POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

CIREG
Climate Information for Integrated Renewable Electricity Generation

Recent and future developments in the Volta River basin from a Nexus perspective

Synergies and trade-offs between different water users under climate change

Liersch, S., Koch, H., de Condappa, D., Abungba, J.A., Salack, S, Hattermann, F.F.

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Leibniz Association

Context...

...of the study on the Volta basin.

To feed the growing populations, achieve SDGs and NDCs, West African countries need to invest in:

- Sustainable agricultural development
- Renewable energy

Irrigation and hydropower are part of solution portfolio

- Both depend on water availability and…
- …compete for the resource!

Hydrological and management modelling

Eco-hydrological model

- Process-based
- Semi-distributed
- Daily time step

Implementing water management

- Reservoirs / dams: Water storage, supply, hydropower, flood protection
- Water allocation between water users
- Irrigation (sources: rivers, reservoirs, external sources)

Volta River Basin

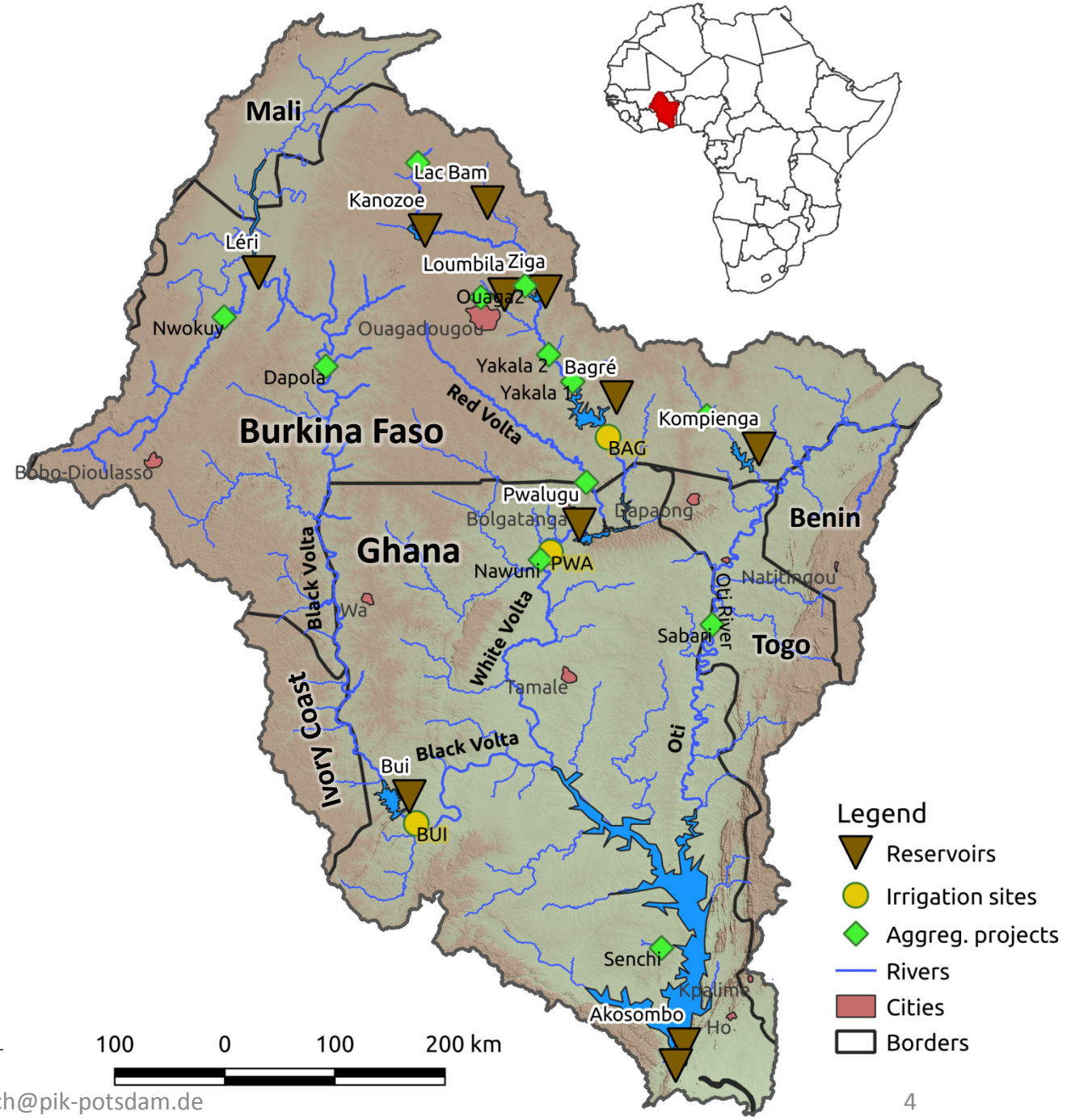
West Africa

Water management

- 10 existing dams, + Pwalugu dam
- 3 irrigation sites (planned)
- 12 aggregate small projects

Attribution

- Impacts of individual projects
  - Water resources
  - Hydropower potential
  - Each other



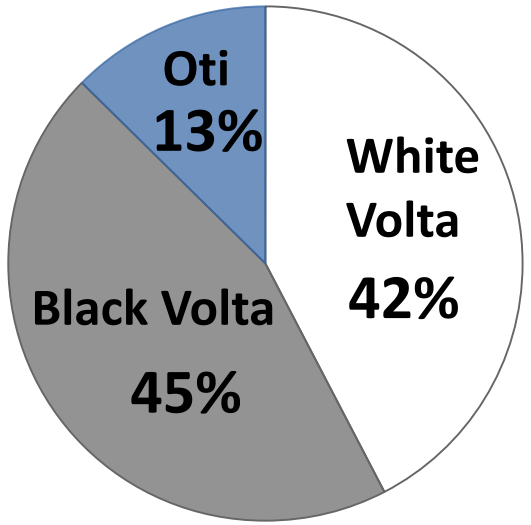
Impacts at Akosombo

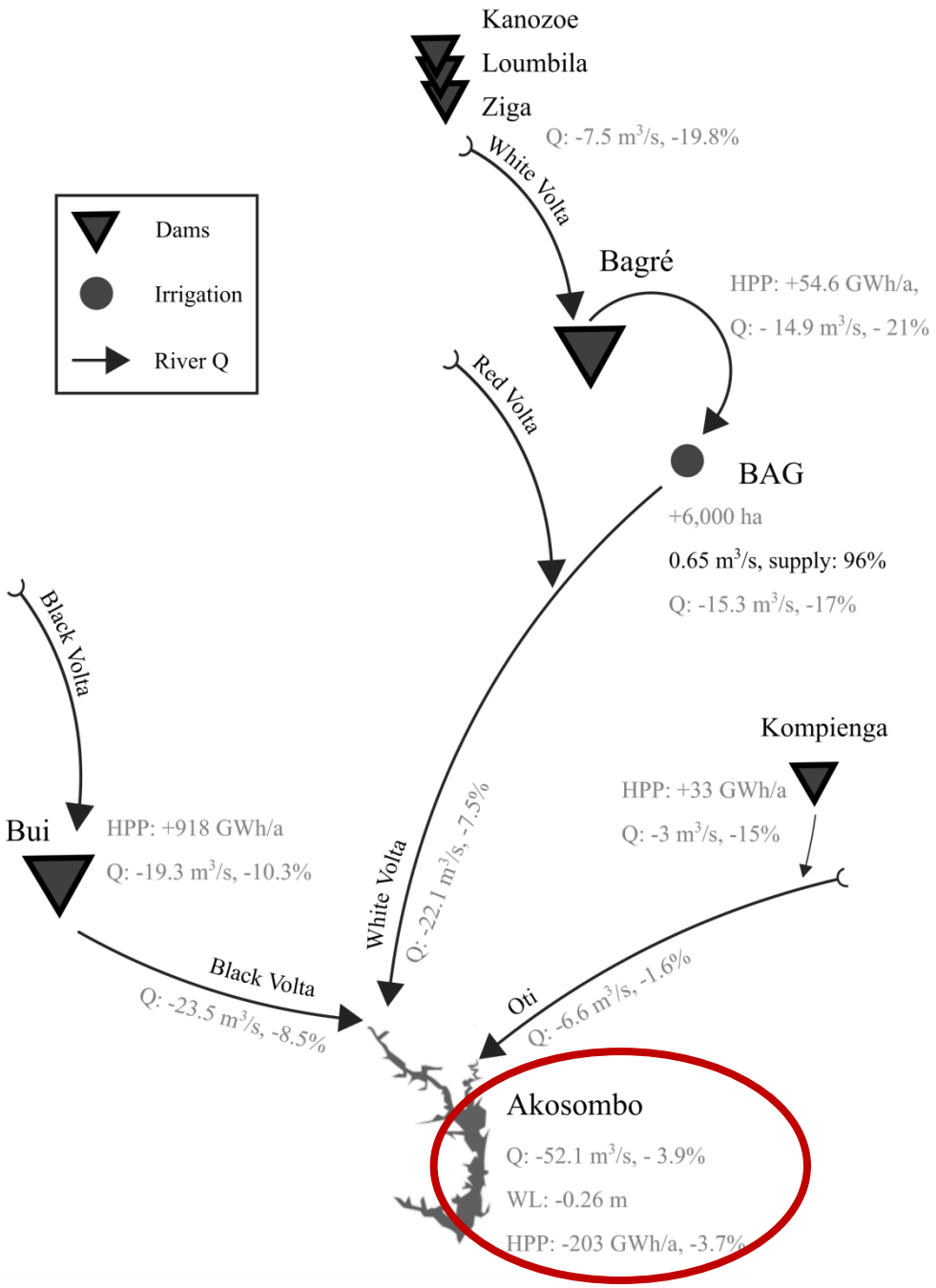
From natural state until today

Akosombo

- **Inflow: -52.1 m³/s (3.9%)**
- **Hydropower: -203 GWh/a (3.7%)**

12% electricity consumption BF
27% of Ghana‘s electricity export (2019)





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Planned infrastructure

Future projects

Irrigation sites

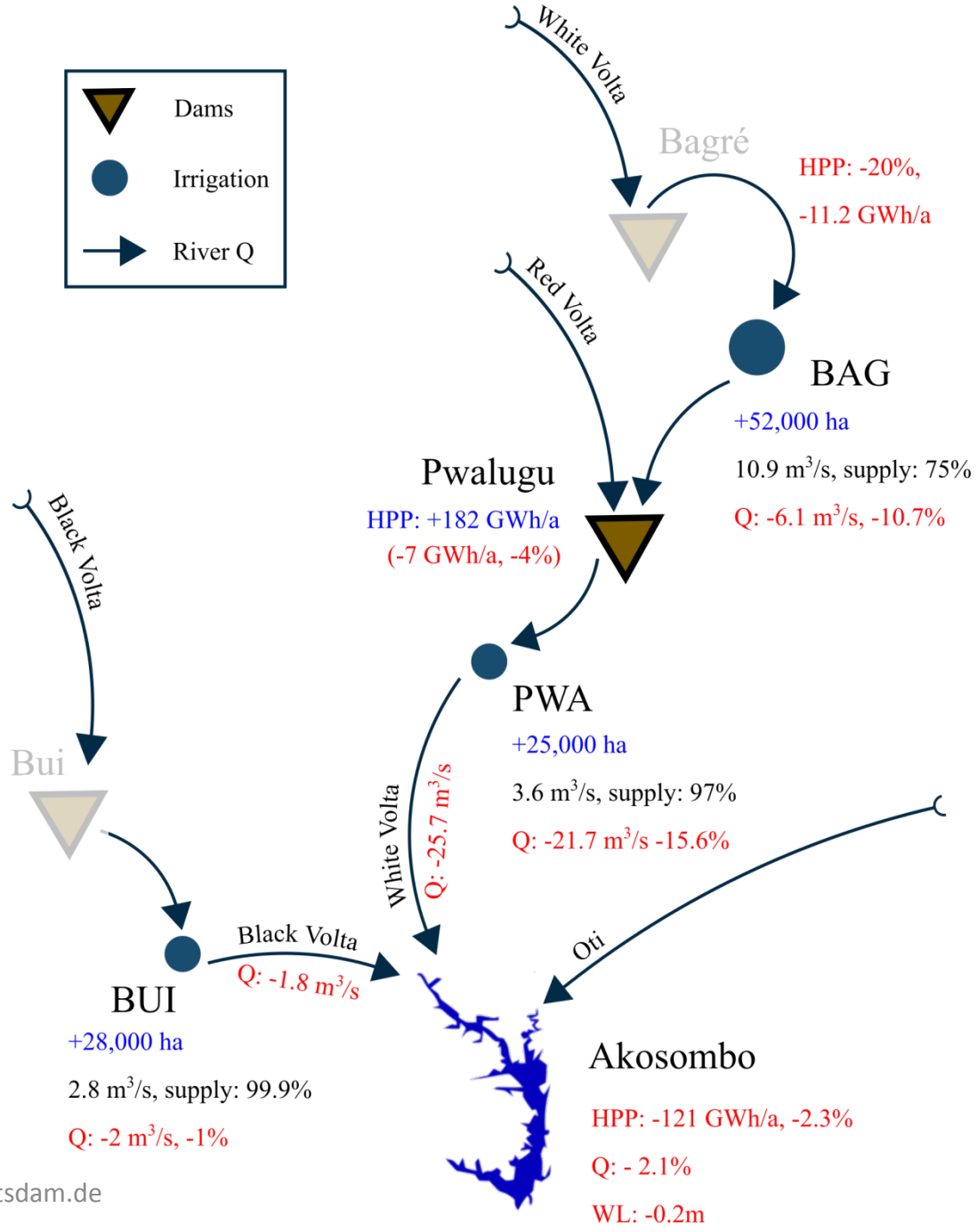
- + 52,000 ha (BAG)
- + 25,000 ha (PWA)
- + 28,000 ha (BUI)

= +105,000 ha

Hydropower

- **Pwalugu multi-prupose dam**

  +189 GWh/a



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Trade-offs

Attribution of future developments

Akosombo

-27.5 m³/s (2.1%)

-121 GWh/a (2.3%)

40% irrigation

60% Pwalugu dam

BAG (22%)

- -6.1 m³/s
- -18.2 GWh/a (Bag & Pwa)
- -26.8 GWh/a (Akosombo)

Pwalugu dam (60%)

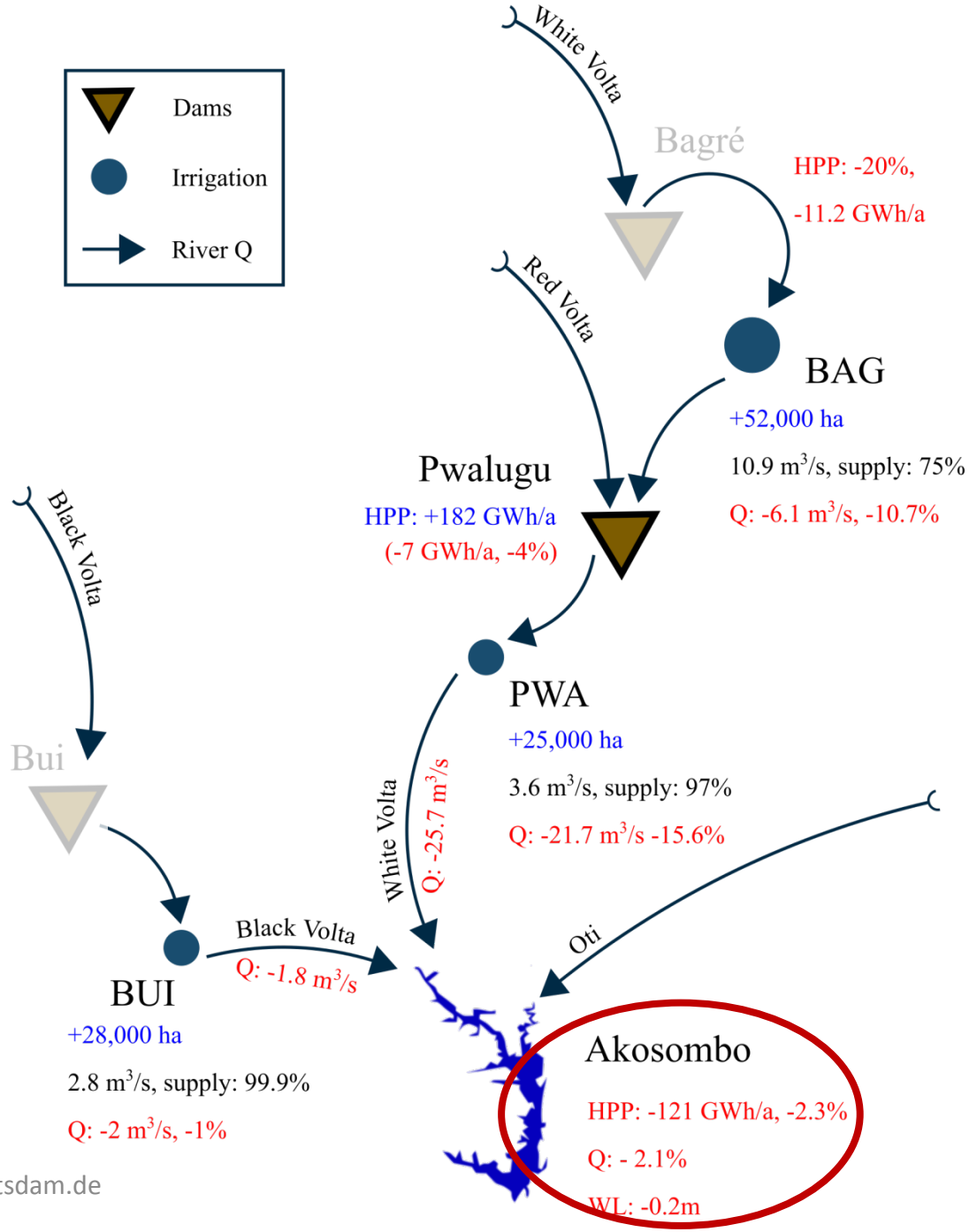
- -16.7 m³/s
- -73.5 GWh/a

PWA (11%)

- -2.9 m³/s
- -12.8 GWh/a

BUI (7%)

- -1.8 m³/s
- -7.9 GWh/a



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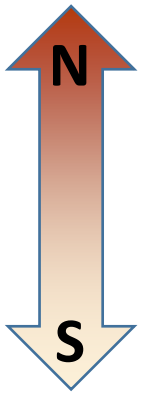
Irrigation water demand

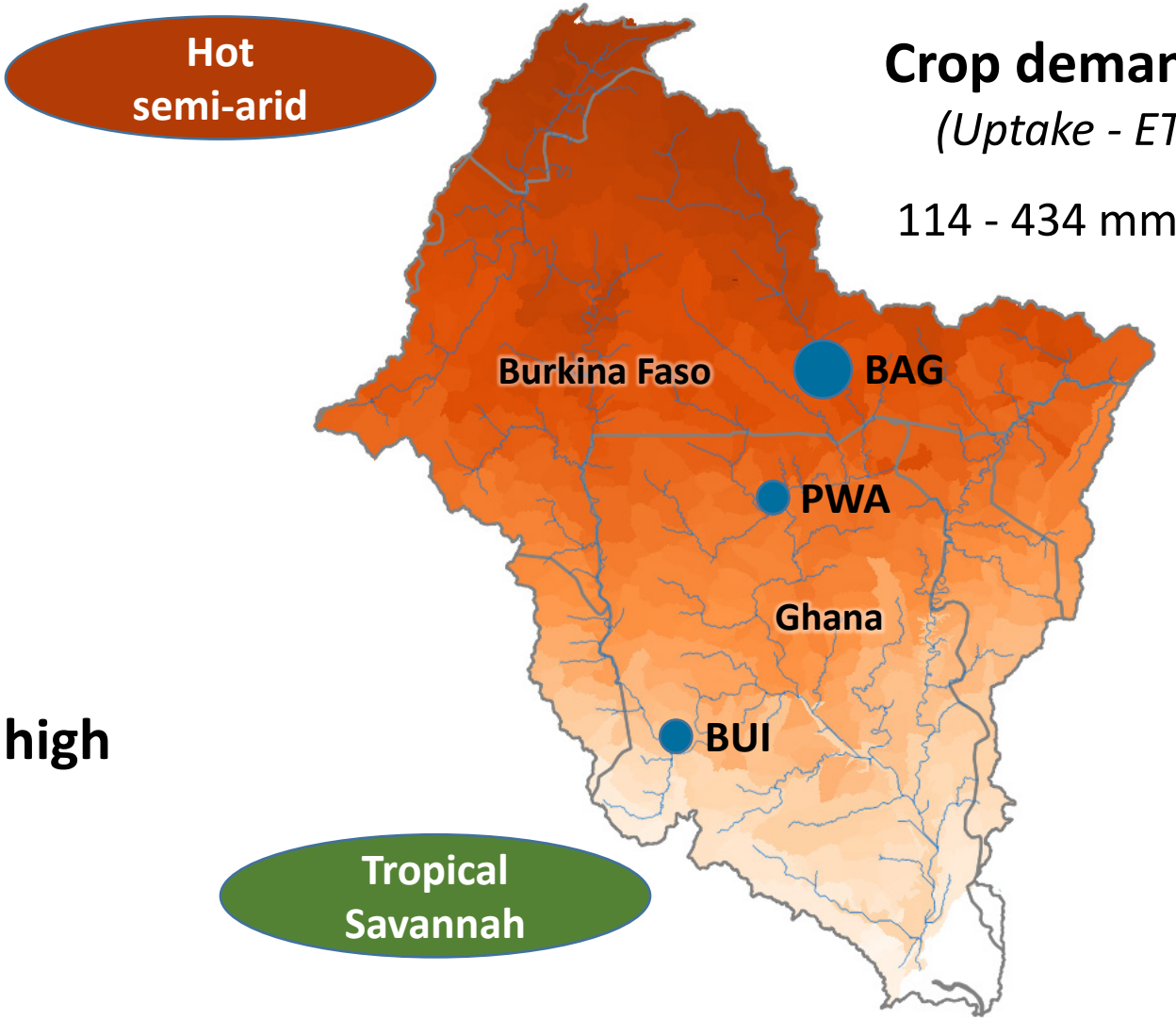
Climate: W5E5 (1984-2014)



Irrigation demand

- BAG: 586 mm/a
- PWA: 480 mm/a
- BUI: 312 mm/a

Relative demand almost twice as high at BAG than at BUI



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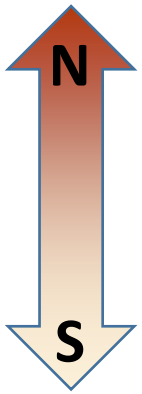

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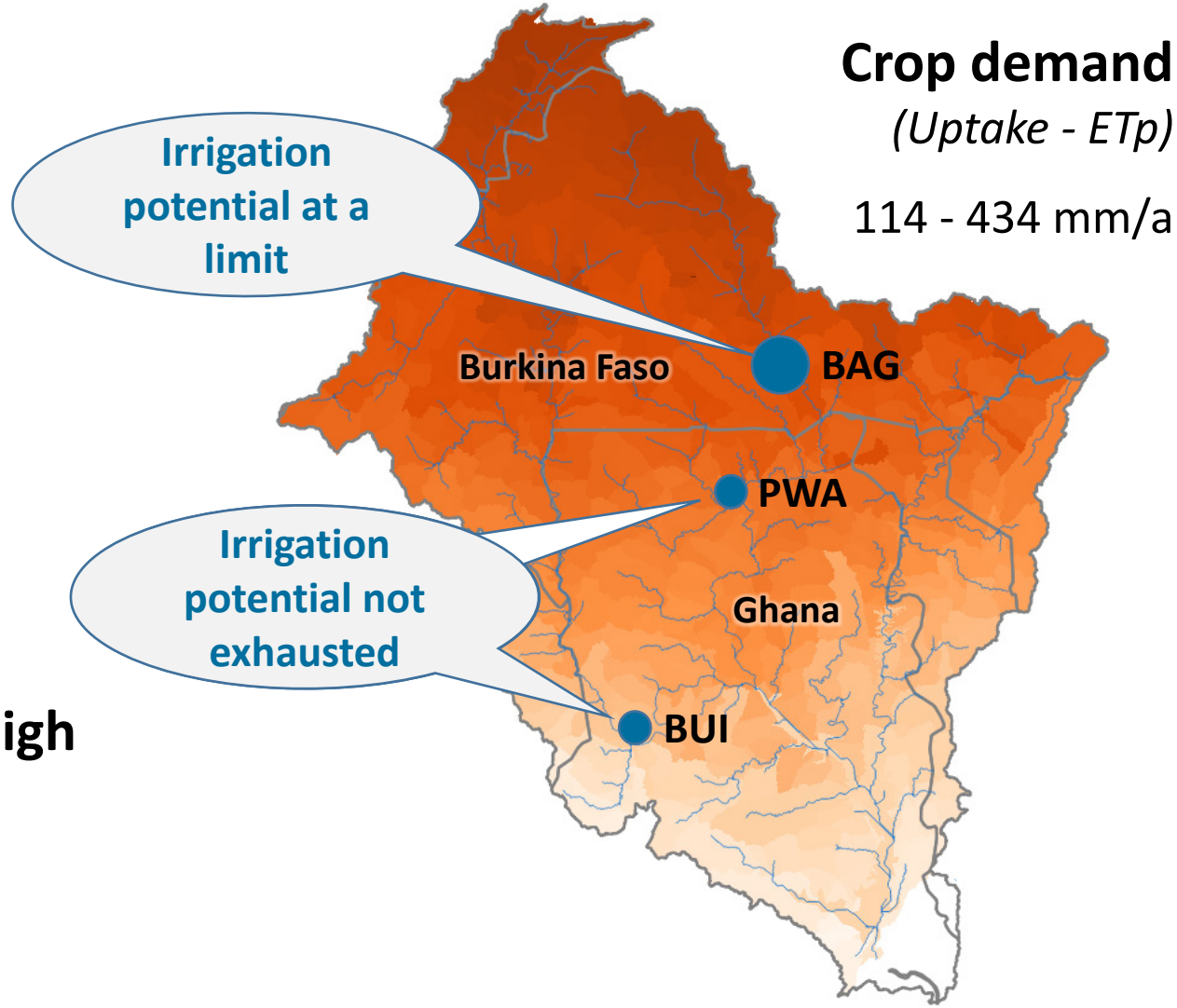


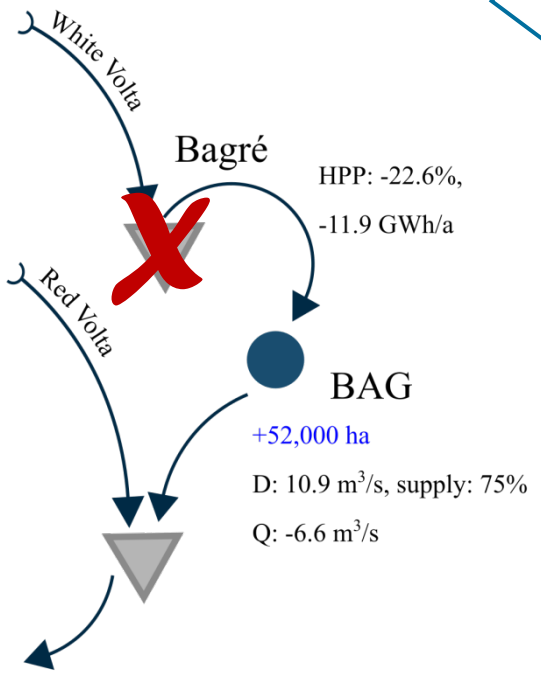
Crop demand
(Uptake - ETp)

114 - 434 mm/a

Synergies

Bagré dam **enabling** dry-season irrigation

No Bagré dam...



...no discharge

November and April

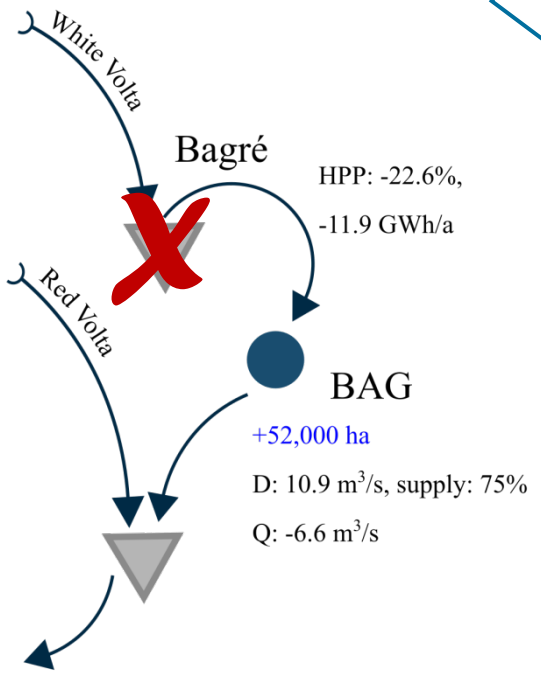
Deficits = 100%

... dry-season irrigation impossible!

Synergies

Bagré dam **enabling** dry-season irrigation

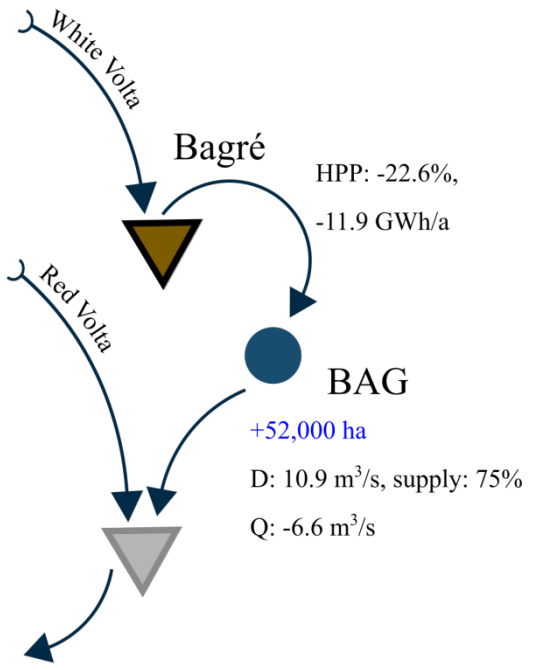
No Bagré dam...



...no discharge
November and April
Deficits = 100%

... dry-season irrigation impossible!

With Bagré dam...



... discharge *all year around*
Deficits = 25%

... dry-season irrigation possible!

Trade-offs

Bagré irrigation (BAG_irr) impacts

Hydropower reduction

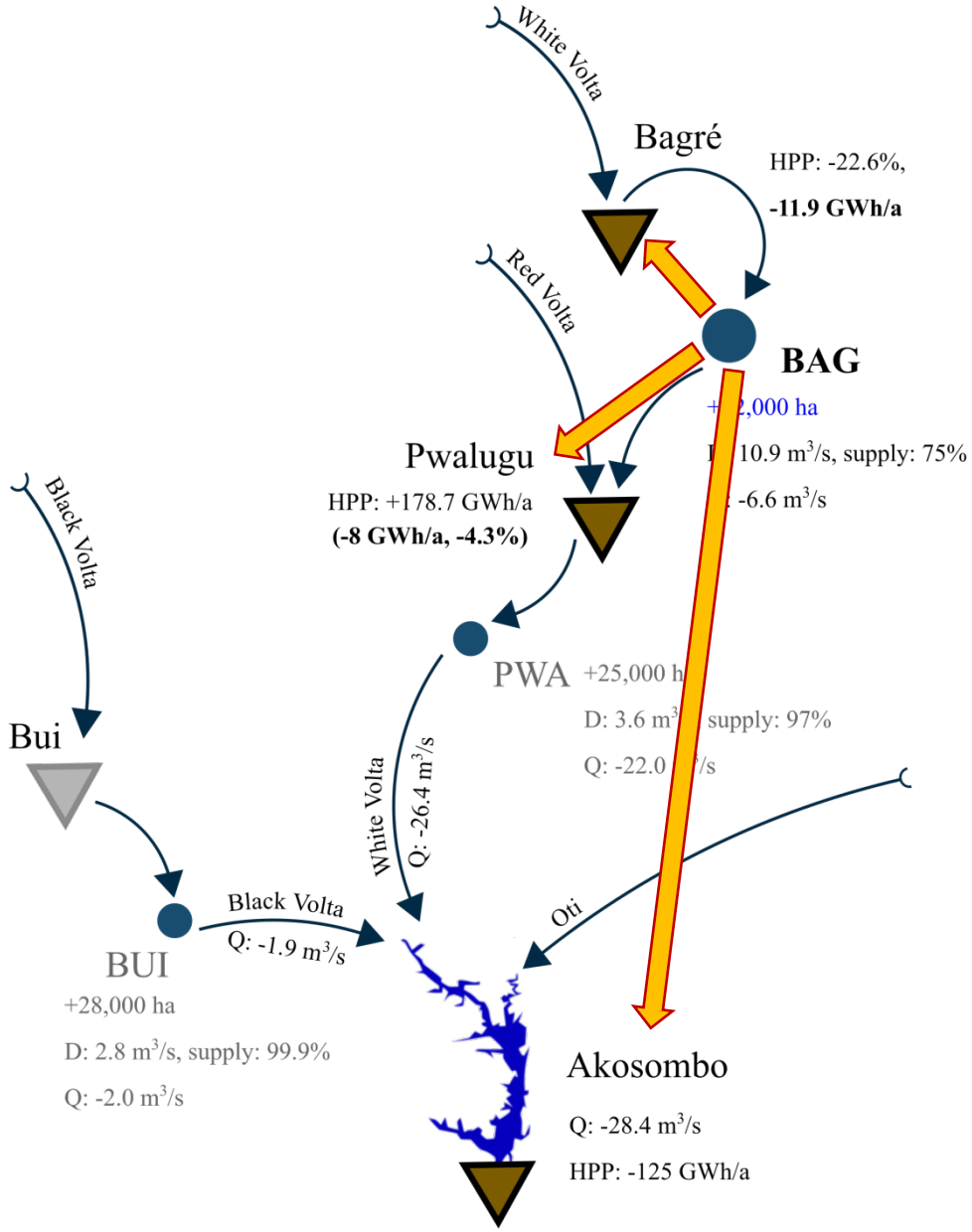
- Bagré: -12 GWh/a
- Pwalugu : -8 GWh/a
- Akosombo : -34 GWh/a

} 3 stations

- **Total: -54 GWh/a**

Water resources

- 6.6 m^3/s
- 12%



Trade-offs

Bagré irrigation (BAG_irr) impacts

Hydropower reduction

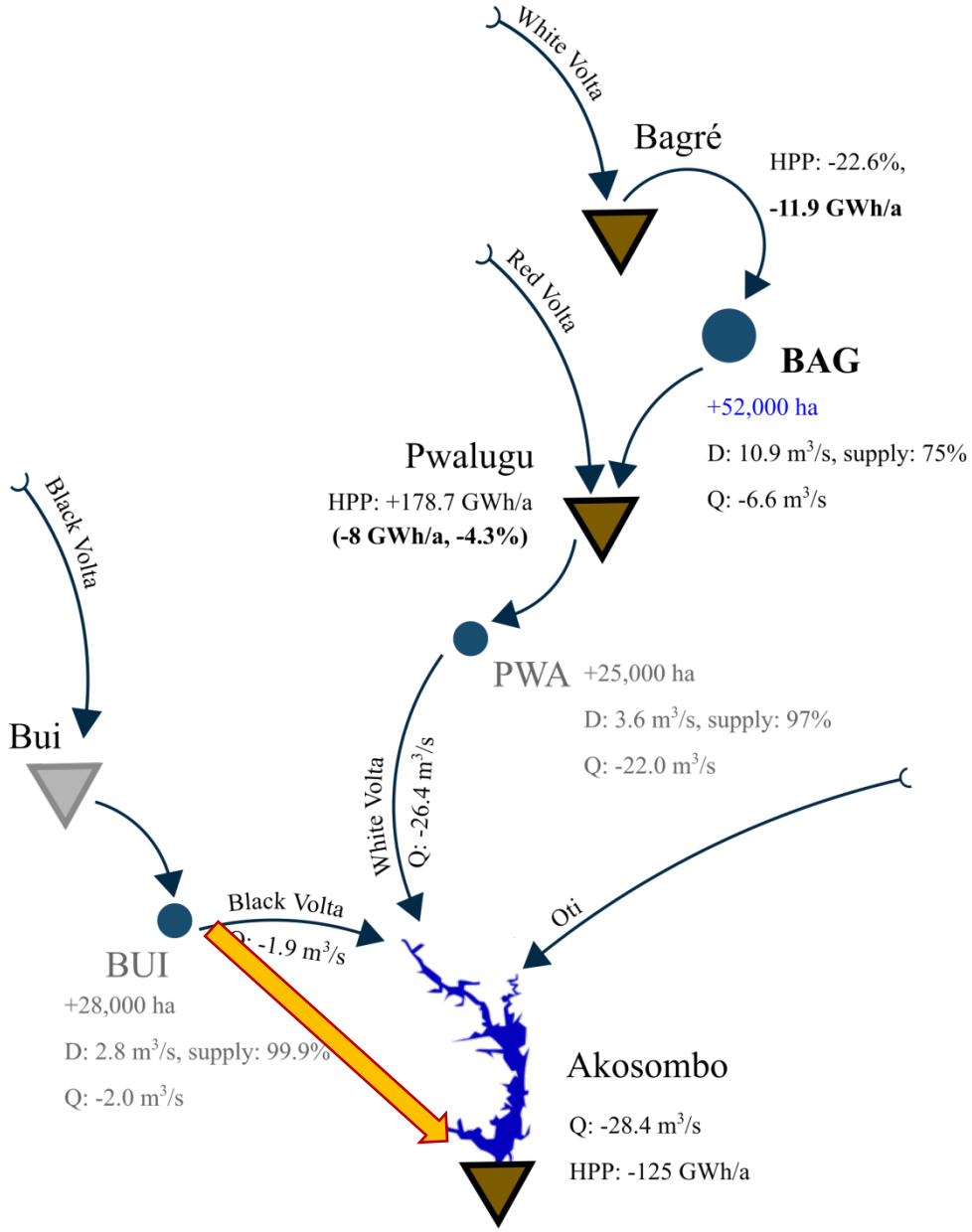
- Bagré: -12 GWh/a
- Pwalugu : -8 GWh/a
- Akosombo : -34 GWh/a

} 3 stations

- **Total: -54 GWh/a** **BUI_irr = -10 GWh/a**

Water resources

- 6.6 m^3/s
- 12%



Irrigation costs

…in terms of hydropower potential

Irrigation site	=	**10-54 GWh/a**
1 ha	=	42-120 Watts

Depending on:

- hydro-climatic conditions
- number of hydropower plants affected

Irrigation costs

…in terms of hydropower potential

Irrigation site	=	10-54 GWh/a
1 ha	=	42-120 Watts
1 Person	=	**8-24 Watts**

Depending on:

- hydro-climatic conditions
- number of hydropower plants affected

1 ha feeds 5 people

(Assumption, global average)

Thank you for your attention!

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