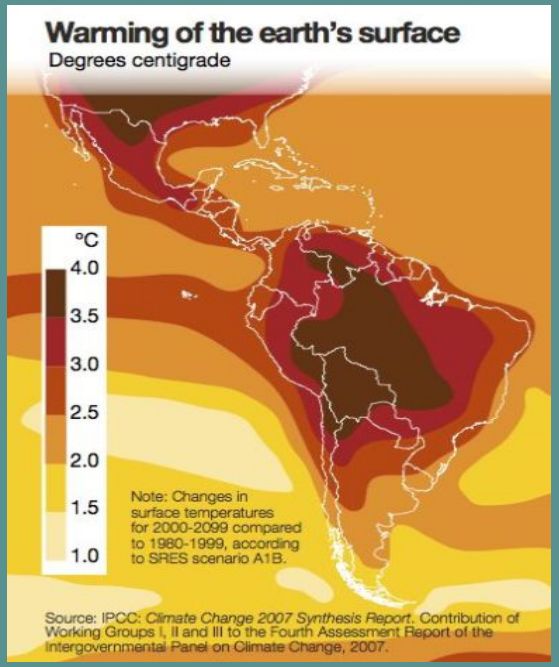
Climate Change Impacts on Peru's Hydropower



GREEN Program Capstone

May 21, 2018

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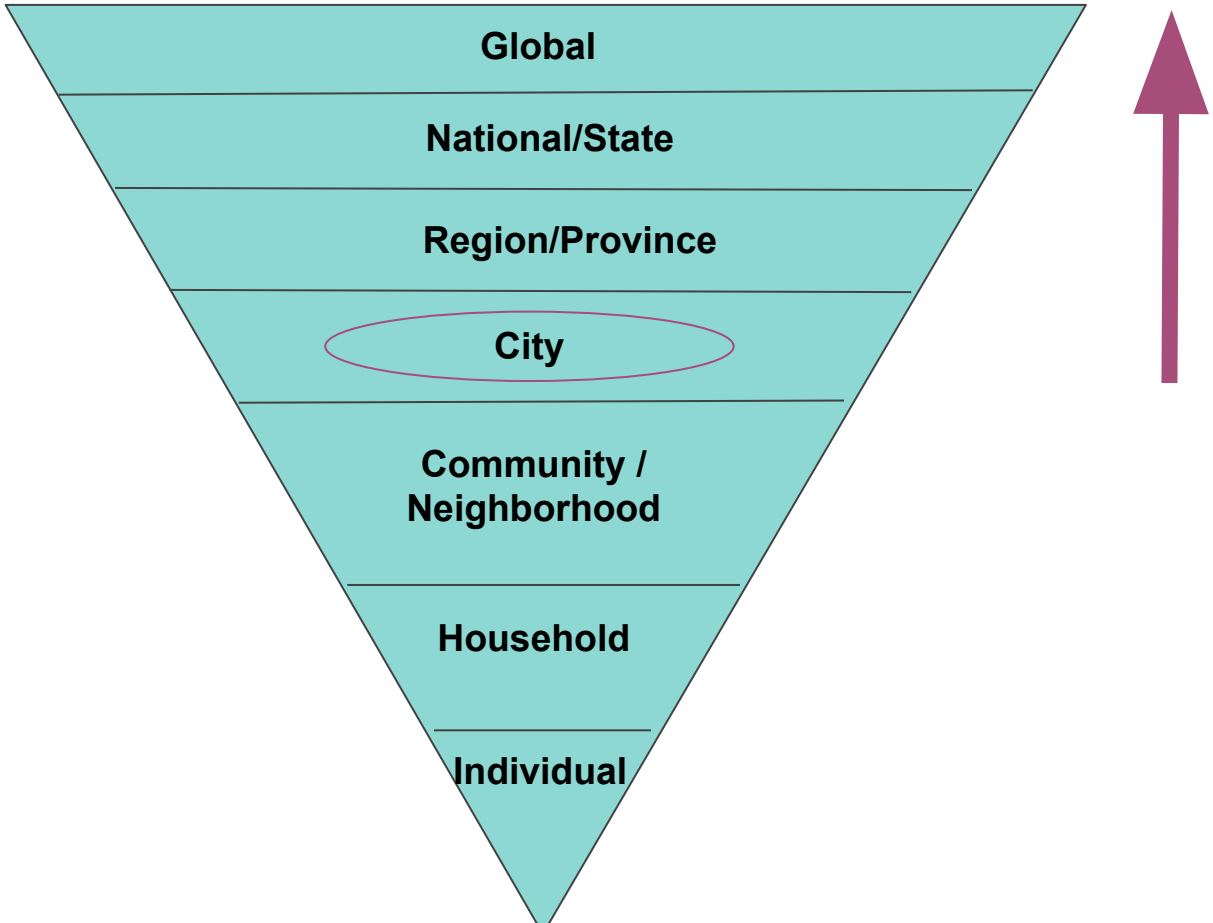
Goals

- Affordable and Clean Energy (#7)
- Industry, Innovation, and Infrastructure (#9)
- Climate Action (#13)

The Sustainability Complex



General Hydropower Information

- Hydropower is largest source of renewable energy in world
  - 16% of all electricity in the world, 65% in Latin America, 52% in Peru
- > 20% of feasible hydro potential in Latin America still untapped
- Major markets:
  - Brazil, Chile, & Colombia
- Countries looking to expand hydropower use:
  - Paraguay, Venezuela, **Peru**, Bolivia, Ecuador, Panama, Haiti, Mexico, Costa Rica & Argentina

Peru's Alternative Energy Sources (2014)

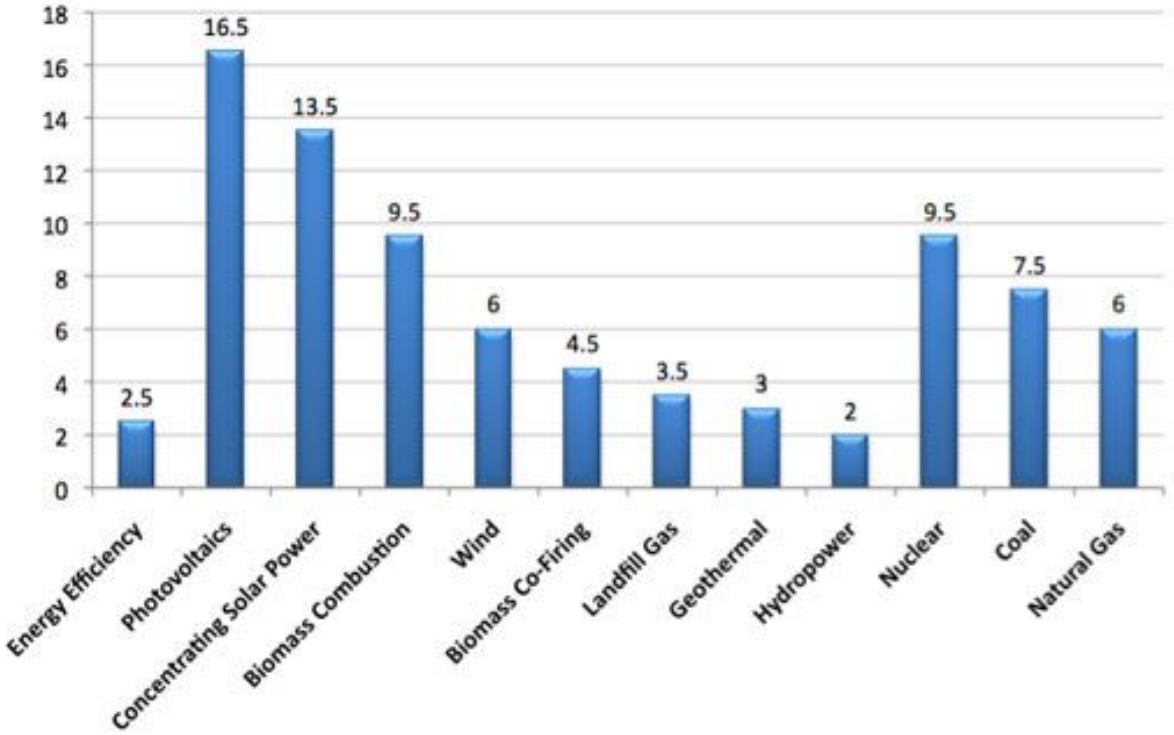
Recourse	Total power potential (MW)	Installed capacity (MW)
Hydroelectric	70,000	3,118
Wind	22,000	142
Solar		80
Biomass	450	27,4
Geothermal	3,000	0

- "High" potential for all, except biomass
- Development favorable in Amazon and Andes regions, but great investment in transmission infrastructure needed

Hydropower

PROS	**CONS**
Cheap to operate & maintain	High construction costs
Long lifespan	Failure hazard
Extremely efficient	Relocation of people
More reliable / stable	Harmful for animals / plants
Emissions-free	Limited number of sites

Electricity Cost for Various Energy Sources (cents per KWH)



- Hydropower is shown to be the least expensive energy source!

Peru Hydropower Facility

Santa Teresa Hydro Plant in Machu Picchu region

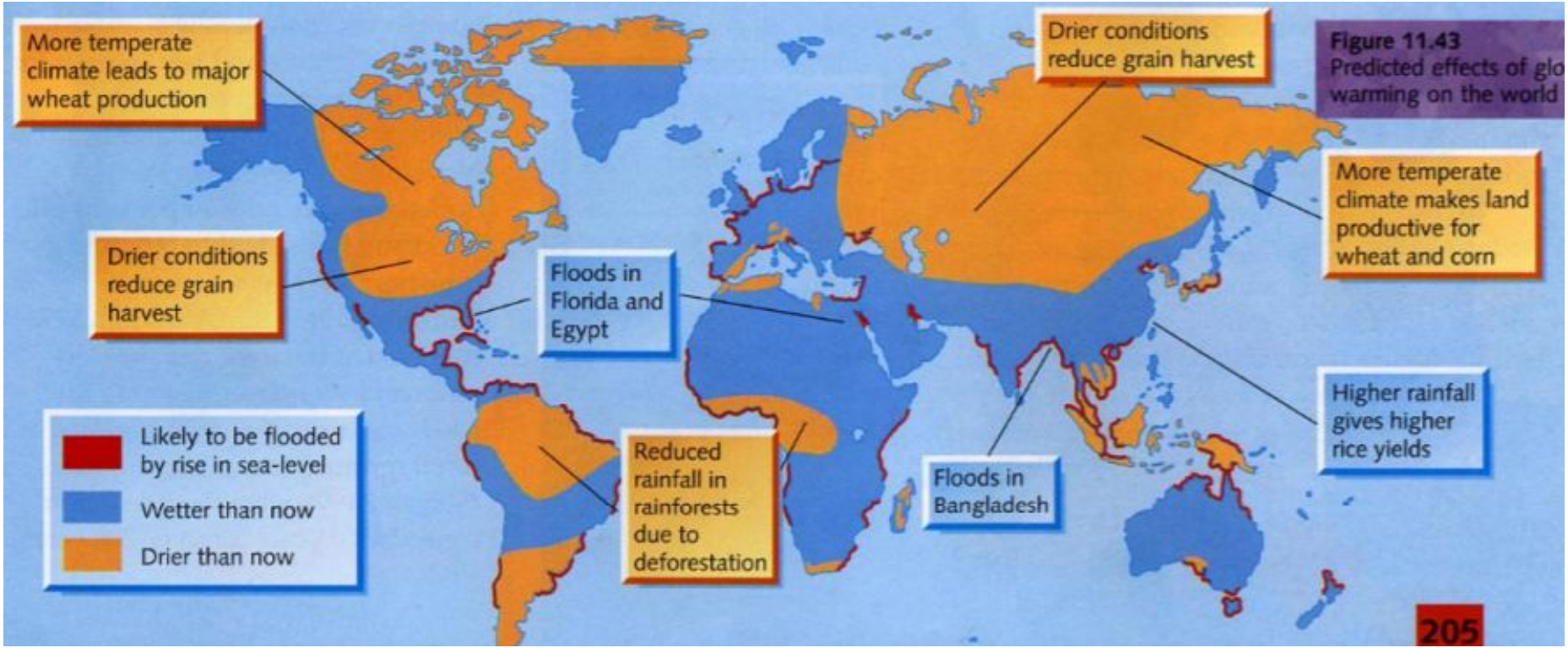
Peru Hydropower Facility

- Collects water from the Cusco polluted river
- First captures larger sediments with bars 1-3 in. apart (i.e. tires, plastic, bodies)
    - Hooks capture these objects, and can be cleaned every set amount of time (i.e. every 2 hours)
- Water then travels through 2 channels on one side, 4 channels on another, which then sends treated water up the mountain (all channels end up meeting together)
    - Systems have windows to catch smaller sediments before going through turbines (1 in. wide, manually remove smaller wastes every 3 min -12 hr)
    - Organic materials released back into river, inorganic sent to landfills

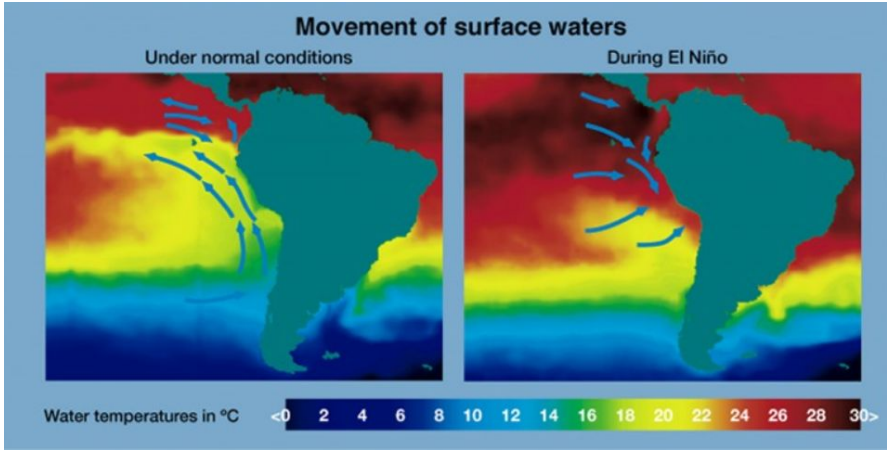
Peru Hydropower Facility

- Once water is sediment free, sent up the mountain (no power used!)
- Funding received due to electricity produced being sold to government & consumers
- 4 generators: 3 produce up to 30 MW each, 1 (Francis) produce 180 MW max
- Turbines: 3 produce up to 20 MW each, Francis produce 100 MW.
    - Transformer: What transforms power into usable electricity; total about 160 MW electricity through Machu Picchu (about 53% of its electricity)
    - Electricity gets sent to other cities such as Cusco

Climate Change Affecting Hydropower



Climate Change Affecting Hydropower



Flooding

- Climate models & scientists do not all agree, but El Nino could increase in intensity & frequency in the future
  - One 2014 study suggested that super El Nino events could double in the future
- Flooding events in certain regions would become more common & catastrophic, especially during the rainy season
- Breaching of hydroelectric dams
  - Hefty costs to fix/rebuild dams, communities, etc.

Climate Change Affecting Hydropower

Pastoruri glacier in Áncash, Peru (30 year difference)

Reduced Water Flow

- Acceleration in glacier melt in the Andes, as a result of rising temperatures
- Increase in flood risk initially, but then reduced water supplies
- Energy sector estimated to lose $40-500 million (2006 World Bank study)
- Peru's glaciers have irretrievably lost over one-third of surface area since 1970

Climate Change Affects Peru Hydropower / Current Adaptations (Part 1 of Facility)

- When river amount gets too low, use the lake in Southern Cusco (water gets sent within 1-2 days), and can compensate for their usage
  - Can get as low as 35 cubic meters and do half the power (usually 60)
  - Usually send about 3-4 cubic meters/sec
- When river amount gets too high, still can only capture most 63 cubic meters
  - Can only maintain a capacity of 900 cubic meters
  - When there is overflow, gates can be shut to resist incoming water
    - If facility needs to be shut down, systems are used to shut down gates and channels
- Use database to keep track of everything
  - Everything is programmed onto the computer
  - Red = Something is wrong

Climate Change Affects Peru Hydropower / Current Adaptations (Part 2 of Facility)

- The climate, amount of supply, & demand affect the amount of energy from the plant
- Everything must be equal at a frequency of 60 Hz (determines the plant reliability!)
  - If freq. drops, must be balanced by other plants (solar, wind, etc)
  - If it drops, plant isn't seen as reliable, and other plants need to increase their supply to meet demand
- Uses its own electricity to sustain itself, rest goes to other cities, then the national grid
- Temperature sensors to determine if the turbines are working, thus if the generators are working
  - Use its own power to keep temperature below 25 Celsius, Humidity is allowed to 80%, or else system will shut down
- Control Room: Takes parameters, identifies any issues with generators
  - If 1 generator stops, Lima needs to use their generator to compensate energy = difficult!

Suggestions for Peru Hydropower Improvement

- Installations of climate monitoring
  - Better adaptations / responses to future droughts & floodings
  - 4 elements of warning system: risk knowledge, monitoring & warning service, dissemination & communication, response capability
- Enforcing climate change / hydropower classes in education
  - I.e. Chile
- Researching water storage sites
  - Even pre-existing dried-out areas for potential use
- Funding
  - For climate monitoring & research
- Public awareness
  - Sharing information behind the hydropower facilities
  - Showing progress over time with more research, monitoring, impact → public can see what their funding is going toward & the improvements being made

Business Model Canvas

Who Will Help You?

Grants / funding through government organizations, public support

How Do You Do It?

Through public awareness, advanced research, risk knowledge, response capability

What Do You Need?

Hydro plant communication & support, Government communication & education

What Do You Do?

Suggesting improvements such as flood/drought monitoring, increased public education, feature water storage sites, and public awareness for further adaptations with climate change in the hydropower facilities

How Do You Interact?

Climate change maps, hydropower information through commercials, flyers

Who Do You Help?

Hydro plants, public communities, eventually regions in L.A.

What Will It Cost?

Average Salary: 1,000 sole each, but specialized for certain positions ; equipment varies; more research needs to be done!

How Much Will You Make?

Not about how much we will make, but how much the community will save through these adaptations

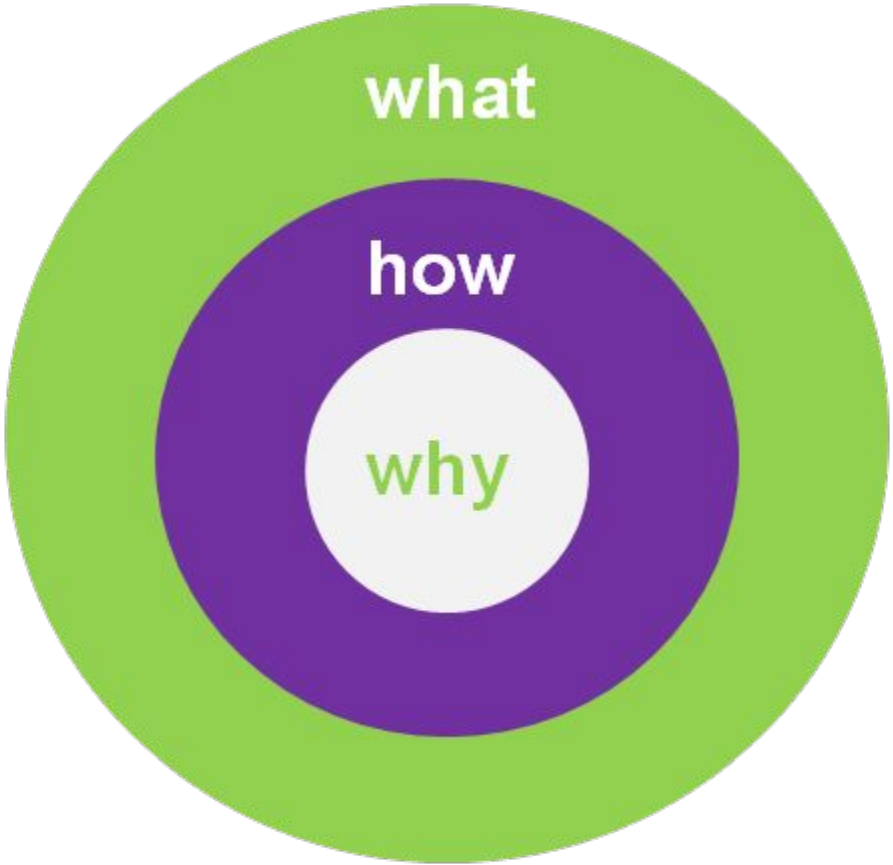
Conclusion

WHAT: Allowing Peru hydropower facilities to adapt to climate change.

HOW: Installing flood/drought warning systems, researching pre-existing water storage sites (possibly even dried out areas)

WHY: Provide water storage, more opportunities for irrigation and freshwater, saving damage costs from flooding in the long run

There needs to be: awareness, research, funding, and implementation!



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Thank You!

Questions?