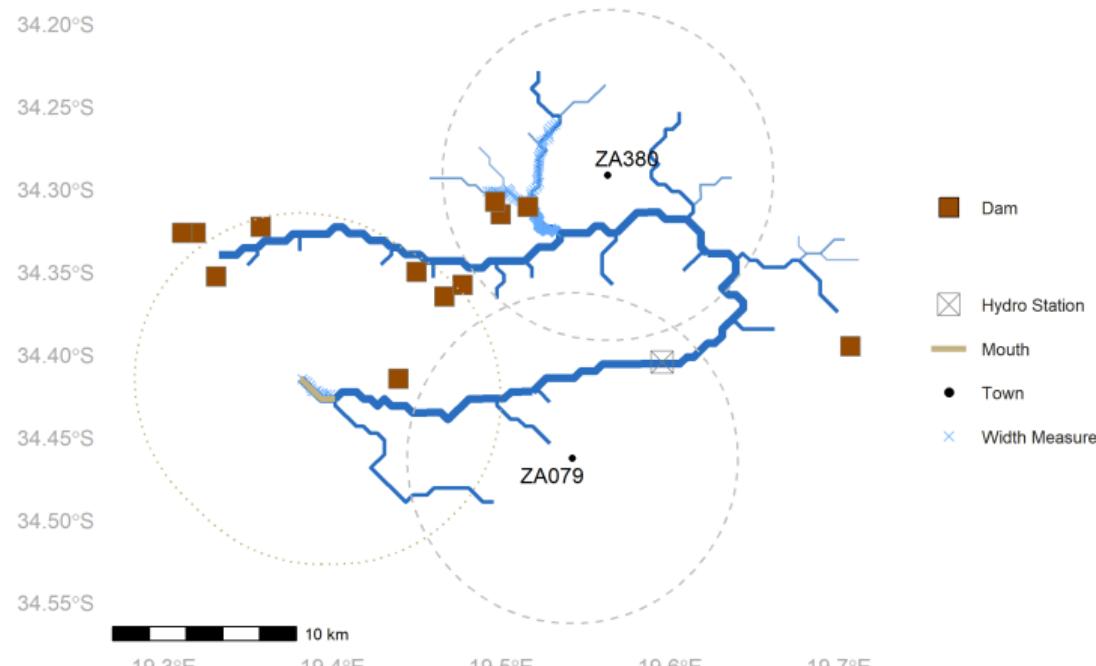
Source: DHS, GADM (2022), AWS (2023), HydroRIVERS (2023), ADHI (2020), GDAT (2023).

DHS Towns Along a River in MOZ



Labels give (Country+DHS cluster number) for DHS 2011.
Includes 132 width location(s), 5 town(s), 0 hydro station(s), 0 dam(s).
Source: DHS, GADM (2022), AWS (2023), HydroRIVERS (2023), ADHI (2020), GDAT (2023).

DHS Towns Along a River in ZAF



Labels give (Country+DHS cluster number) for DHS 2017.

Includes 116 width locations, 2 towns, 1 hydro station, 12 dams.

Source: DHS, GADM (2022), AWS (2023), HydroRIVERS (2023), ADHI (2020), GDAT (2023).

Motivation

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Water scarcity and tensions:

Current outcome (infant mortality) is less extreme than conflict ("latent"); eventually add remote-sensing data for mechanisms (satellite lights, farm yields, greenness) (McGuirk and Nunn, ming; Burke et al., 2015) / child mortality (Persson et al., 2012)

Water agreements and cooperation/externalities:

Informal arrangements, can bring in formal arrangements and whether those mitigate. Novel(?) use of DHS and remote sensing data to look at *revealed* choices (Wolf, 1999; Dinar et al., 2019)

Water Externalities:

Remote-sensing data application to allow consideration of quantity, and upstream-downstream relationships rather than common-pool considerations (Lipscomb and Mobarak, 2017; Ryan and Sudarshan, 2022)

Modelling innovations:

Application of a simple model that generates predictions about when actors would act less cooperatively, opens up the search for what kinds of relationships work well (Ligon et al., 2002; Meghir et al., 2019)

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Setting:

- Two towns $i \in \{u, d\}$ (upstream, downstream)

Timing:

1. Endowments of water $\varepsilon_u, \varepsilon_d$ fall from the sky and are observed by upstream
2. Upstream chooses a quantity of water to transfer to downstream, keeps the rest
3. Everyone receives their payoffs

Simplifications:

- One-shot game (for now)
- Just consider upstream's choices (for now)
- Not considering whole-river solutions (for now)

Stone-Geary utility:

$$U_u(x_u, x_d) = \theta_u u_u(x_u - b_u) + \theta_d u_d(x_d - b_d) \quad (1)$$

u_i : utility i receives from just the water. $u'_i > 0, u''_i < 0$

b_i : minimum acceptable payoff for i (from u 's perspective)

θ_u : u 's selfishness

x_u : water quantity kept for upstream, $x_u > b_u$

x_d : water quantity sent downstream, $x_d > b_d$

Normalizations

$\theta_u + \theta_d = 1$: (Cobb-Douglas-like)

$b_u + b_d = 0 \Rightarrow u$ has to trade off who they guarantee.

Interpretation

$b_i < 0 \Rightarrow u$ is able to conceive of i getting a minimum acceptable payoff

If $b_u > 0$: u guarantees itself, and if it can pass some share of the excess to d

\Rightarrow sometimes u keeps everything

$$\max_{x_u, x_d} U_u(x_u, x_d) = \theta_u u_u(x_u - b_u) + \theta_d u_d(x_d - b_d) \quad (2)$$

such that

$$0 \leq p_u x_u$$

NN1 (μ_1)

$$p_u x_u \leq m_u$$

NN2 (μ_2)

$$p_u x_u + p_d x_d \leq \varepsilon_u + \varepsilon_d$$

BC (λ)

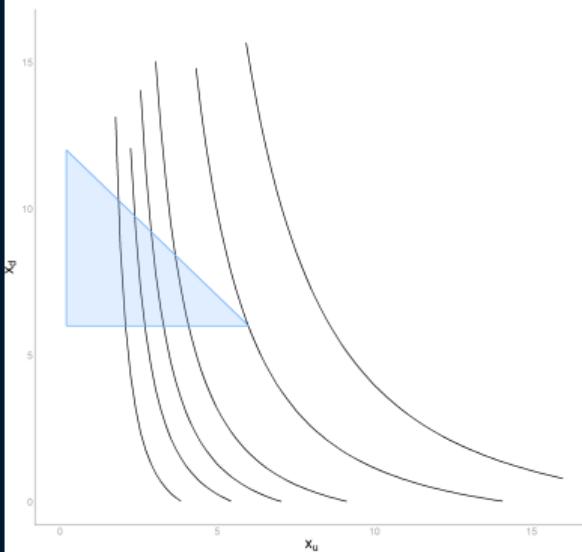
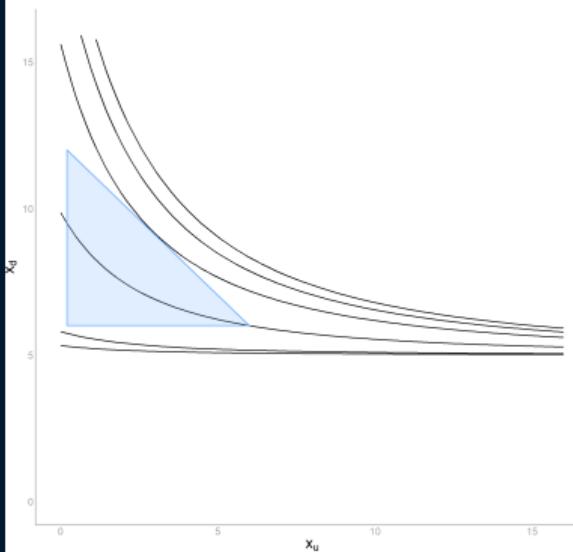
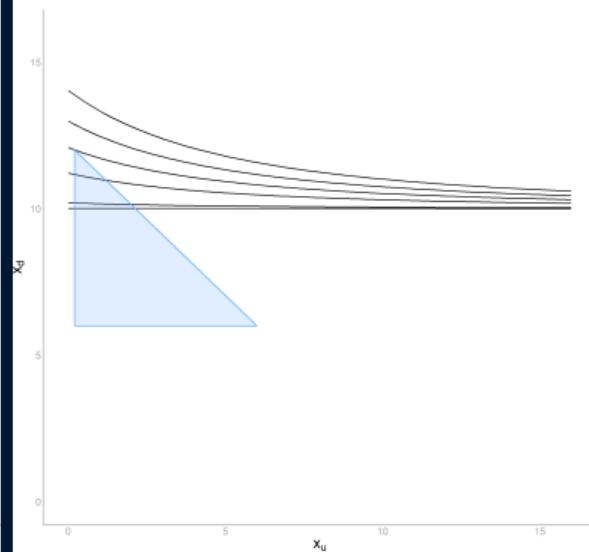
$$\max_{x_u, x_d} U_u(x_u, x_d) = \theta_u u_u(x_u - b_u) + \theta_d u_d(x_d - b_d) \quad (2)$$

Kuhn-Tucker Conditions:

$$\frac{\theta_u}{p_u} u'_u(x_u - b_u) = \frac{\theta_d}{p_d} u'_d(x_d - b_d) \iff 0 < p_u x_u < \varepsilon_u \quad (\text{Interior})$$

$$\frac{\theta_u}{p_u} u'_u(x_u - b_u) = \frac{\theta_d}{p_d} u'_d(x_d - b_d) - \mu_1 \iff p_u x_u = 0 \quad (\text{All to } d)$$

$$\frac{\theta_u}{p_u} u'_u(x_u - b_u) = \frac{\theta_d}{p_d} u'_d(x_d - b_d) + \mu_2 \iff p_u x_u = \varepsilon_u \quad (\text{All to } u)$$

Corner, Upstream Takes All, $p_u x_u = m_u$ Interior, $0 < p_u x_u < m_u$ Corner, Upstream Gives All, $0 = p_u x_u$ 

If utilities are logs:

- We get some testable implications about how u 's choice varies with the endowments and its lower bounds of acceptable minima for u and d

Expenditures: (recall $\theta_d = 1 - \theta_u$)

Define $\Gamma := p_u b_u + \theta_u(\varepsilon_u + \varepsilon_d - p_u b_u - p_d b_d)$

$$p_u x_u = \theta_u \varepsilon_u + \theta_u \varepsilon_d - \theta_u p_d b_d - (1 - \theta_u) p_u b_u \quad (\text{Interior}) \iff \Gamma \in (0, \varepsilon_u)$$

$$p_d x_d = (1 - \theta_u) \varepsilon_u + (1 - \theta_u) \varepsilon_d + \theta_u p_d b_d - (1 - \theta_u) p_u b_u \quad (\text{Interior}) \iff \Gamma \in (0, \varepsilon_u)$$

$$p_u x_u = \varepsilon_u \quad (\text{All to } d) \iff \Gamma \geq \varepsilon_u$$

$$p_u x_u = 0 \quad (\text{All to } d) \iff \Gamma \leq 0$$

And then we can rearrange for b_u the selfishness parameter of u

Motivation

Overview

Contribution to the Literature

Model

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Results

Next Steps

Mortality data: Demographic Health Surveys (DHS)

Over 320 surveys in over 90 countries over past 30 years, nationally representative.

Currently just using Africa (over 100 surveys)

DHSs are cross-sections; but mortality data is retrospective

Why not a panel? We would observe households at different life cycle stages.

Interpretation murkier. (Thoughts?)

Rain: European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5 (ERA5): models disciplined by observations. Aggregated to average monthly rainfall over the year (will change to CHiRP for better spatial resolution)

River locations: HydroSHEDS river networks (plus R riverdist) (alt. Digital Elevation Model (DEM))

Also: Global Administrative Areas (GADM); **Global Long Term River Width:** satellite data capturing river widths over time (1984-2020); GDAT dams panel

Infant mortality is sensitive to water availability:

- Water availability affects: agricultural outcomes (e.g. nutrition); hygiene (e.g. diarrhea); disease vectors (e.g. malaria). All these have been found to influence infant mortality (e.g.(Persson et al., 2012))

Spatio-temporal comparability:

- Retrospectively asking about fertility isn't subject to (too much) recall bias (cite)
- Can build out panel-esque information from many cross-sections over a wide geography (71k towns,30-some countries), 1954-now

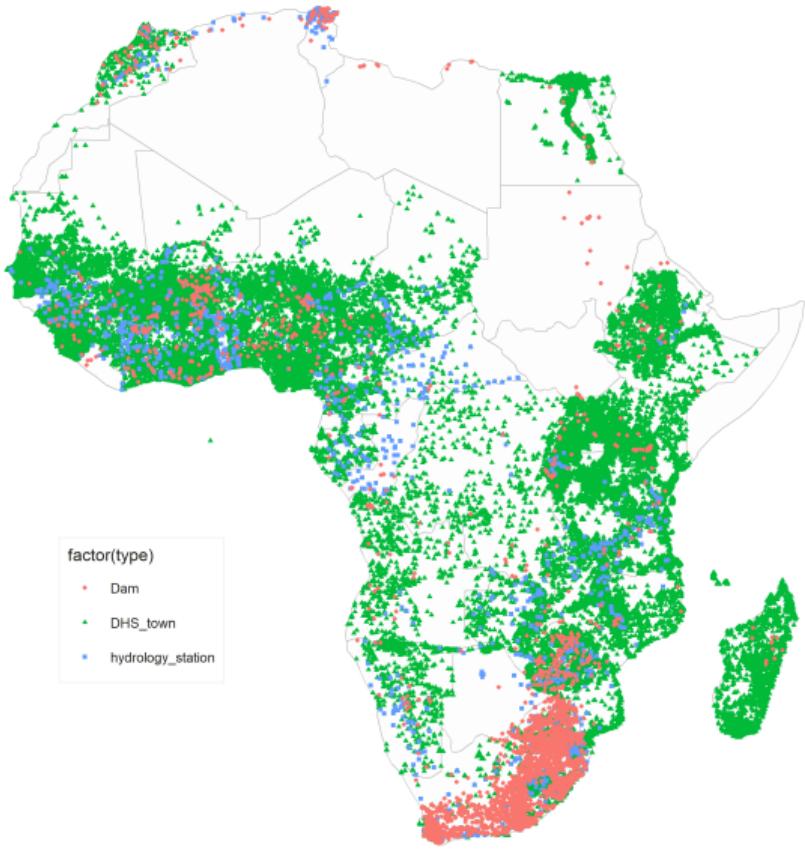
Mechanisms also of interest:

- Mechanisms for water → infant mortality include: in-HH asset accumulation (can get some with DHS household); agricultural productivity and overall community incomes (satellite data: lights, greenness (caveat, only 1992-on))

Not the only analysis?:

- Country-specific section with... better data? better time? more institutional analysis? really lucky identification?
- e.g. dams on River Senegal re-flooding
- Big caveat: short-term for now, *given* dam choice

Dams, Hydro Stations, and DHS Clusters in Africa



Data from GDAT (2023), DHS (2023), ADHI (2019)

Summary Statistics

Statistic	N	Min	Mean	Median	Max	St. Dev.
Year	248,678	1,957	1,999.38	2,000	2,022	11.09
Average annual precip. (mm/month)	248,678	0.00	0.001	0.001	0.01	0.001
Long-run avg. precip (mm/month)	248,678	0.0000	0.001	0.001	0.01	0.001
Annual precipitation Z-score	248,678	-2.45	-0.18	-0.30	8.59	0.84
3-year avg. precip.	248,678	0.0000	0.001	0.001	0.01	0.001
5-year avg. precip.	248,678	0.0000	0.001	0.001	0.01	0.001
Infant Mortality (/1000 births)	248,678	0	57.21	0	1,000	232.25
Infant Mort., Exposure-weighted	248,678	0.00	28.56	0.00	1,000.00	134.74
Rural	248,678	0	0.58	1	1	0.49
On a Dammed River	248,678	0	0.13	0	1	0.34
On a River with Width Obs	248,678	0	0.41	0	1	0.49
On a River with Hydro Station	248,678	0	0.20	0	1	0.40
N infants per town	248,678	0.50	53.08	48.50	178.00	28.86
N infants per year	248,678	1.50	7,831.37	8,575.50	10,813.00	2,713.27
N infants/town/year	248,678	0.50	2.60	2.00	12.50	1.79

N is infant-by-year. Precipitation data from Hersbach et al. (2020) in mm per month, averaged over the year. Mortality data from over 100 DHS surveys. Currently unweighted by DHS weights for survey probabilities. River data from HydroATLAS (2022), additional calculations use `riverdist` package in R. Data restricted to 60% of cluster-years on rivers with < 100 towns (7223 clusters)

Summary Statistics

Statistic	N	Min	Mean	Median	Max	St. Dev.
Year	13,675	1,965	1,995.91	1,997	2,014	9.53
Average annual precip. (mm/month)	13,675	0.0000	0.001	0.001	0.004	0.001
Long-run avg. precip (mm/month)	13,675	0.0001	0.001	0.001	0.002	0.001
Annual precipitation Z-score	13,675	-1.67	0.12	-0.002	4.99	0.95
3-year avg. precip.	13,675	0.0000	0.001	0.001	0.003	0.001
5-year avg. precip.	13,675	0.0001	0.001	0.001	0.003	0.001
Infant Mortality (/1000 births)	13,675	0	40.07	0	1,000	196.14
Infant Mort., Exposure-weighted	13,675	0.00	20.30	0.00	1,000.00	115.24
Rural	13,675	0	0.40	0	1	0.49
On a Dammed River	13,675	0	0.22	0	1	0.41
On a River with Width Obs	13,675	0	0.24	0	1	0.43
On a River with Hydro Station	13,675	0	0.36	0	1	0.48
N infants per town	13,675	0.50	31.43	27.00	96.00	17.36
N infants per year	13,675	131.00	7,862.97	8,575.50	10,813.00	2,649.46
N infants/town/year	13,675	0.50	1.66	1.50	6.50	1.08

N is infant-by-year. Precipitation data from Hersbach et al. (2020) in mm per month, averaged over the year. Mortality data from over 100 DHS surveys. Currently unweighted by DHS weights for survey probabilities. River data from HydroATLAS (2022), additional calculations use `riverdist` package in R. Data restricted to 60% of Namibia's-years on rivers with < 100 towns (293 clusters)

Motivation

Overview

Contribution to the Literature

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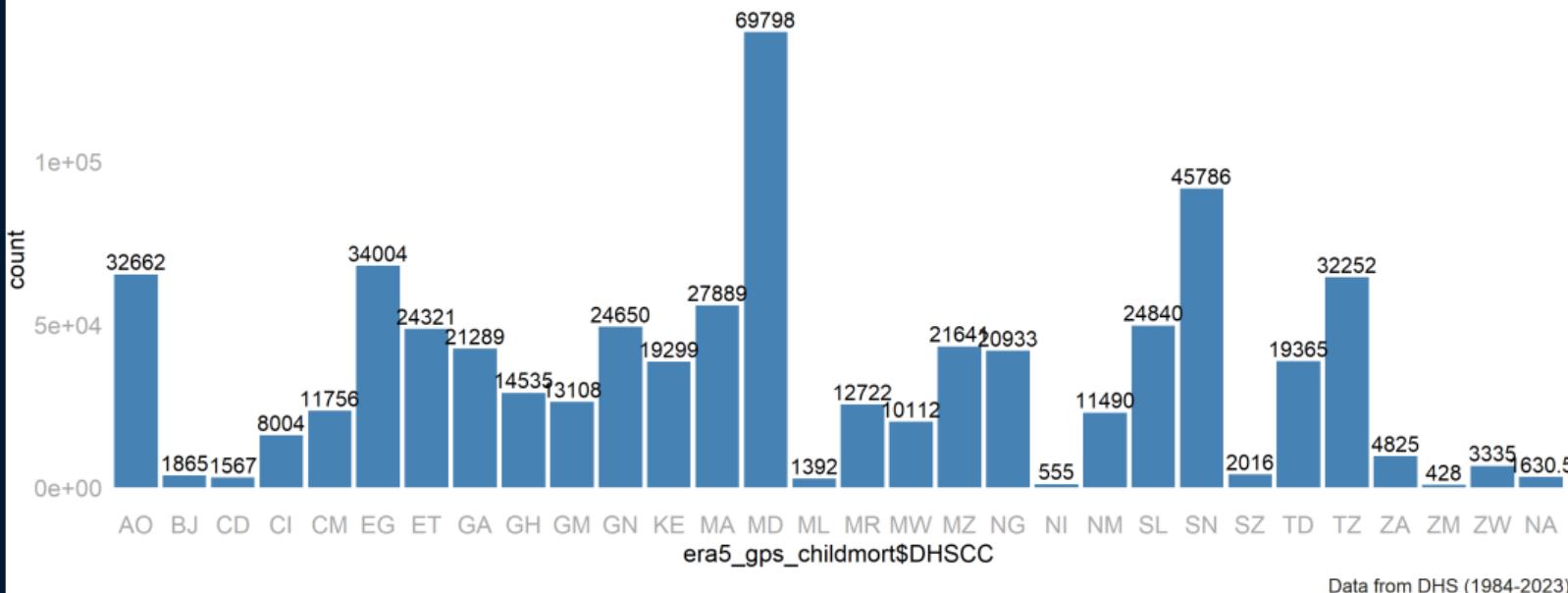
Next Steps

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	26.031 (0.466)			25.828 (0.467)		
Annual avg precip	-428.899 (943.647)	780.196 (947.642)	1412.516 (1005.618)	-366.323 (943.808)	781.712 (947.673)	1415.134 (1005.608)
5-year avg precip	2724.538 (1000.256)	6829.531 (2150.993)	-2314.844 (2314.810)	2132.502 (1006.695)	6390.520 (2435.252)	-1194.588 (2582.609)
5-yr precip x Dist to source				26.242 (5.023)	16.730 (47.202)	-43.234 (47.310)
Mean	28.56	28.56	28.56	28.56	28.56	28.56
Cluster FE	N	Y	Y	N	Y	Y
Year FE	N	N	Y	N	N	Y
Num.Obs.	248678	248678	248678	248678	248678	248678
R2	0.000	0.029	0.033	0.000	0.029	0.033

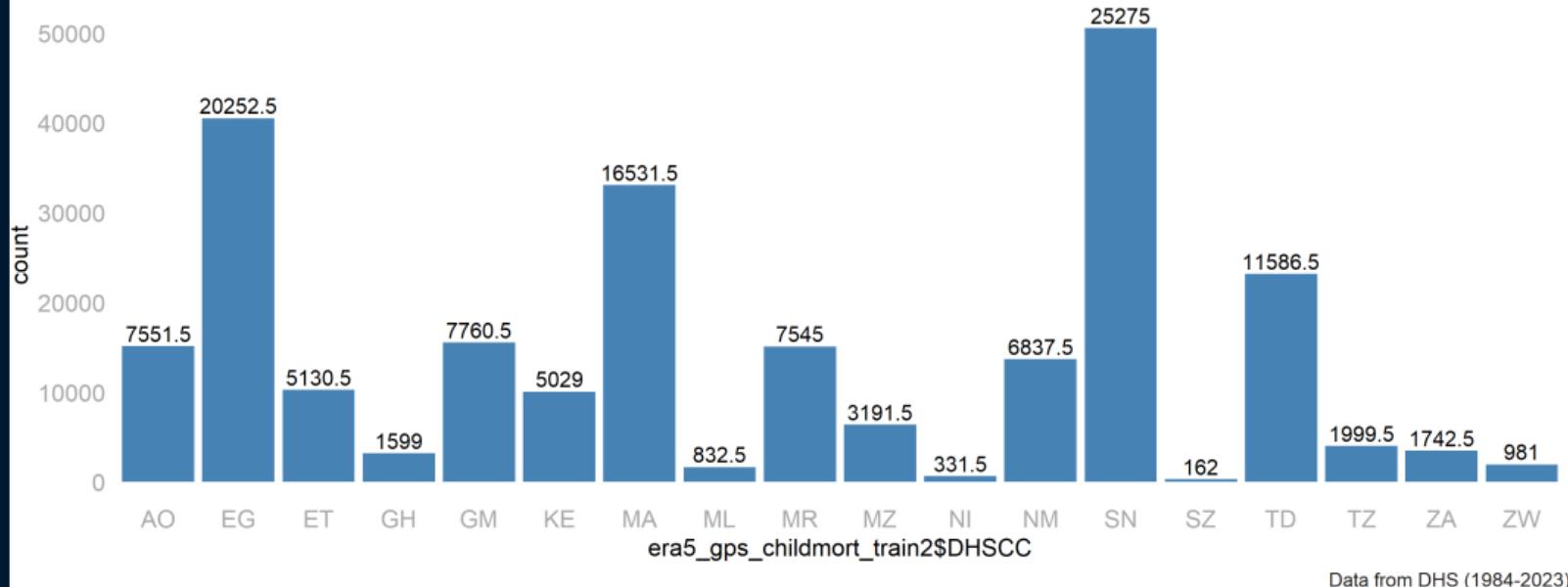
Notes:

Outcome is infant deaths per 1000 infants observed. Precipitation data from ERA5 (2023), in millimeters per month (averaged over the year); river data from HydroSHEDS (2022); DHS surveys from 1988 to 2023, covering 3488 towns on 533 rivers over 1957-2022. Omits Madagascar and any rivers with rainfall above the median of river-level mean precipitation.

Observations per country



Observations per country, below-median rain



Motivation

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Next Steps

Analysis:

1. Write out specifications and show
2. Add in river widths and distances (placement of width measurement is frustrating)

Refine for rest of Africa

Analysis:

1. Trace out implicit contracts
2. Give interesting correlates of better risk-sharing (e.g.)

Economic: Basin management committee, water market in existence, within a country with fossil fuel subsidies across areas? (defines price for pumping)

Socio-cultural: religion, ethnicity, language

Physical: ruggedness, potential yields, dam/canal infrastructure

Model:

1. Go back to model
2. Work through findings of edited model vs. original(s)

Data:

1. Explore whether an ML method with higher-res images would help clean up some of the issues with measurement (river widths / agricultural yields)

- Potential yield (richer downstream, better contracts?)
- Technology change (better outside insurance, better contracts?) e.g. cell tower roll-out
- Introduction of water markets (not too common in low-income?)
- Forced relocations e.g. after dams on different river systems (changes number of towns / people on river); some instrument of population growth (trade shock?)
- **Other ideas?**

Country-level sub-analysis?

- Data that would be helpful to show mechanisms more clearly:
 - Higher-resolution rainfall data
 - Census-level outcomes (*all* towns/HHs on a river)
 - Better agricultural yields measures
 - Closer crop prices
 - Better measures of HH-level outcomes (e.g. wealth) and choices (irrigated area, crops planted)

International Water Basins



Data from Transboundary Freshwater Dispute Database, Oregon State University 2022

310 total international basins.



Example: River Distance Calculations, GIN 2017 DHSs



Reported cluster in black; buffer of 10 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number)
Data from a compilation of DHS surveys in 2012-2017 GADM (2022), AWS (2023), HydroRIVERS (2023)

Example: River Distance Calculations, GIN 2017 DHS

10.40°N

10.35°N

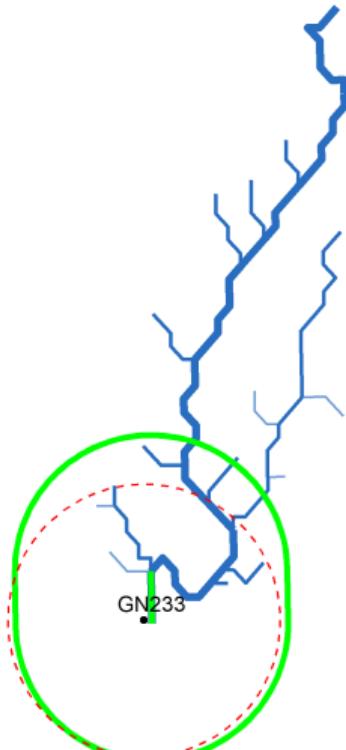
10.30°N

10.25°N

10.20°N

10.15°N

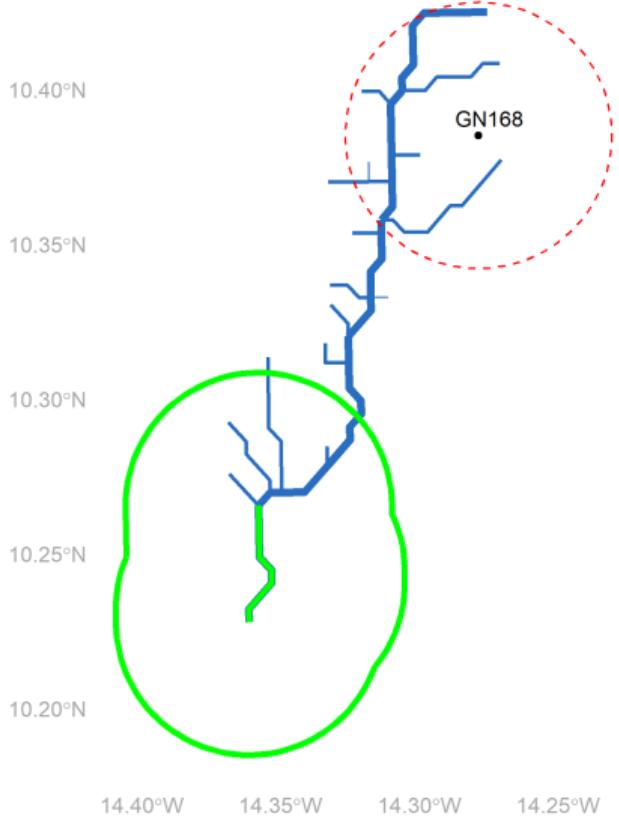
14.36°W/34°W/32°W/30°W/28°W/26°W/24°W



Reported cluster in black; buffer of 5 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number, segment vertex number)
Data from DHS (2017)/GADM (2022), AWS (2023), HydroRIVERS (2023).

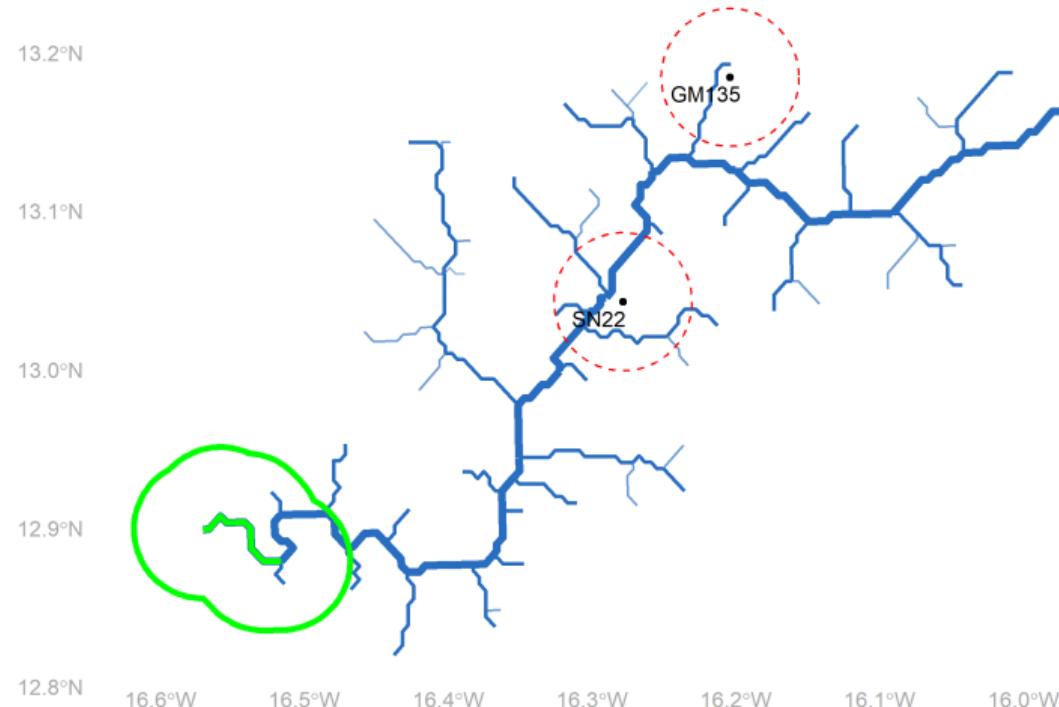


Example: River Distance Calculations, GIN 2016 DHS



Reported cluster in black; buffer of 5 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number, segment vertex number)
Data from DHS (2016)GADM (2022), AWS (2023), HydroRIVERS (2023).

Example: River Distance Calculations, GMB SEN 2018-2020 DHSs



Reported cluster in black; buffer of 5 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number, segment vertex number)
Data from DHS (2018-2020)GADM (2022), AWS (2023), HydroRIVERS (2023).

Example: River Distance Calculations, COG GAB 2010 DHS

3.3°S

3.4°S

3.5°S

3.6°S

3.7°S

3.8°S

10.7°E

10.8°E

10.9°E

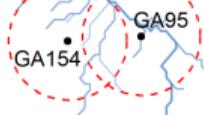
11.0°E

11.1°E

11.2°E

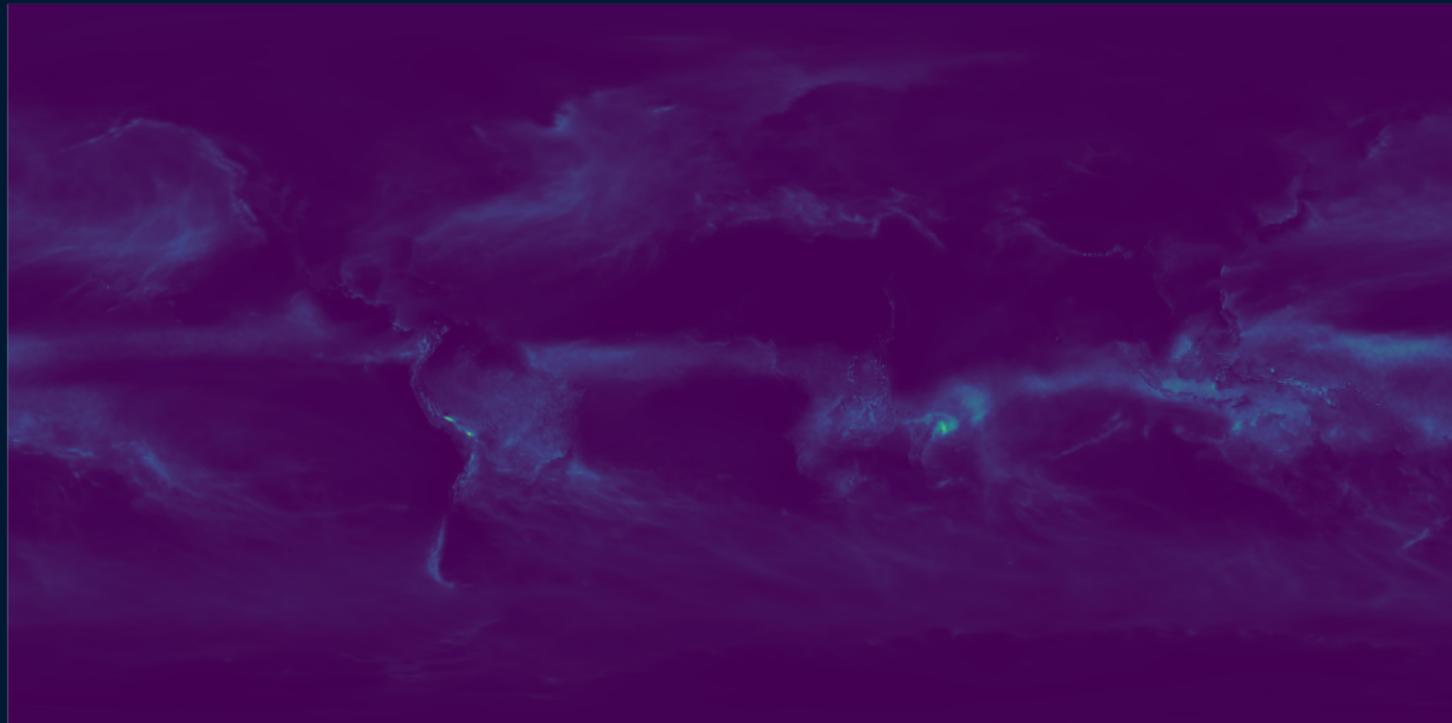
11.3°E

11.4°E

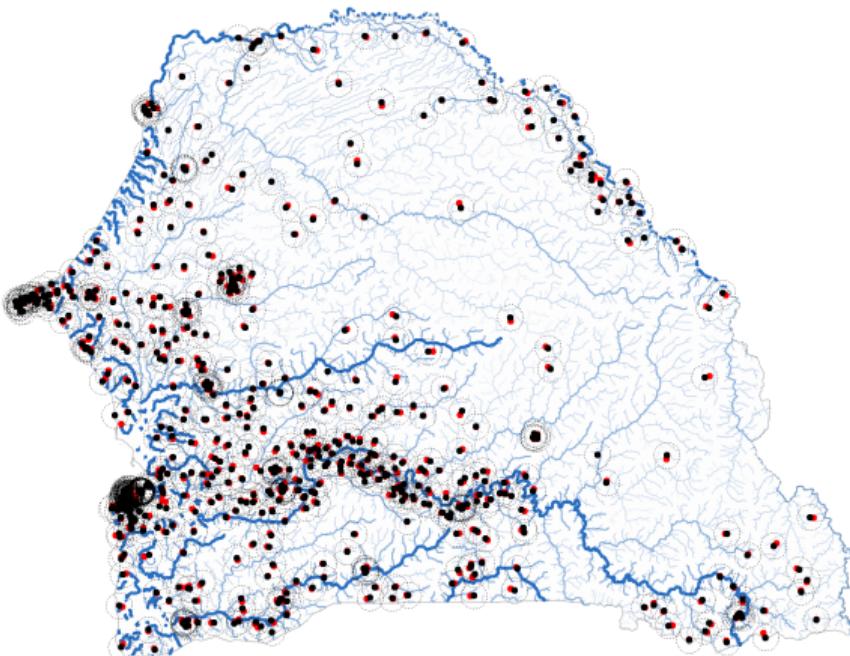


Reported cluster in black; buffer of 5 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number, segment vertex number)
Data from DHS (2010)GADM (2022), AWS (2023), HydroRIVERS (2023)

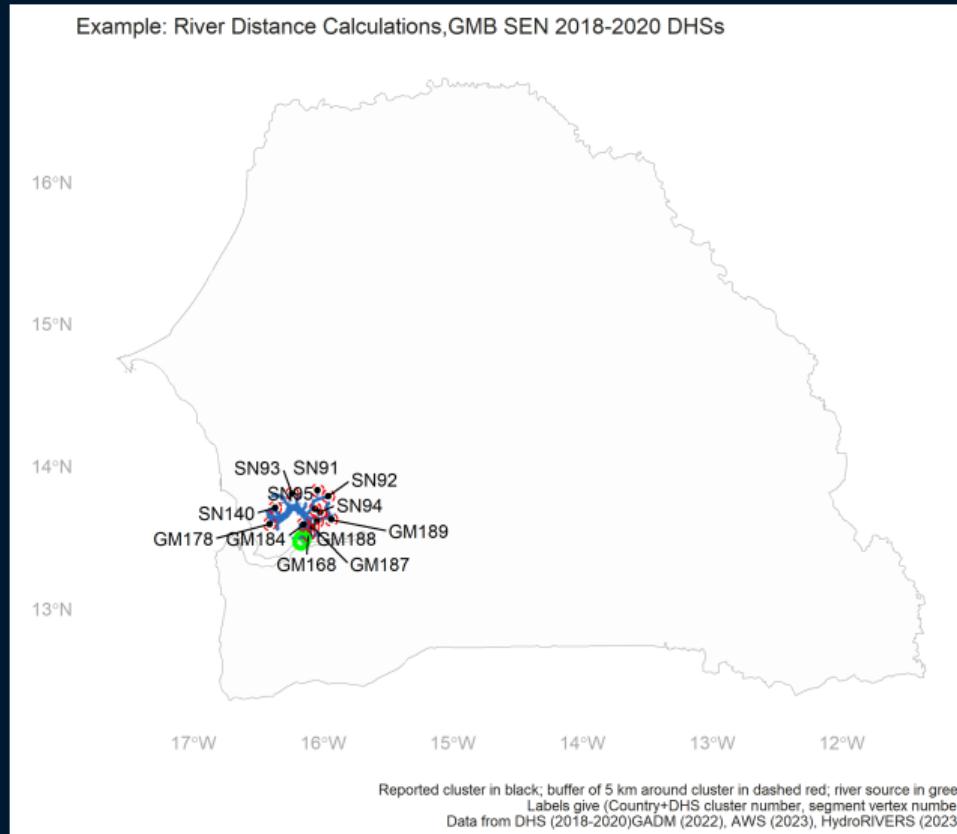


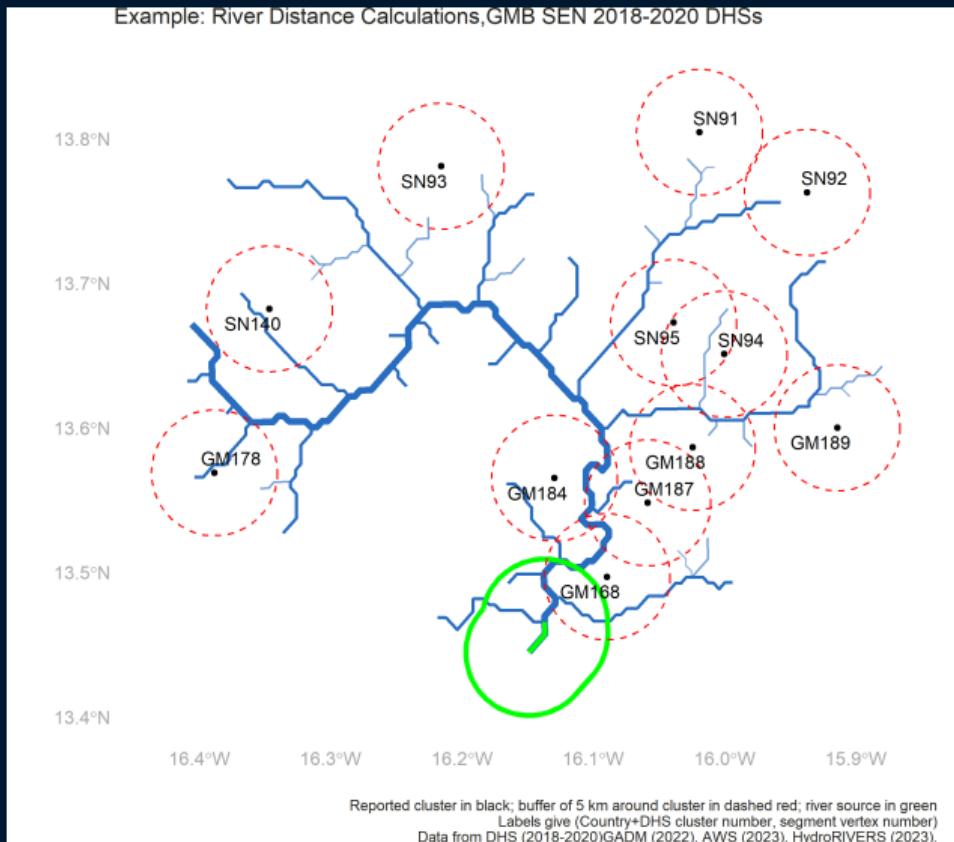


Survey Clusters and Snapping to River Segments GMB SEN, DHS 2018 to 2020

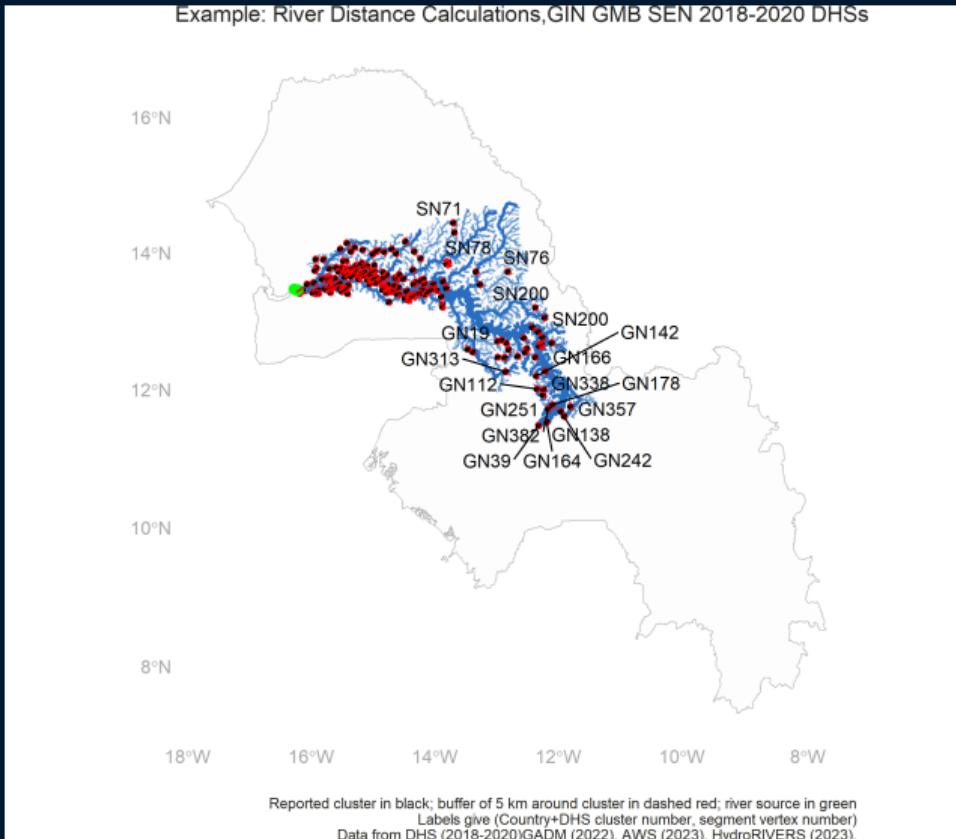


Snapped points in red; original cluster in black; buffer of 10 km around DHS clusters.
Data from DHS (2018 - 2020), GADM (2022), HydroRIVERS (2023)

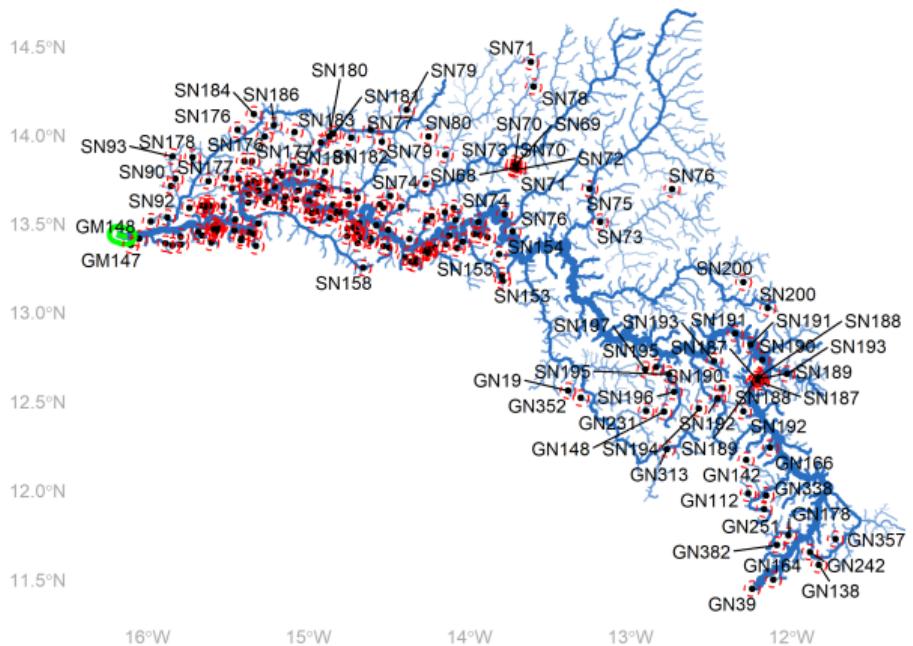




Example: River Distance Calculations, GIN GMB SEN 2018-2020 DHSs



Example: River Distance Calculations, GIN GMB SEN 2018-2020 DHSs



Reported cluster in black; buffer of 5 km around cluster in dashed red; river source in green
Labels give (Country+DHS cluster number, segment vertex number)
Data from DHS (2018-2020)GADM (2022), AWS (2023), HydroRIVERS (2023)

Statistic	N	Min	Mean	Median	Max	St. Dev.
Year	15,005	1,988	2,007.05	2,010	2,018	8.43
Average annual precip. (mm/month)	15,005	4.13	44.08	38.30	132.79	25.66
Annual precipitation SD (mm/month)	15,005	6.03	74.05	66.46	238.66	39.06
Annual precipitation Z-score	15,005	-0.83	-0.54	-0.57	2.67	0.27
Neonatal Mort. Rate (NNMR)	15,003	0.00	29.87	16.26	500.00	40.53
Infant Mortality Rate (IMR)	15,003	0.00	51.12	41.67	600.00	54.12
Under-5 Mort. Rate (U5MR)	14,999	0.00	87.16	70.81	602.32	79.77
Under-10 Mort. Rate (U10MR)	14,993	0.00	100.08	82.54	625.71	85.46
NNMR Weighted Number (WN)	15,005	0	26.47	21	233	20.58
IMR WN	15,005	0	32.84	27	297	25.10

N is number of cluster-by-years, for clusters on rivers intersecting with Senegal. Precipitation data from Hersbach et al. (2020) in mm per month, averaged over the year. Border data from GADM (2022). Mortality data from various DHS surveys. NNMR denotes neonatal mortality rate (months 0-1) per 1,000 live births; IMR denotes infant (months 0-12) mortality rate per 1,000 live births, calculated with modification of the R package DHS.rates. Weighted numbers are DHS weights for survey probabilities. Mortality truncated between median and 90th percentile due to small exposed populations.

Statistic	N	Min	Mean	Median	Max	St. Dev.
Year	8,624	1,988	2,009.49	2,012	2,019	6.45
Cluster distance (m)	8,624	475.53	42,496.11	25,383.45	251,488.90	47,437.44
International	8,624	0	0.002	0	1	0.04
Cross-Adm 1 (state)	8,624	0	0.24	0	1	0.43
Cross-Adm 2 (county)	8,624	0	0.60	1	1	0.49
Urban U, Urban D	8,624	0	0.22	0	1	0.41
Urban U, Rural D	8,624	0	0.05	0	1	0.22
Rural U, Urban D	8,624	0	0.24	0	1	0.43
Rural U, Rural D	8,624	0	0.49	0	1	0.50
(NNMR U)/(NNMR D)	8,624	0.12	1.23	1.09	7.74	0.73
NNMR Weighted N (U)	8,624	15	51.70	49	166	25.93
NNMR Weighted N (D)	8,624	15	41.85	35	183	25.66
(IMR U)/(IMR D)	8,624	0.34	1.19	1.08	3.62	0.52
IMR Weighted N (U)	8,624	15	51.17	47	174	25.77
IMR Weighted N (D)	8,624	15	41.42	34	183	25.26

N denotes a dyad-year, only dyad-years with NNMR and IMR within 50-90th percentiles (to avoid small sample infinite values). Cluster distance is along-river flow-connected distance between dyads. International denotes crossing an international border; Cross-Adm 1 is crossing a state/province border; Cross-Adm 2 is crossing a county/district border. Urban U, Urban D denotes urban up and downstream clusters.

Statistic	N	Min	Mean	Median	Max	St. Dev.
Year	181,020	1,988	2,006.27	2,011	2,019	9.53
Cluster distance (m)	181,020	434.98	36,429.00	4,138.88	292,775.30	49,679.83
International	181,020	0	0.001	0	1	0.03
Cross-Adm 1 (state)	179,870	0	0.23	0	1	0.42
Cross-Adm 2 (county)	179,870	0	0.77	1	1	0.42
Urban U, Urban D	181,020	0	0.55	1	1	0.50
Urban U, Rural D	181,020	0	0.05	0	1	0.21
Rural U, Urban D	181,020	0	0.25	0	1	0.44
Rural U, Rural D	181,020	0	0.15	0	1	0.36
(NNMR U)/(NNMR D)	118,319	0.00	Inf.00	1.28	Inf.00	
NNMR Weighted N (U)	181,020	0	38.49	32	236	30.56
NNMR Weighted N (D)	181,020	0	28.04	22	236	23.48
(IMR U)/(IMR D)	141,614	0.00	Inf.00	1.26	Inf.00	
IMR Weighted N (U)	181,020	0	38.22	32	233	30.13
IMR Weighted N (D)	181,020	0	27.84	22	233	23.12

N denotes a dyad-year, all dyad-years included. Cluster distance is along-river flow-connected distance between dyads. International denotes crossing an international border; Cross-Adm 1 is crossing a state/province border; Cross-Adm 2 is crossing a county/district border. Urban U, Urban D denotes urban up and downstream clusters.

- Because of Markov structure and since the SCs are forward-looking, sustainable continuation contracts depend on current state s only
- Pareto frontier at time t state s depends on s and not past history
- **Want to Know:** Shape of Pareto frontier and where it's defined
- **First need:**
 1. Convexity of set of sustainable contracts
 2. Convexity of set of sustainable discounted surpluses (i.e. \exists a sustainable contract delivering such surpluses) for each representative consumer

Show that a convex combination of two sustainable contracts is a sustainable contract:

- For $\alpha \in (0, 1)$, consider two original contracts $\mathcal{T}(\cdot) = \{\tau(\cdot), \omega(\cdot)\}$ and $\hat{\mathcal{T}}(\cdot) = \{\hat{\tau}(\cdot), \hat{\omega}(\cdot)\}$, and define the consumption and water transfers respectively after each history h_t to as follows:

$$\alpha\tau(h_t) + (1 - \alpha)\hat{\tau}(h_t)$$

$$\alpha\omega(h_t) + (1 - \alpha)\hat{\omega}(h_t)$$

- $u(\cdot)$ and $v(\cdot)$ are concave, so this new average contract offers at least the average of surpluses from the original \mathcal{T} and $\hat{\mathcal{T}}$ for both consumers from any history h_t , so SCs (Equations ?? and ??) hold, i.e. this is a sustainable contract.

« Include subset of characterization from original Ligon et al. (2002), see what might be different » [Additional Slides](#)

Because of

- 1) Markov structure (can be irreducible)
- 2) Efficient contract \Rightarrow efficient continuation contract
- 3) Concavity of period utility functions

The set of sustainable discounted surpluses for each household is an interval!

Because of

- 1) Markov structure (can be irreducible)
- 2) Efficient contract \Rightarrow efficient continuation contract
- 3) Concavity of period utility functions

The set of sustainable discounted surpluses for each household is an interval!

For Upstream: $[\underline{U}_s, \bar{U}_s]$, and $\underline{U}_s \geq -P_1(s)$

For Downstream: $[\underline{V}_s, \bar{V}_s]$, and $\underline{V}_s \geq -P_2(s)$

Let $V_s(U_s)$ be the ex-post Pareto efficient frontier.

Goal: Be on the Pareto Frontier $V_s(U_s)$

$$V_s(U_s) = \max_{\tau_s, (U_r)_{r=1}^S} (v(y_2(s)) + \tau_s) - v(y_2(s)) + \delta \sum_{r=1}^S \pi_{sr} V_r(U_r)$$

Subject to:

- 1) Upstream getting surplus at least U_s (LM: λ)
- 2) Upstream not walking away (LM: ϕ_r)
- 3) Downstream not walking away (LM: μ_r)
- 4) Upstream's nonnegativity of consumption (LM: ψ_1)
- 5) Downstream's non-negativity of consumption (LM: ψ_2)

$$\text{Characterization: } \lambda_r = \frac{v'}{u'} - \frac{\psi_1 - \psi_2}{u'} = -V'_r(U_r)$$

Proposition 1: Constrained-Efficient Contract

A constrained-efficient contract is a transfer scheme where there exist S state-dependent intervals $[\underline{\lambda}_r, \bar{\lambda}_r]$, $r = 1, 2, \dots, S$ such that $\lambda(h_t)$ is given by, for r the state at $t+1$:

$$\lambda(h_{t+1}) = \begin{cases} \underline{\lambda}_r & \text{if } \lambda(h_t) < \underline{\lambda}_r := -V'_r(\underline{U}_r) \\ \lambda(h_t) & \text{if } \lambda(h_t) \in [\underline{\lambda}_r, \bar{\lambda}_r] \\ \bar{\lambda}_r & \text{if } \lambda(h_t) > \bar{\lambda}_r := -V'_r(\bar{U}_r). \end{cases} \quad (3)$$

This characterizes the contract completely for initial value λ_0

- If you can get first-best, don't change λ
- If you can't, change as little as possible to get into the new interval

Examples

Miscellaneous

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

Identical prefs $\Rightarrow \xi_{hh} = \xi_{\ell\ell} = 1$

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

Low period:

$$y_\ell = y_h - d$$

Expected income per period:

$$y_h - pd$$

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

Low period:

$$y_\ell = y_h - d$$

Expected income per period:

$$y_h - pd$$

Four states (Upstream, Downstream): $(h\ell), (hh), (\ell\ell), (\ell h)$

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

Low period:

$$y_\ell = y_h - d$$

What's the full-insurance transfer?

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

Low period:

$$y_\ell = y_h - d$$

What's the full-insurance transfer?

$$\tau_{h\ell} = \frac{d}{2}, \text{ Upstream gives Downstream half}$$

$$\tau_{\ell h} = -\frac{d}{2}$$

$$\tau_{\ell\ell} = \tau_{hh} = 0$$

- IID income shocks, no punishments
- Two states y_h, y_ℓ
- Each HH suffers loss d with probability $p \in (0, 1)$
- Identical log preferences $u(c) = v(c) = \log(c)$

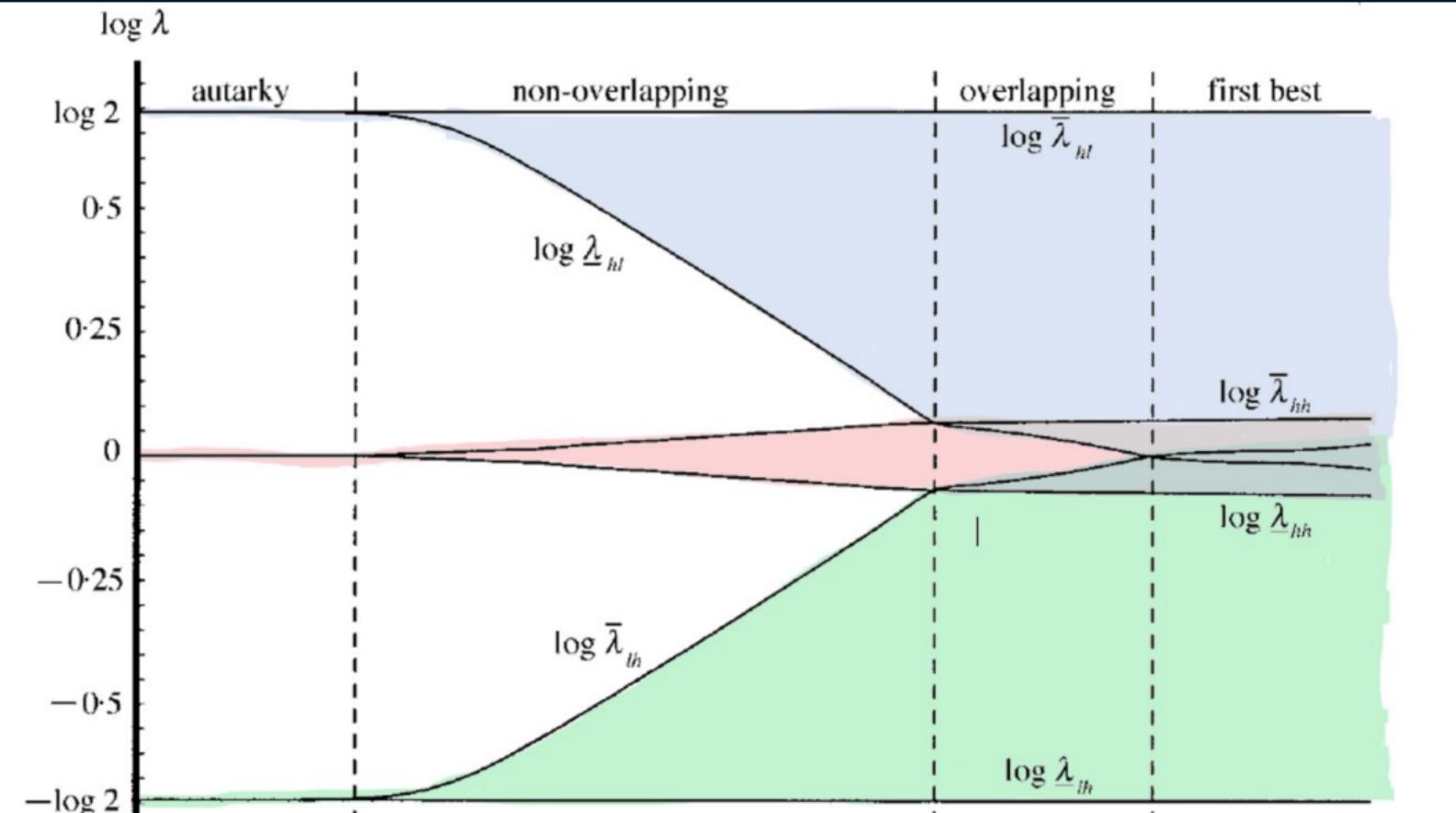
Because of the log, $[\underline{\lambda}_{hh}, \bar{\lambda}_{hh}] = [\underline{\lambda}_{\ell\ell}, \bar{\lambda}_{\ell\ell}]$

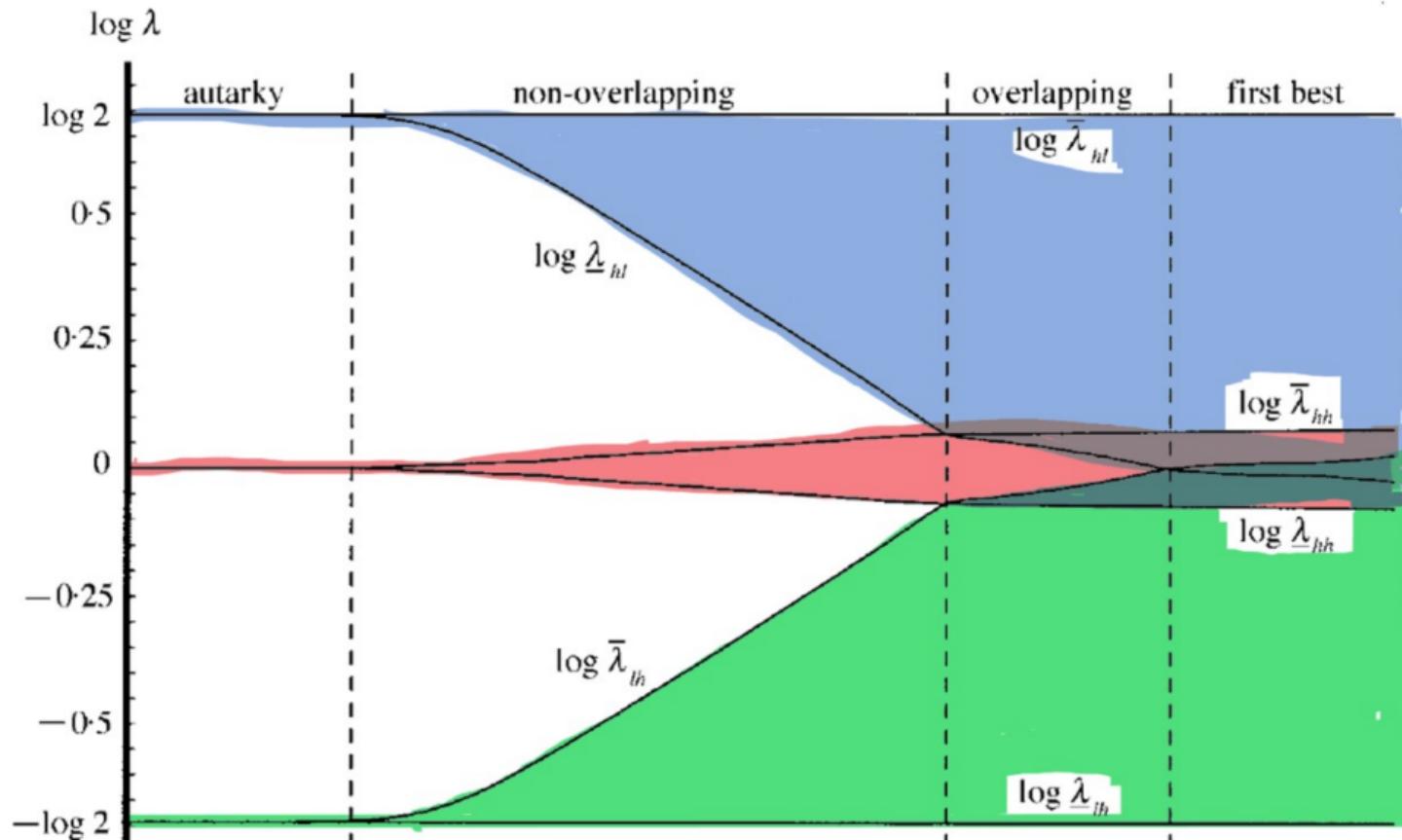
By symmetry:

$$\underline{\lambda}_{h\ell} = \frac{1}{\bar{\lambda}_{\ell h}}$$

$$\underline{\lambda}_{\ell h} = \frac{1}{\bar{\lambda}_{h\ell}}$$

$$\underline{\lambda}_{hh} = \frac{1}{\bar{\lambda}_{hh}}$$





- 1) Suppose we're in $\delta \in (.935, .965)$
- 2) Upstream gets a bad shock: ℓh
- 3) $\lambda \rightarrow \bar{\lambda}_{\ell h}$, for $1 > \bar{\lambda}_{\ell h} > \xi_{\ell h} = \frac{1}{2}$
- 4) Downstream transfers $\tau < \frac{d}{2}$ to Upstream s.t. $\frac{v'(c^2)}{u'(c^1)} = \bar{\lambda}_{\ell h}$
- 5) Updating rule: $\frac{v'(c^2)}{u'(c^1)} = \bar{\lambda}_{\ell h}$ until $h\ell$ occurs ($hh, \ell\ell$ Upstream \rightarrow Downstream. Why?)
- 6) At $h\ell$, situation reverses: $\lambda \rightarrow \underline{\lambda}_{h\ell}$
- 7) Like a debt contract that gets repaid until another bad shock hits only one HH
 - If both HHs hit, still repay
 - If one HH hit, the previous history is forgiven, start fresh

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Professors (occasional): Rohini Pande, Ken Gillingham, Robert Jensen

Ideas: Pam Jakiela, Owen Ozier, Carl Obst

Peers:

Fellowships: SYLFF

Examples

Miscellaneous

DHS contains:

HV101: relationship to household head (use for: do parents live in household)

HV221: whether household has telephone

HV236: person fetching water (only old DHS)

Child Labor Module Variables: worked for someone outside household, hours worked,fetched wood or water (hours); worked for family member (hours); did domestic household work (hours)

V130: religion; V131 Ethnicity (for size of other possible insurance networks?)

V167: number of trips away from home for one or more nights in last 12 months

V740: whether respondent works on own land, family land, rented land, or someone else's land (not core DHS VII anymore)

DHS contains:

- HV111: whether mother of household member is still alive (base: children < 18)
- HV113: whether father of household member is alive (base: children aged < 18)
- H11: whether child had diarrhea in last 24 hours or last 2 weeks

DHS contains:

HV201: main source of drinking water

HV202: main source of water for use other than drinking

HV204: time taken to get water source for drinking water

HV244: owns land usable for agriculture; HV245 hectares for agricultural land

DHS contains:

HV205: type of toilet

HV 20x: whether household has certain durables

HV21x: materials of floors and roofs

HV221: whether household has telephone

HV24x: assets, including most livestock

HV244: owns land usable for agriculture; HV245 hectares for agricultural land

HV270: wealth index

MV484: smoking per week

DHS contains:

- V104: number of years living in the village/town/city of being interviewed
- V705: partner's occupation groups; V717 respondent's occupation group
- MV605: desire for more children; MV613: ideal number of children; MV621 whether partner agrees
- MV72x: working, at home or away; worked in the last 12 months; seasonal, occasional, or annual worker
- MV740: whether respondent works in own, family, rented or someone else's land (not core DHS VII anymore)
- V169: owns mobile telephone (and uses for financial transactions)
- V167-168: times away from home for 1 night or more in last 12 months

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