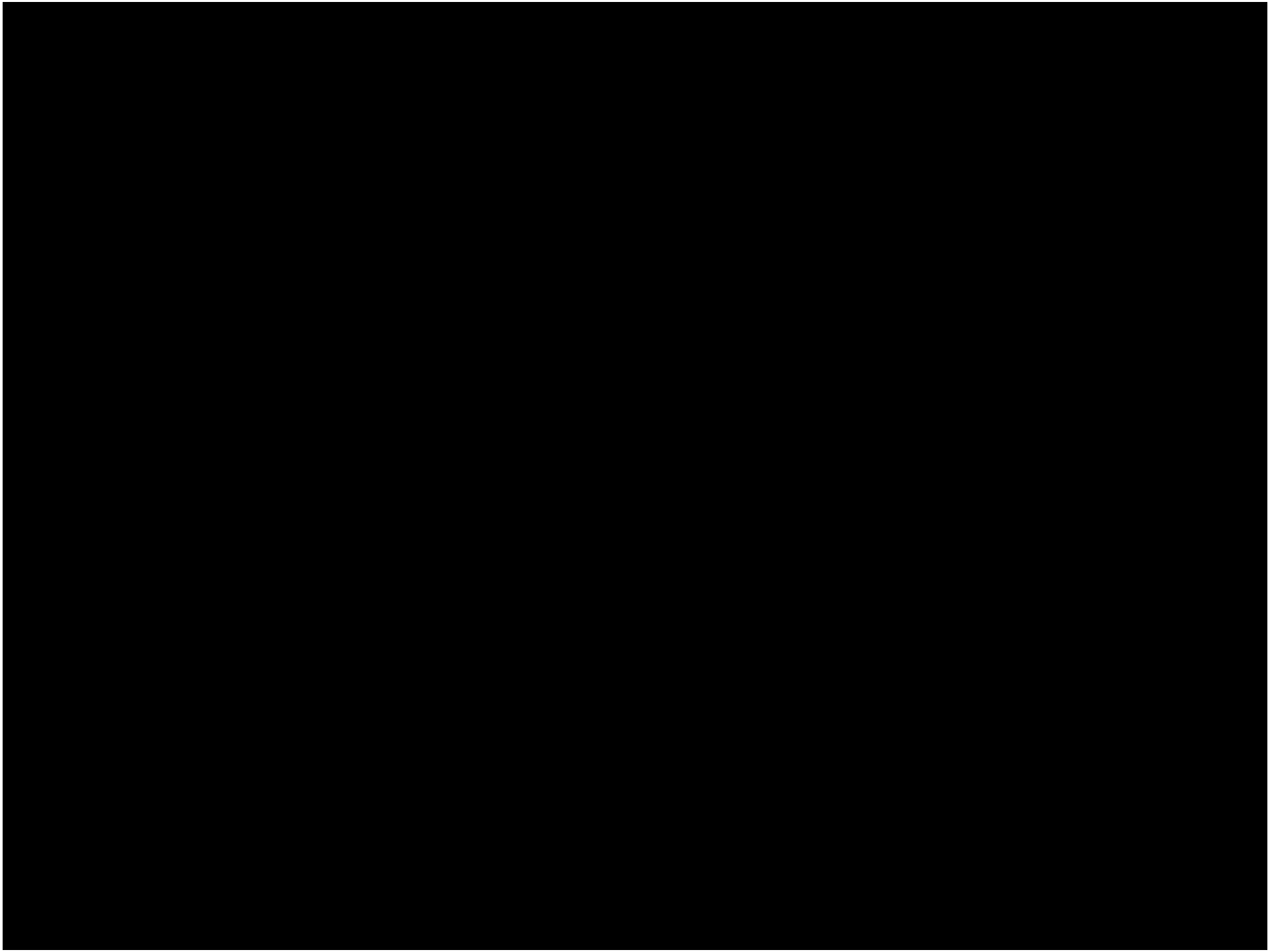
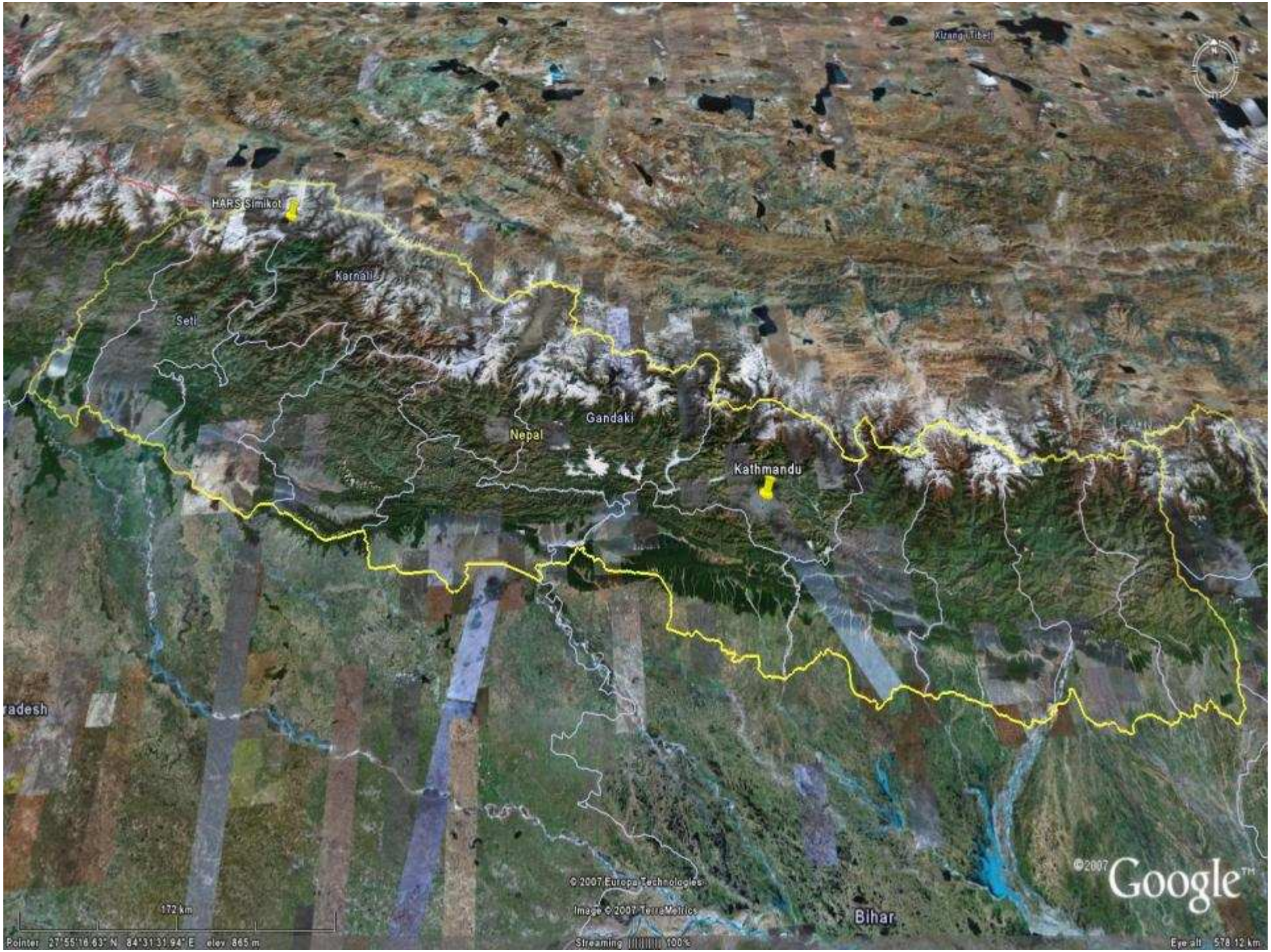
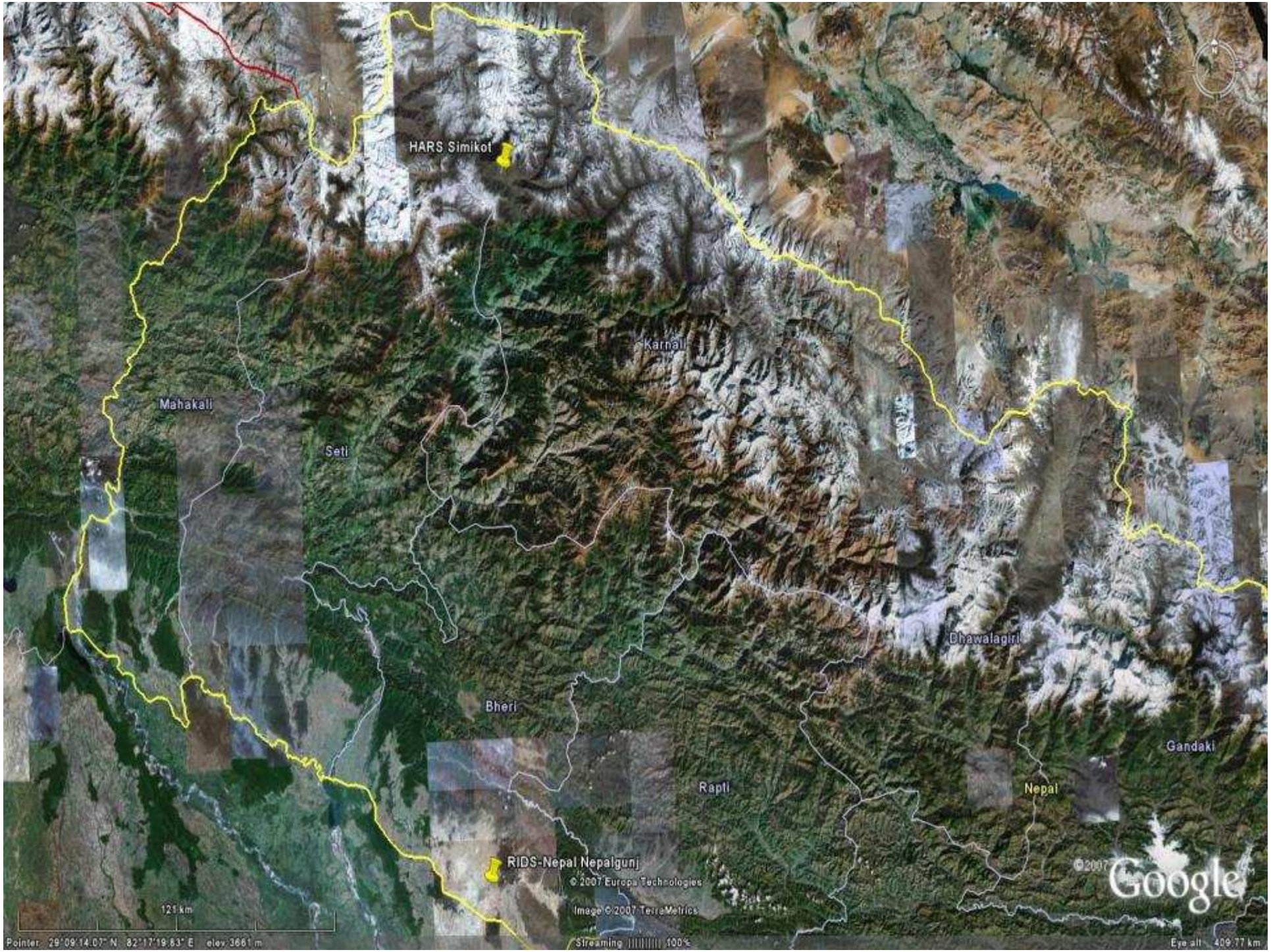



NEPAL


Kyrgyzstan
Uzbekistan
Tajikistan
Turkmenistan
Afghanistan
China
Xizang (Tibet)
Pakistan
Nepal
Bhutan
Bangladesh
Myanmar (Burma)
India
© 2007 Europa Technologies
Image NASA
Image © 2007 TerraMetrics
© 2007 ZENRIN
Google
735 km
Pointer 28°15'25.50" N 83°34'54.03" E
Streaming 100%
Eye alt 2309.27 km


Xizang (Tibet)
HARS Simikot
Karnali
Seti
Gandaki
Nepal
Kathmandu
radesh
Bihar
172 km
© 2007 Europa Technologies
Image © 2007 TerraMetrics
©2007 Google™
Pointer 29°55'16.63" N 84°31'31.94" E elev 865 m
Streaming 100%
Eye alt 578.12 km


HARS Simikot
Karnali
Mahakali
Seti
Dhawalagiri
Bheri
Gandaki
Rapti
Nepal
RIDS-Nepal Nepalgunj
© 2007 Europa Technologies
Image © 2007 TerraMetrics
121 km
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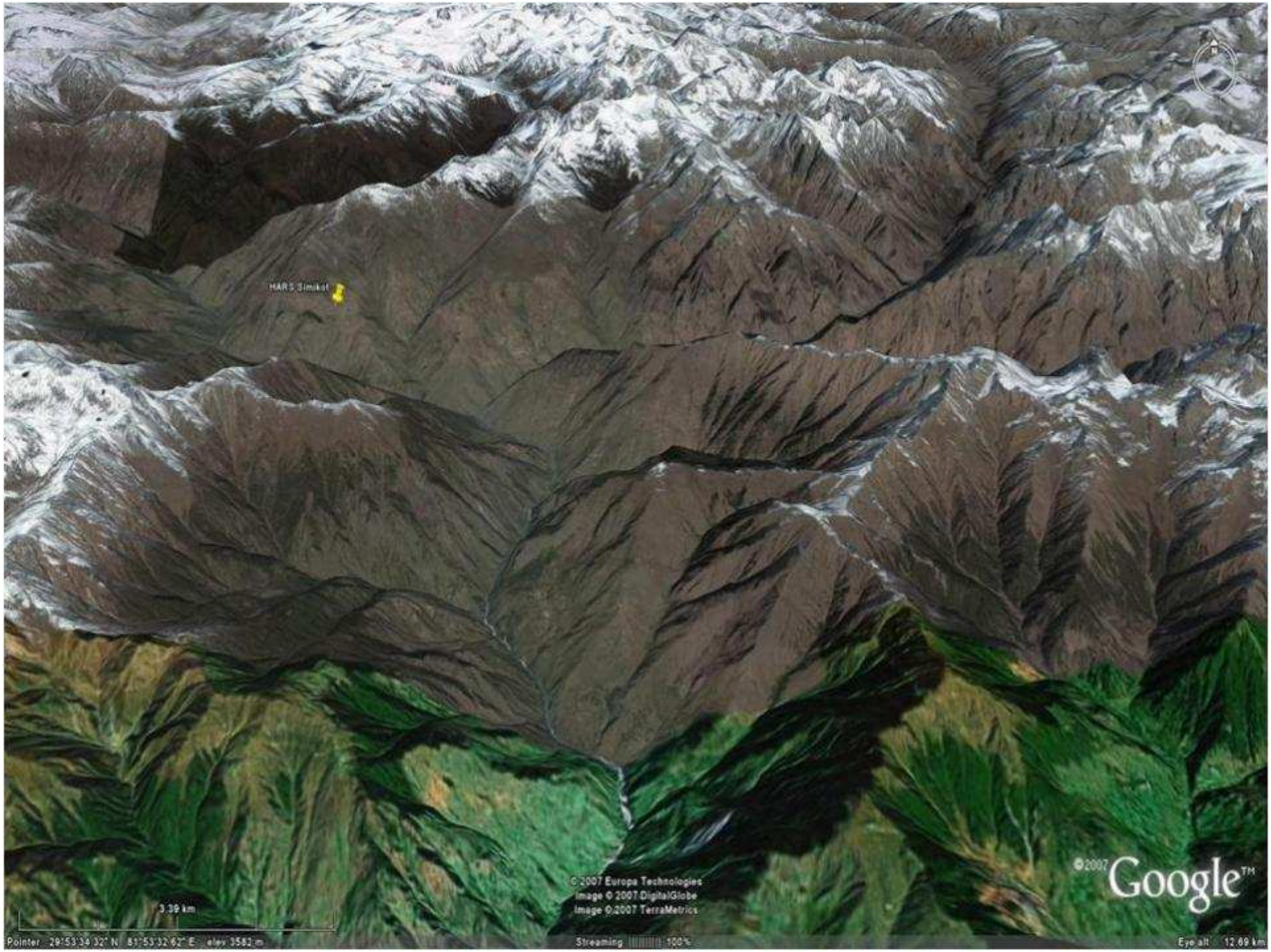
Streaming 100%
©2007 Google
Eye alt 409.77 km


HARS Simkat
© 2007 Europa Technologies
Image © 2007 DigitalGlobe
Image © 2007 TerraMetrics
©2007 Google™
3.39 km
Pointer 29°53'34.32" N 81°53'32.62" E elev 3582 m
Streaming 100%
Eye alt 12.69 km


Tangin
Chyaduk
Hepka
Gadapari
Pamlatum
Jhar Kholsi
Chauganphaya
Kholsi
Darapori
Tulin
HARS Simikot
Syada Health Post
Dhadhaphaya
Image © 2007 TerraMetrics
Image © 2007 DigitalGlobe
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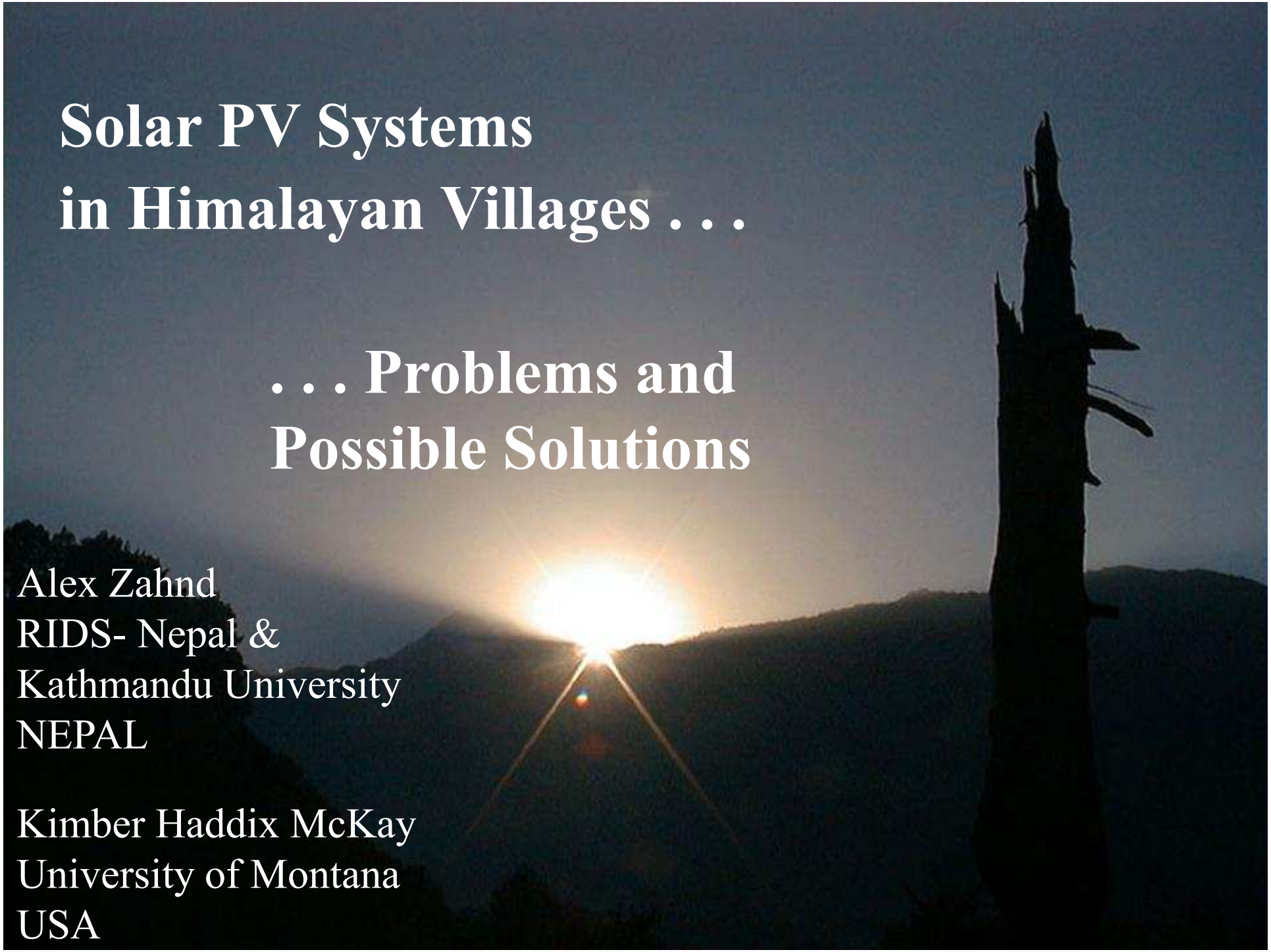
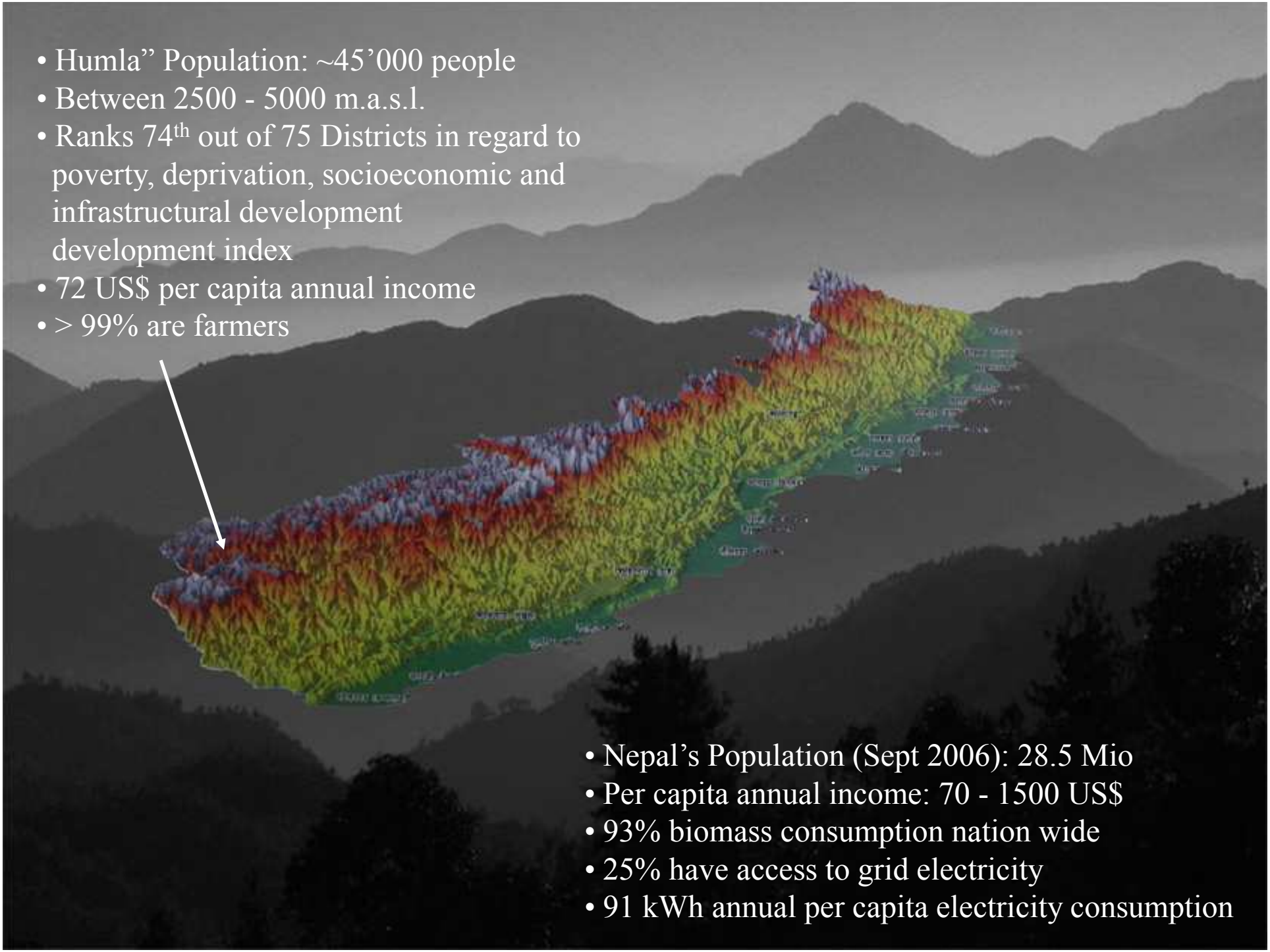


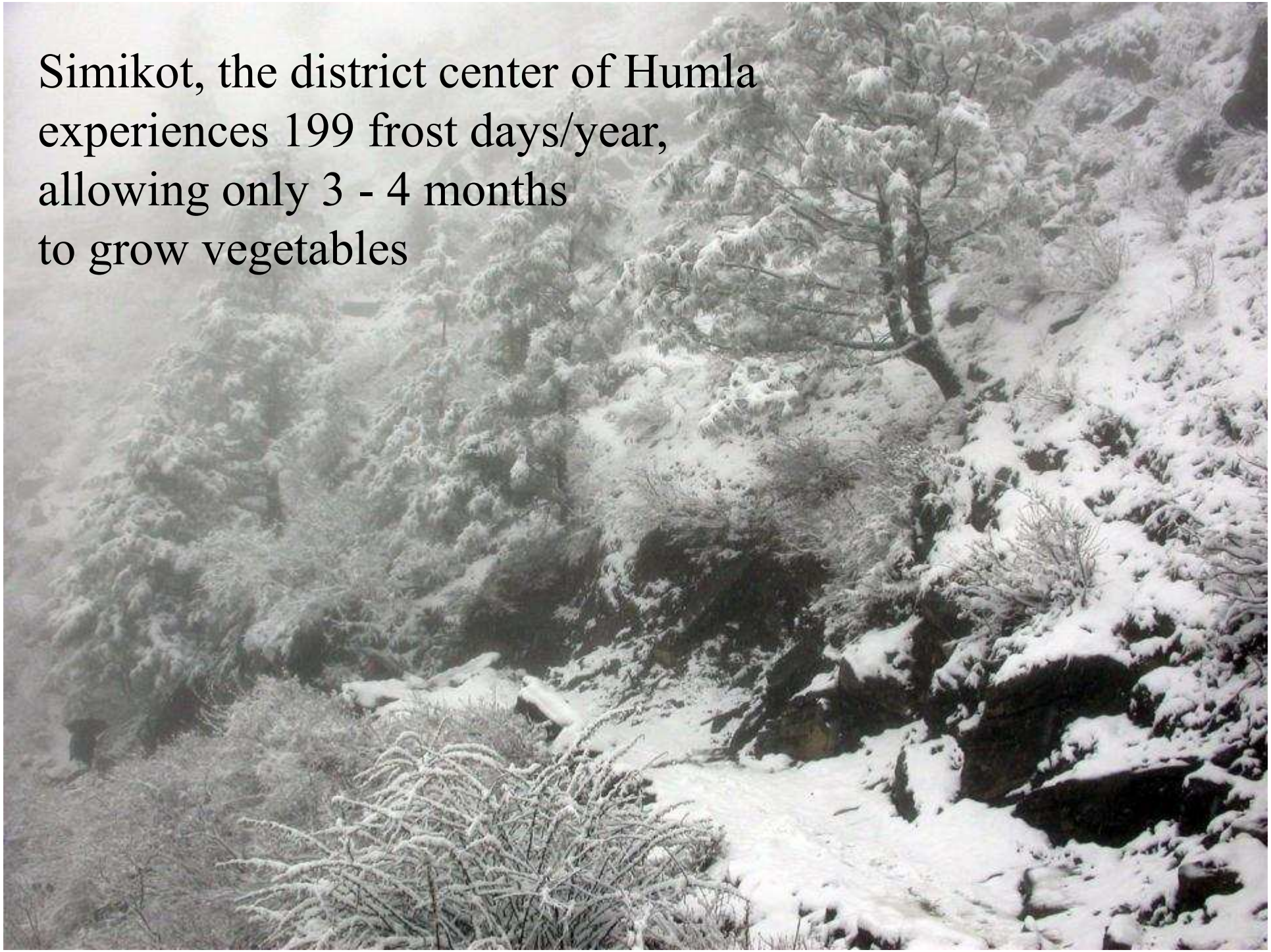
Solar PV Systems in Himalayan Villages . . .

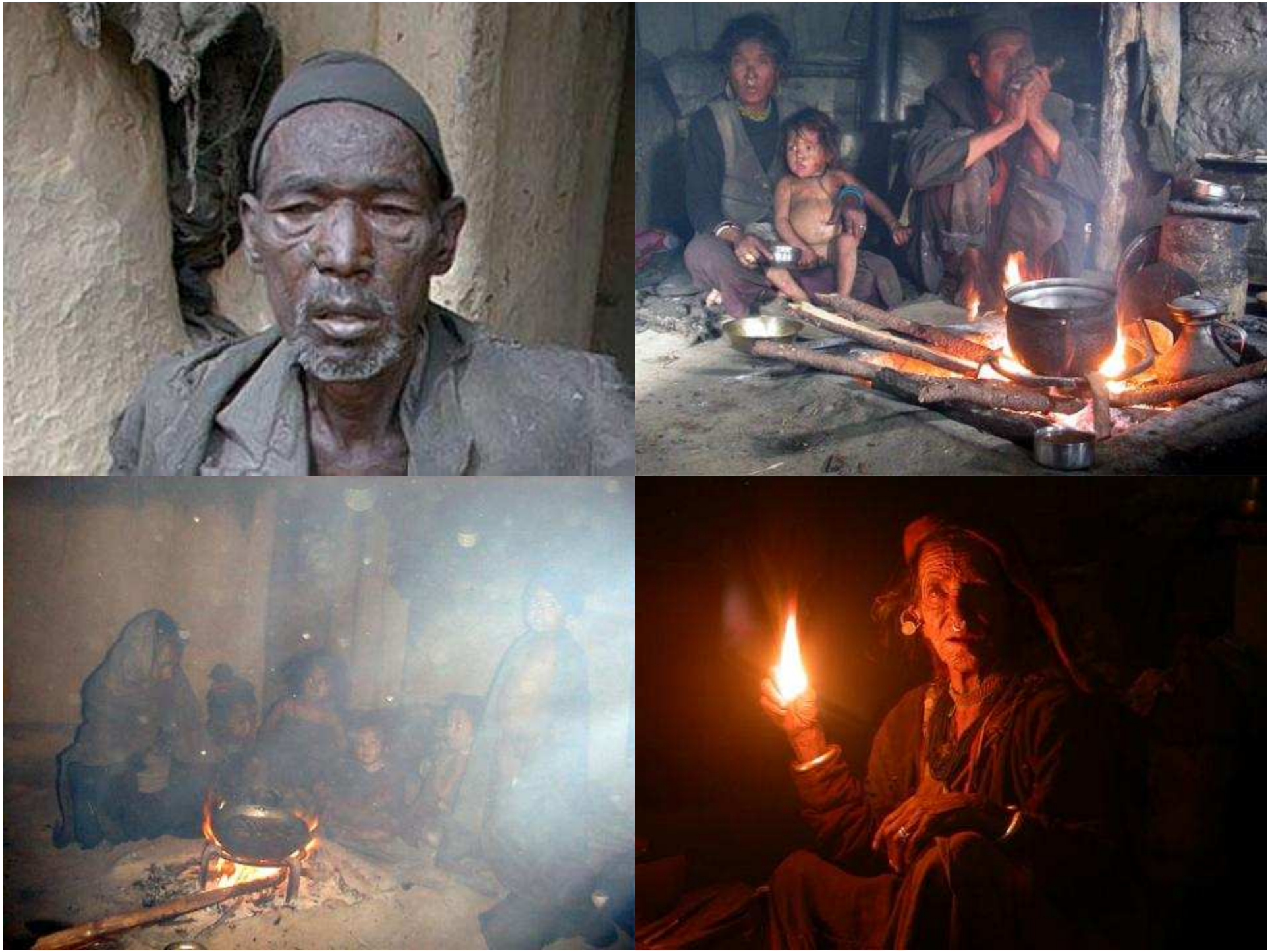
. . . Problems and Possible Solutions

Alex Zahnd
RIDS- Nepal &
Kathmandu University
NEPAL

Kimber Haddix McKay
University of Montana
USA

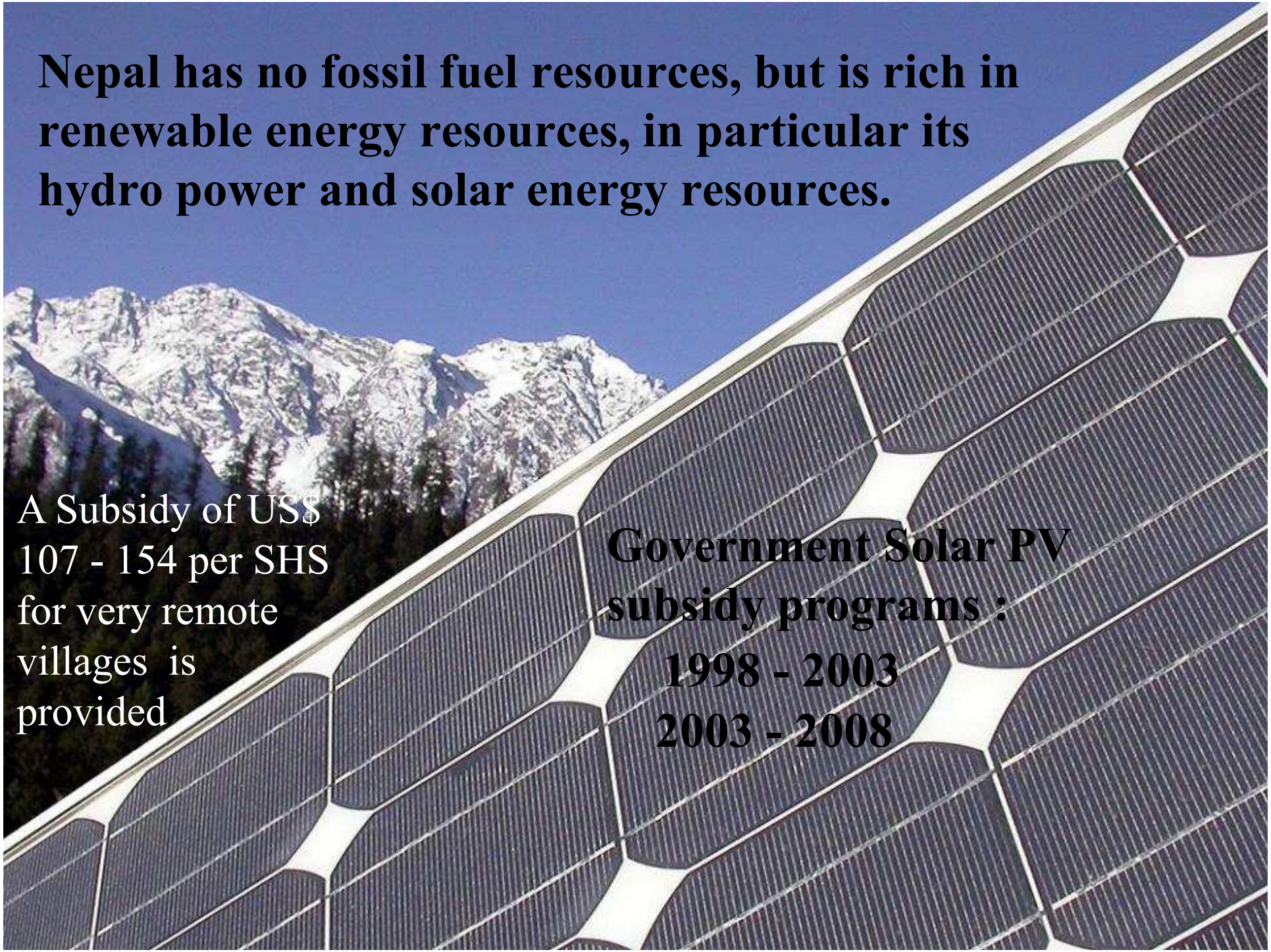

• Humla" Population: ~45'000 people
• Between 2500 - 5000 m.a.s.l.
• Ranks 74th out of 75 Districts in regard to poverty, deprivation, socioeconomic and infrastructural development development index
• 72 US$ per capita annual income
• > 99% are farmers
• Nepal's Population (Sept 2006): 28.5 Mio
• Per capita annual income: 70 - 1500 US$
• 93% biomass consumption nation wide
• 25% have access to grid electricity
• 91 kWh annual per capita electricity consumption


Simikot, the district center of Humla
experiences 199 frost days/year,
allowing only 3 - 4 months
to grow vegetables









Nepal has no fossil fuel resources, but is rich in renewable energy resources, in particular its hydro power and solar energy resources.
A Subsidy of US$ 107 - 154 per SHS for very remote villages is provided
Government Solar PV subsidy programs :
1998 - 2003
2003 - 2008

The number of Solar PV Companies increased from 3 in 1997 to 46 in 2007, mostly based on the available subsidies.

Major Problems fall into Two Categories : Technical and Non - Technical

Competition focuses on the price, resulting in lower quality products and minimal/no training/follow-up of installed PV systems.

The urban driven business does not account for the end users' context and needs.

The end users lack awareness und education, resulting in unrealistic expectations.

Two mismatching worldviews threaten the local RE industry and disappoint the users.

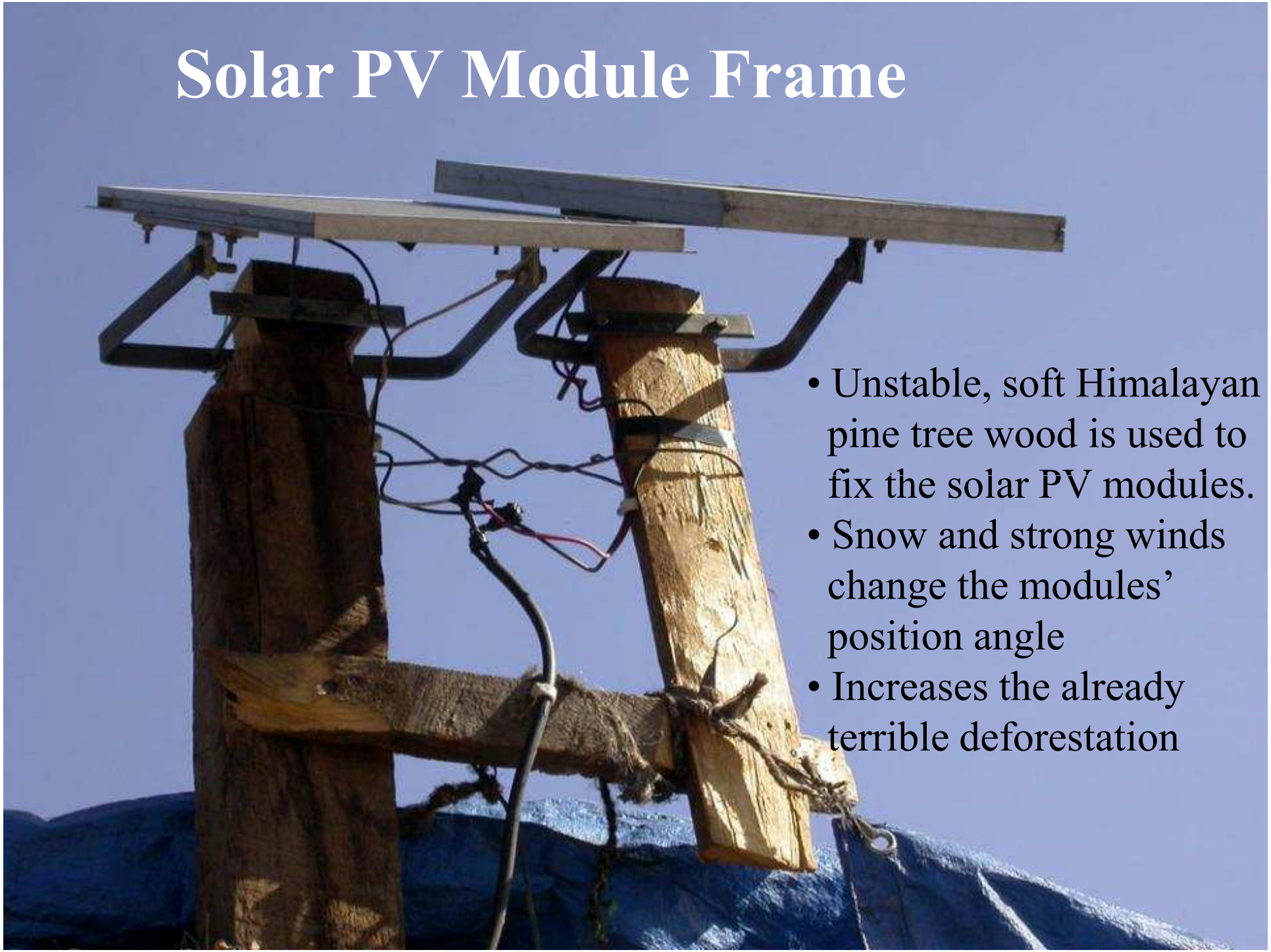
Technical Problems Encountered

- Solar PV Module
- Solar PV Module Frame
- Charge – and Discharge – Controller
- Solar System - and House Wiring
- Battery Bank
- Indoor Lighting

Solar PV Module

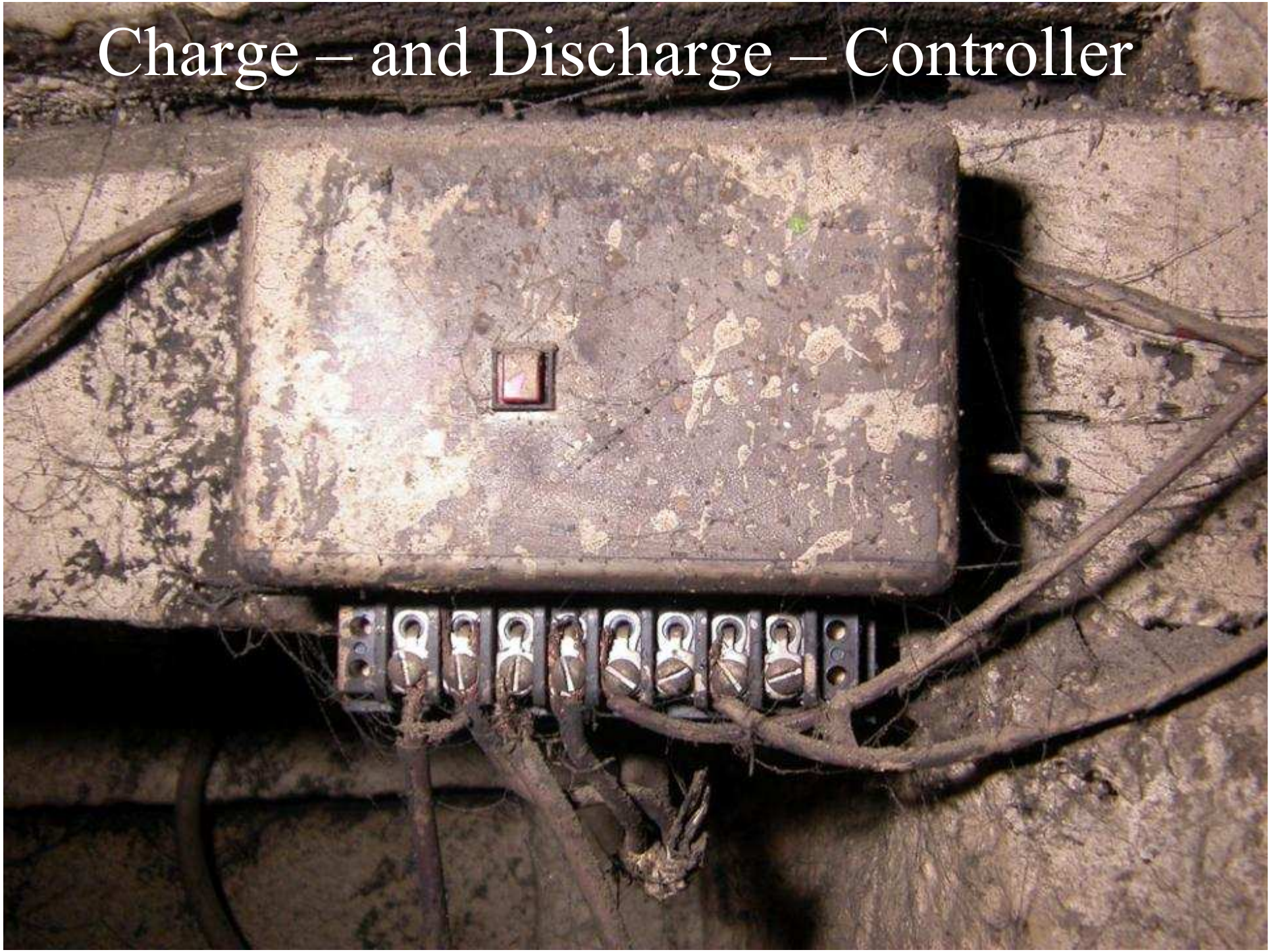
- All solar PV modules installed in Nepal are imported.
- All branded solar PV modules are of acceptable/good quality, and thus there are very low failure rates.
- No-name Chinese PV modules were the ones with the greatest failure rate and poorest performance.
- Most common technical fault identified were the broken and corroded connections in the connection box and the serial connected cells

Solar PV Module Frame



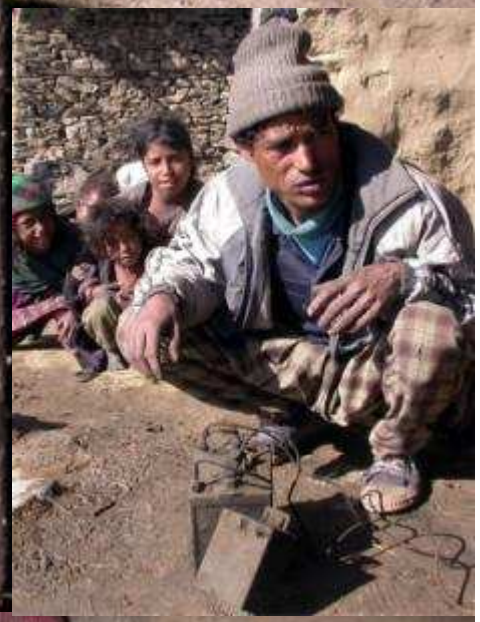
- Unstable, soft Himalayan pine tree wood is used to fix the solar PV modules.
- Snow and strong winds change the modules' position angle
- Increases the already terrible deforestation

Charge – and Discharge – Controller



Charge – and Discharge – Controller

- **Many Charge Controllers (CC) have too low voltage (< 10.5 Volt) cut off values**
- **Many CC are installed inside the homes and thus operate under high indoor air pollution and soot from open cooking places**



Solar System - and House Wiring

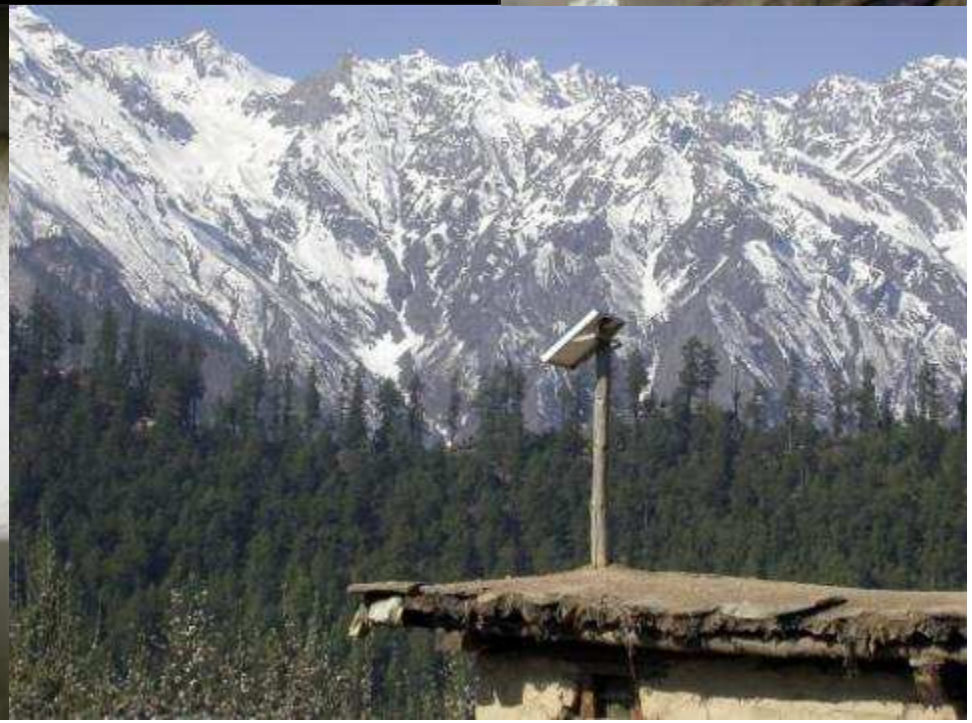
- Loose wiring is soon damaged
- Mice find easy access to the cables
- Danger for children to get harmed

Battery Bank

- **No periodical topping up**
- **Dirty conditions**
- **Mismatched batteries**
- **Directly connected to module**
- **No temperature adjustment**
- **Uneven, unprotected placed**

Indoor Lighting

- Most Home Systems have 10-16 W_R PV modules
- Mostly Homes use three 10 watt Tube Lights
- Installed Battery Capacity is usually 20-40 Ah
- Thus the Battery Banks have HIGH Daily DoD



Non - Technical Problems Encountered

- Energy Demand / Need Assessment
- Awareness Raising for the Need of Improved Lighting
- Training for Solar PV System O & M
- Installation and Follow-up
- Performance Monitoring

Energy Demand / Need Assessment

- No Understanding of the traditional Habit and Method of “jharro” lighting
- No Identify of the minimal Needs of Lighting for the daily tasks

Awareness Raising for the Need of Improved Lighting

- It is important to alert people of the damaging health consequences associated with the use of “jharro”
- Teach about the low luminous efficacy of “jharro”
- Provide example of possible Lighting


SUNERA

Training for Solar PV System O & M

- Under the government subsidy scheme no training for O & M is provided to the users
- Systems fail early due to the lack of basic issues such as protecting and topping up of batteries, . .
- exchanging broken fuses, or cleaning the lights.

Installation and Follow-up

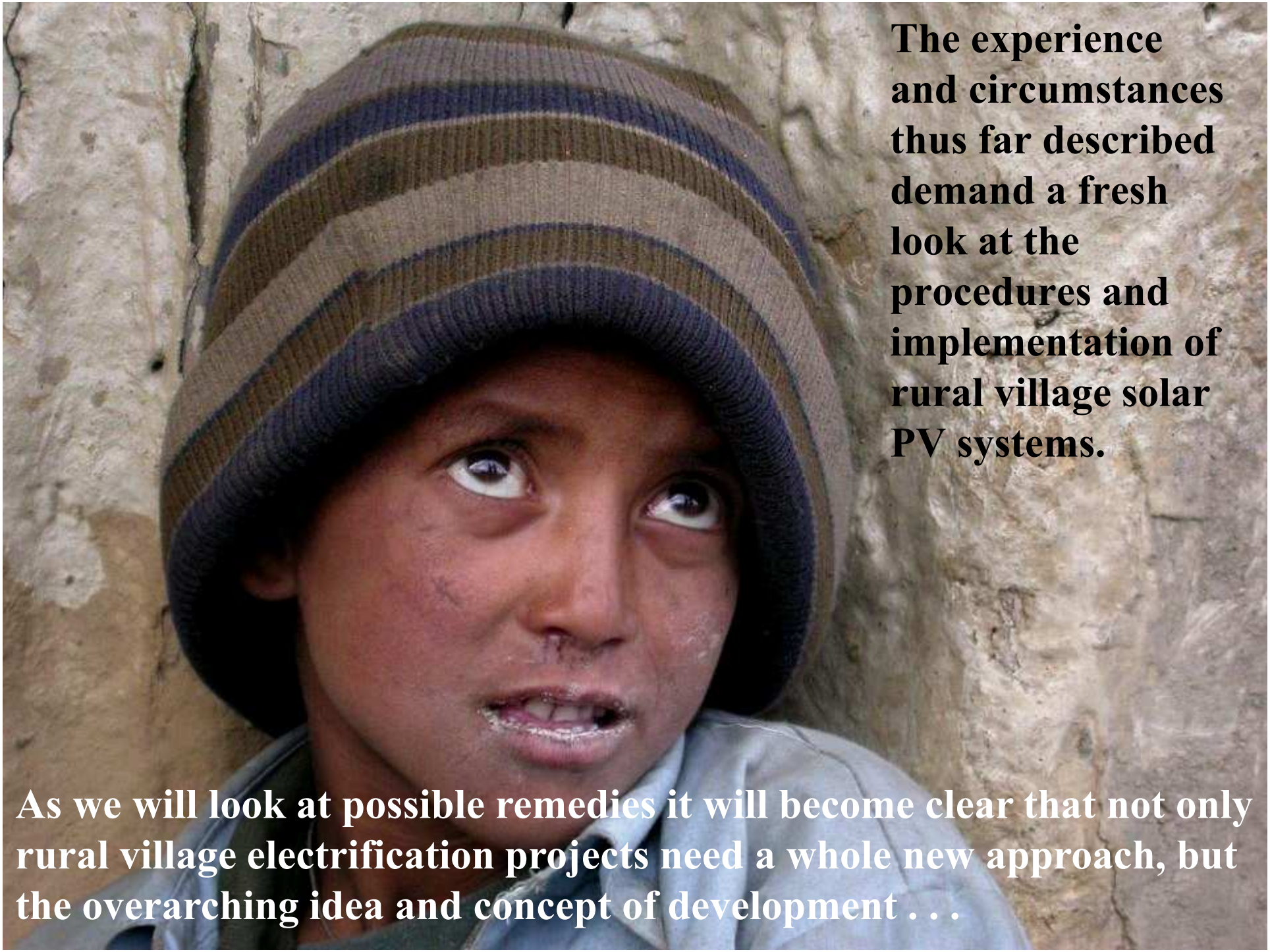
- Frequently users report that companies brought and installed the government subsidised solar PV systems, charged extra for the installation, and left as soon as the system was put in.
- No contact person was provided in case of equipment failure. No follow-up visits take place. The users were left with their new purchased system all by themselves.
- A Kathmandu based solar PV company had previously a small PV shop in Simikot, Humla's district center, but low turn over and high staff and transport costs due to the remoteness, made the business not worth while continuing. Thus the shop closed.

Performance Monitoring

- **"Out of Sight …. Out of Mind" …that is the harsh reality of most of the installed village-based solar PV systems.**
- **Neither anecdotal nor recorded technical data are collected under the government subsidised installed Solar PV systems.**
- **This does not allow the improvement of installed field systems nor does it encourage any learning from users' feedback.**


These Conditions Demand Changes. .
. . as this is neither Responsible, nor Dignified Development !
. . and it is Our Responsibility to Act . . . !

Possible Remedies . . .



The experience and circumstances thus far described demand a fresh look at the procedures and implementation of rural village solar PV systems.

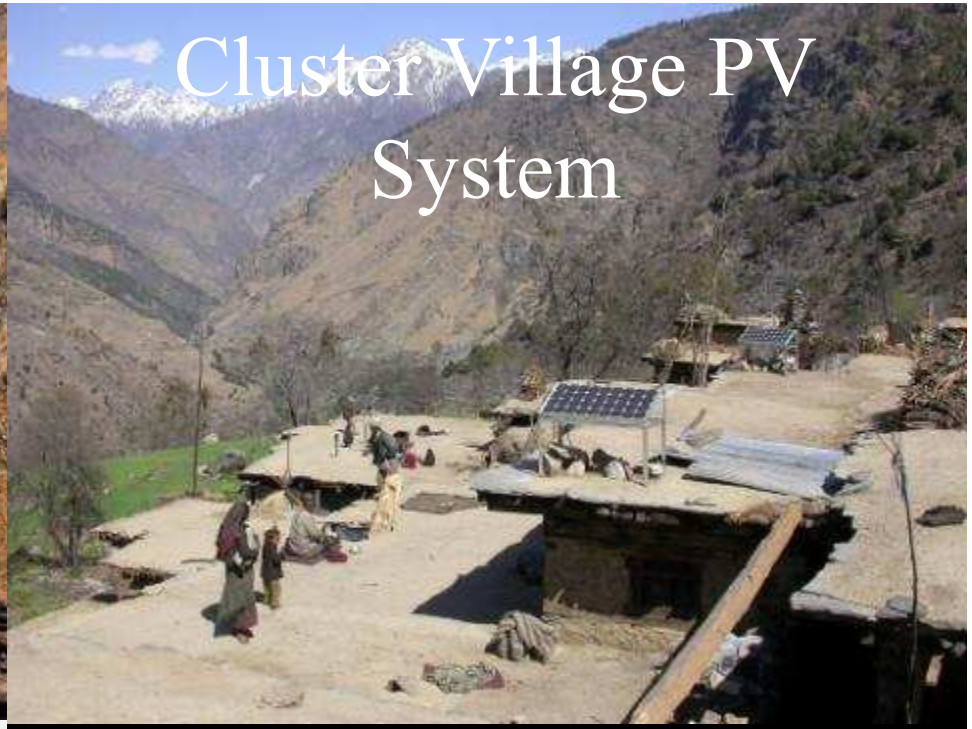
As we will look at possible remedies it will become clear that not only rural village electrification projects need a whole new approach, but the overarching idea and concept of development . . .


Here the research project prototype stoves, greenhouses, solar driers, slow sand water filters, solar water heaters, solar PV modules, etc. are first installed and tested, before they find their final application in the local communities.
At an altitude of 3,000 meter above sea level, lies RIDS-Nepal's High Altitude Research Station (HARS) in Simikot Humla

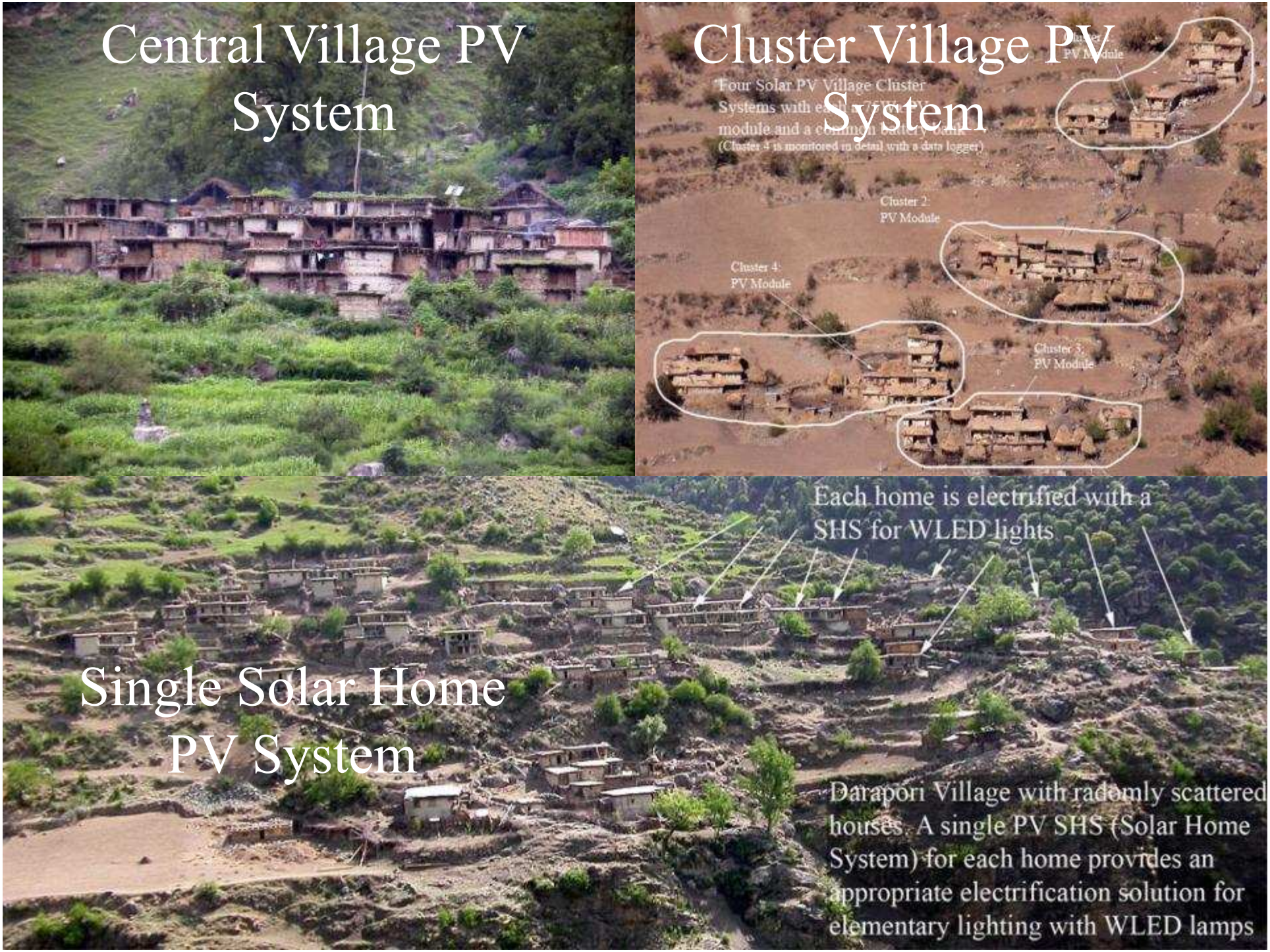

RIDS-Nepal's Staff Live
in the Project Area . . .
. . . thus they Experience First
Hand the Community's Needs
Community Participation in Each
Step of Every Project is Crucial


RIDS-Nepal
developed 3 Different
Solar PV System
Approaches
. . . considering the local
communities' defined
needs and their cultural and
geographical context.


Central Village PV System


Cluster Village PV System


Single Solar Home PV System


Central Village PV System
Cluster Village PV System
Four Solar PV Village Cluster
Cluster 2
PV Module
Cluster 4
PV Module
Cluster 3
PV Module
Each home is electrified with a SHS for WLED lights
Single Solar Home PV System
Darapori Village with radomly scattered houses. A single PV SHS (Solar Home System) for each home provides an appropriate electrification solution for elementary lighting with WLED lamps

Possible Remedies for the Same Technical and Non – Technical Problems Encountered

Possible ***Technical*** Remedies:

- Solar PV Module
- Solar PV Module Frame
- Charge – and Discharge – Controller
- Solar System - and House Wiring
- Battery Bank
- Indoor Lighting

Possible ***Non – Technical*** Remedies:

- Energy Demand / Need Assessment
- Awareness Raising, Lighting Technology & “Family of 4” Concept
- Training for Solar PV System O & M
- Installation and Follow-up
- Performance Monitoring

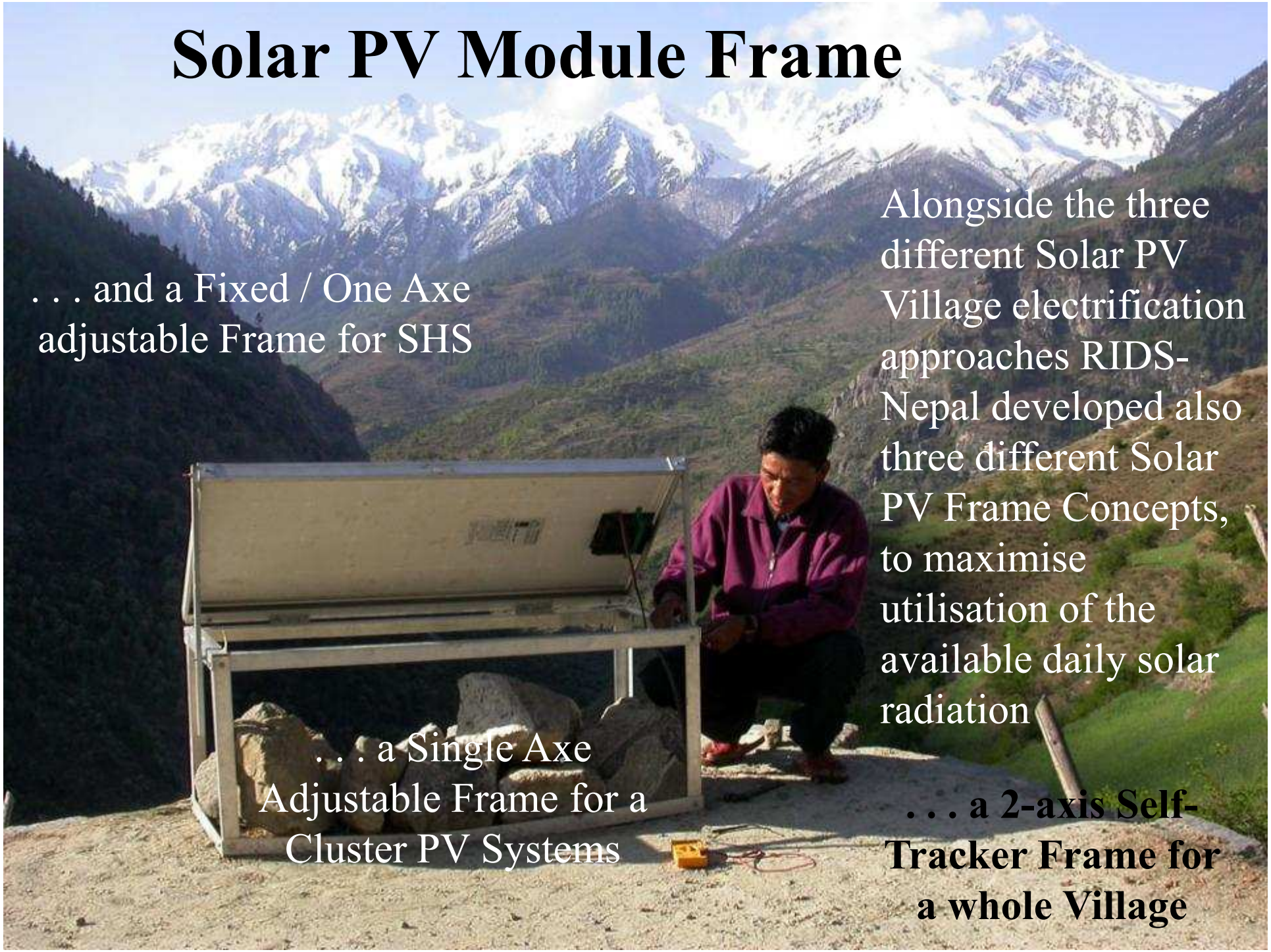
Solar PV Module

Imported Solar PV Modules cause the fewest problems in rural solar PV village systems. Thus by relaying on well known PV companies' proven products, little risk is taken.

RIDS-Nepal uses two types of PV Modules for the three different Solar PV System Approaches:

- The mono-crystalline BP275F ($75W_R$)
- The poly-crystalline K16T (Kyocera 16 W_R)

Solar PV Module Frame



. . . and a Fixed / One Axe adjustable Frame for SHS

Alongside the three different Solar PV Village electrification approaches RIDS-Nepal developed also three different Solar PV Frame Concepts, to maximise utilisation of the available daily solar radiation

. . . a Single Axe Adjustable Frame for a Cluster PV Systems

. . . a 2-axis Self-Tracker Frame for a whole Village

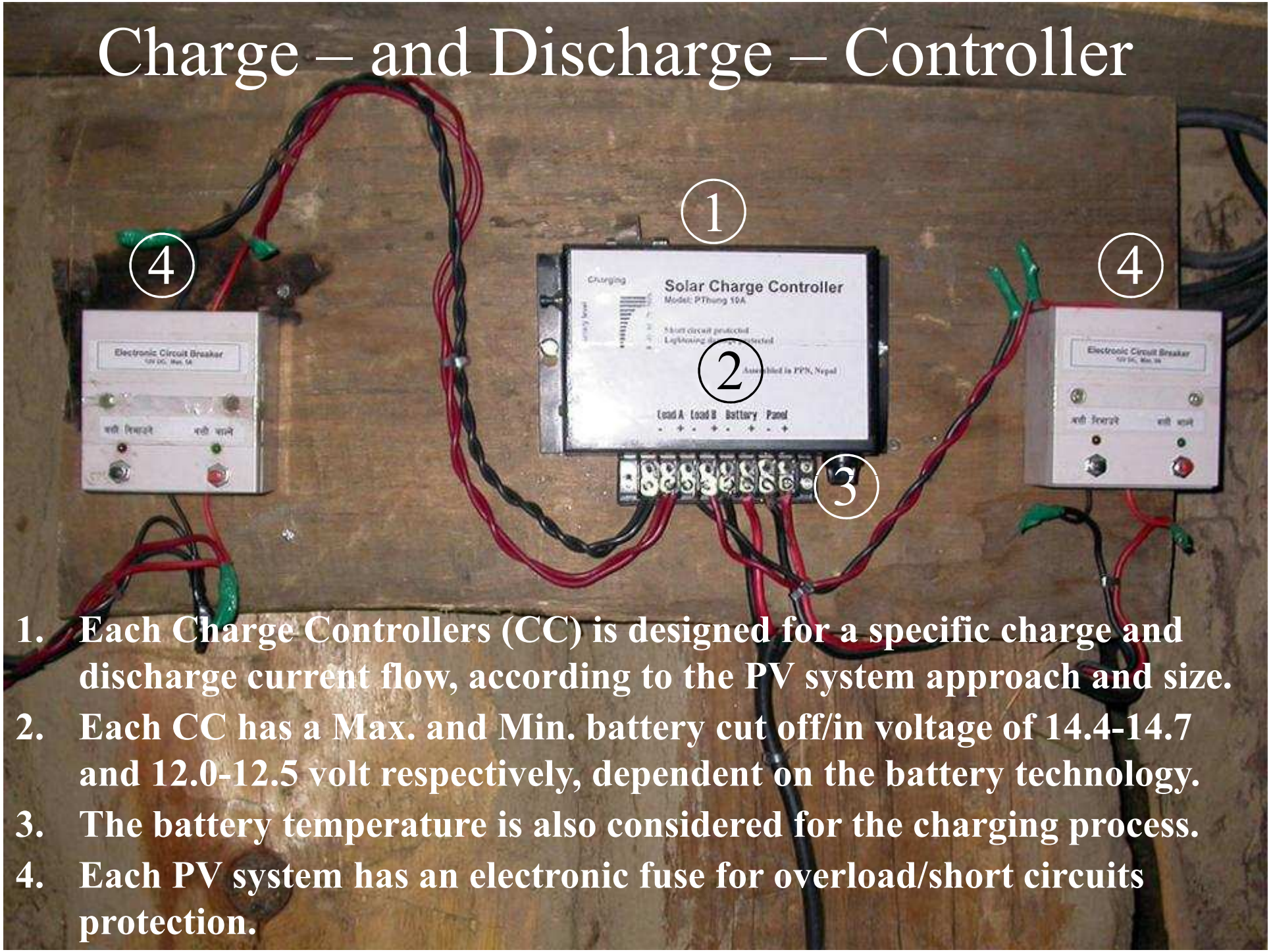
. . . and a Fixed / One Axe adjustable Frame for SHS

. . . a Single Axe Adjustable Frame for a Cluster PV Systems

Alongside the three different Solar PV Village electrification approaches RIDS-Nepal developed also three different Solar PV Frame Concepts, to maximise utilisation of the available daily solar radiation

. . . a 2-axis Self-Tracking Frame for a whole Village

Charge – and Discharge – Controller



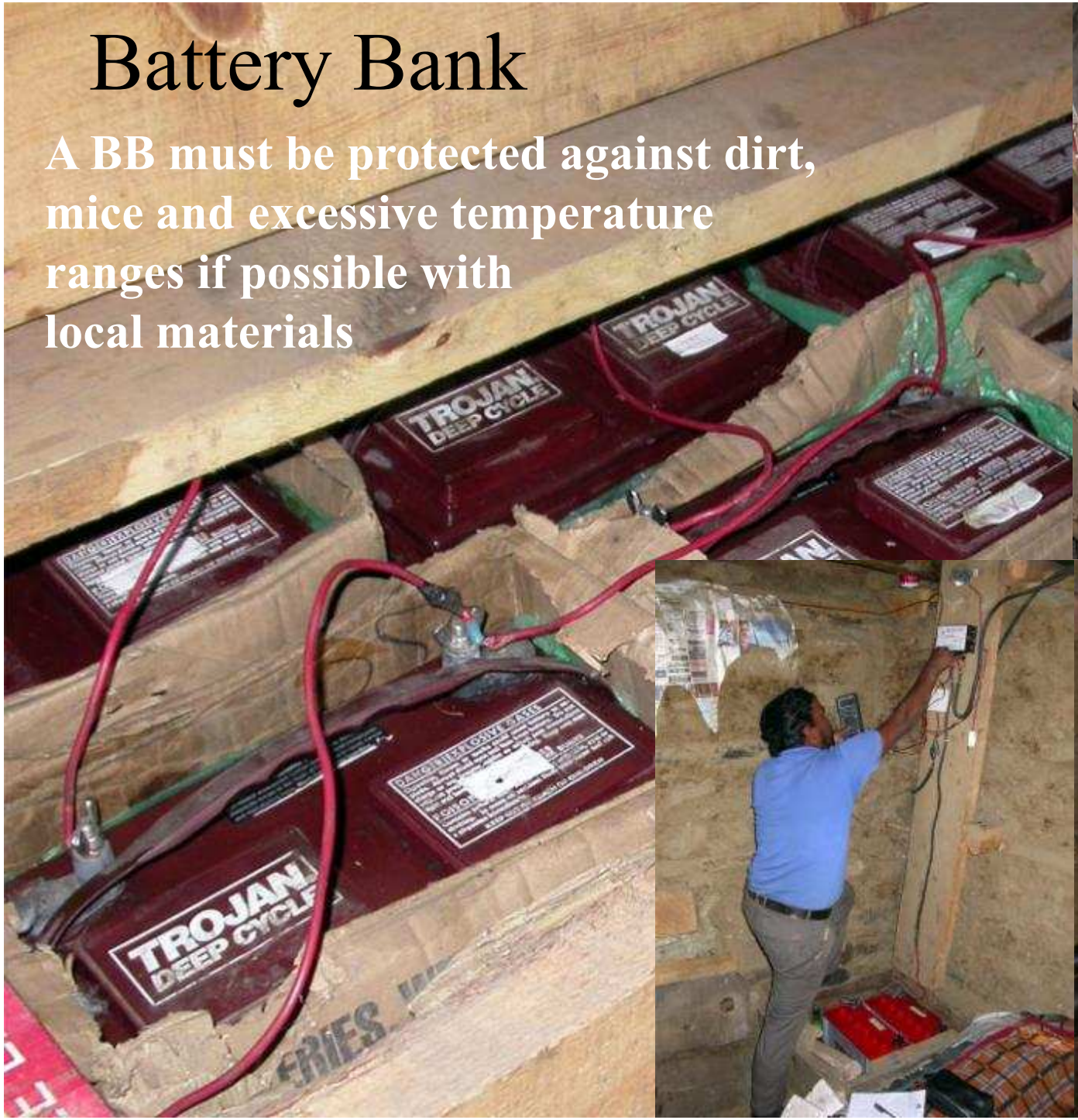
1. **Each Charge Controllers (CC) is designed for a specific charge and discharge current flow, according to the PV system approach and size.**
2. **Each CC has a Max. and Min. battery cut off/in voltage of 14.4-14.7 and 12.0-12.5 volt respectively, dependent on the battery technology.**
3. **The battery temperature is also considered for the charging process.**
4. **Each PV system has an electronic fuse for overload/short circuits protection.**

Solar System - and House Wiring

- Outdoor cables are protected within pipes against weather and people
- Indoor wiring is installed so that mice can not easily get at the cables
- Switches/connections are installed save and out of reach for children

Battery Bank

A BB must be protected against dirt, mice and excessive temperature ranges if possible with local materials



Indoor Lighting

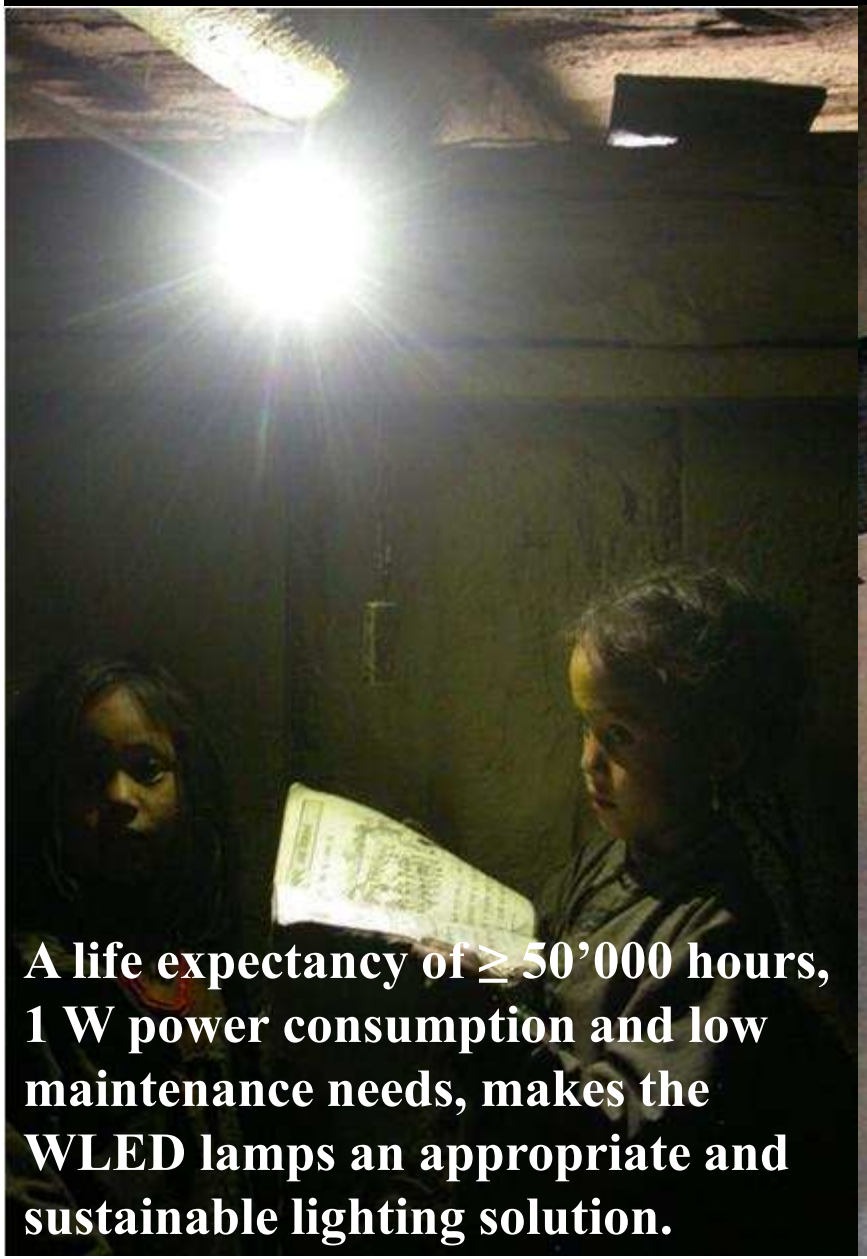
- Only High Quality White LEDs are used for Lamps
- Three 1 watt WLED Lamps are installed in each Home
- Battery Capacity lasts for 3-5 Days independence
- Battery DoD is Max. 30% -35% after 3 Days
- All WLED Lamps are Manufactured and Tested in Nepal



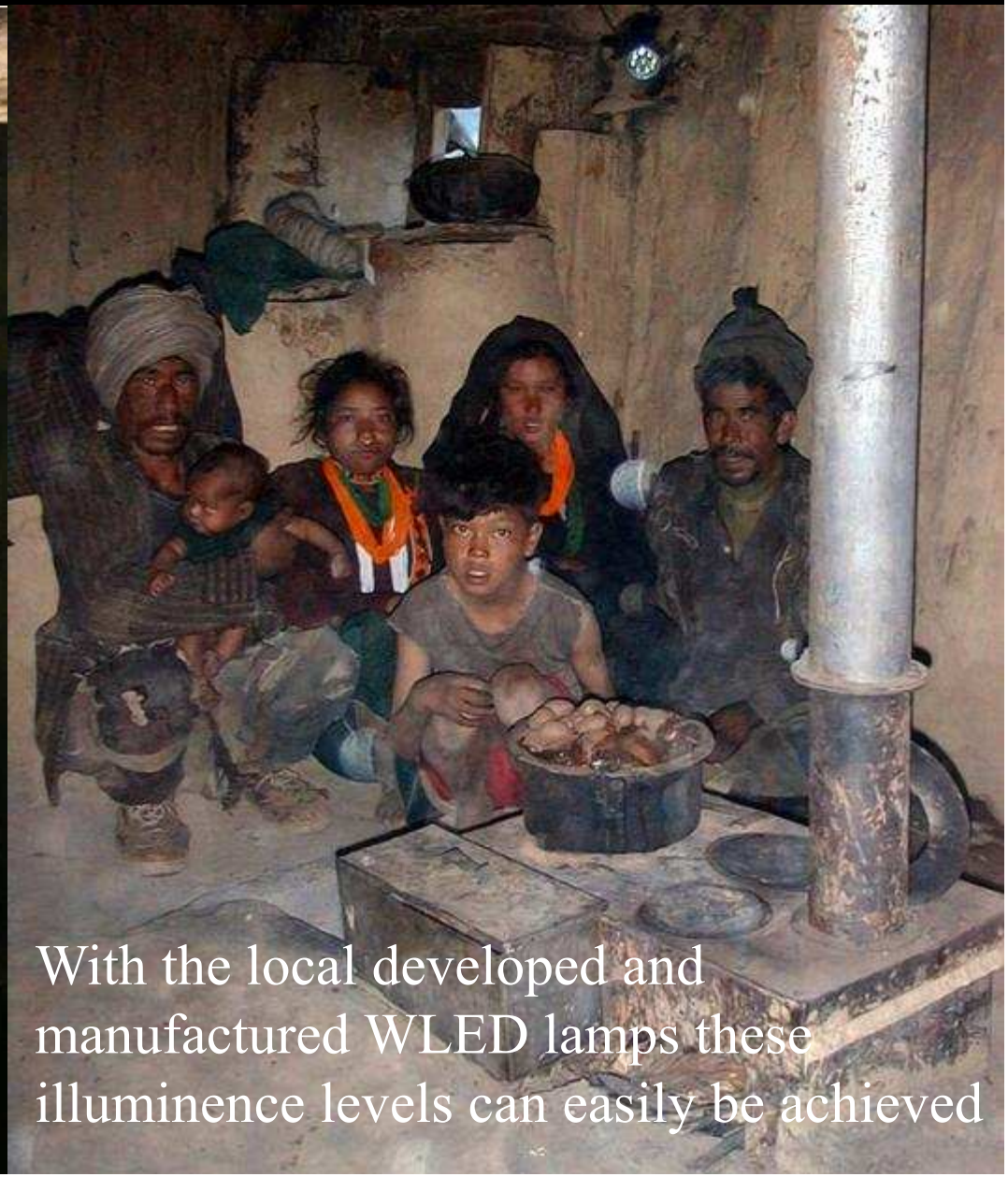



Possible *Non – Technical* Remedies

Energy Demand / Need Assessment



A life expectancy of ≥ 50'000 hours, 1 W power consumption and low maintenance needs, makes the WLED lamps an appropriate and sustainable lighting solution.



With the local developed and manufactured WLED lamps these illuminence levels can easily be achieved

Awareness Raising, Lighting Technology & "Family of 4" Concept

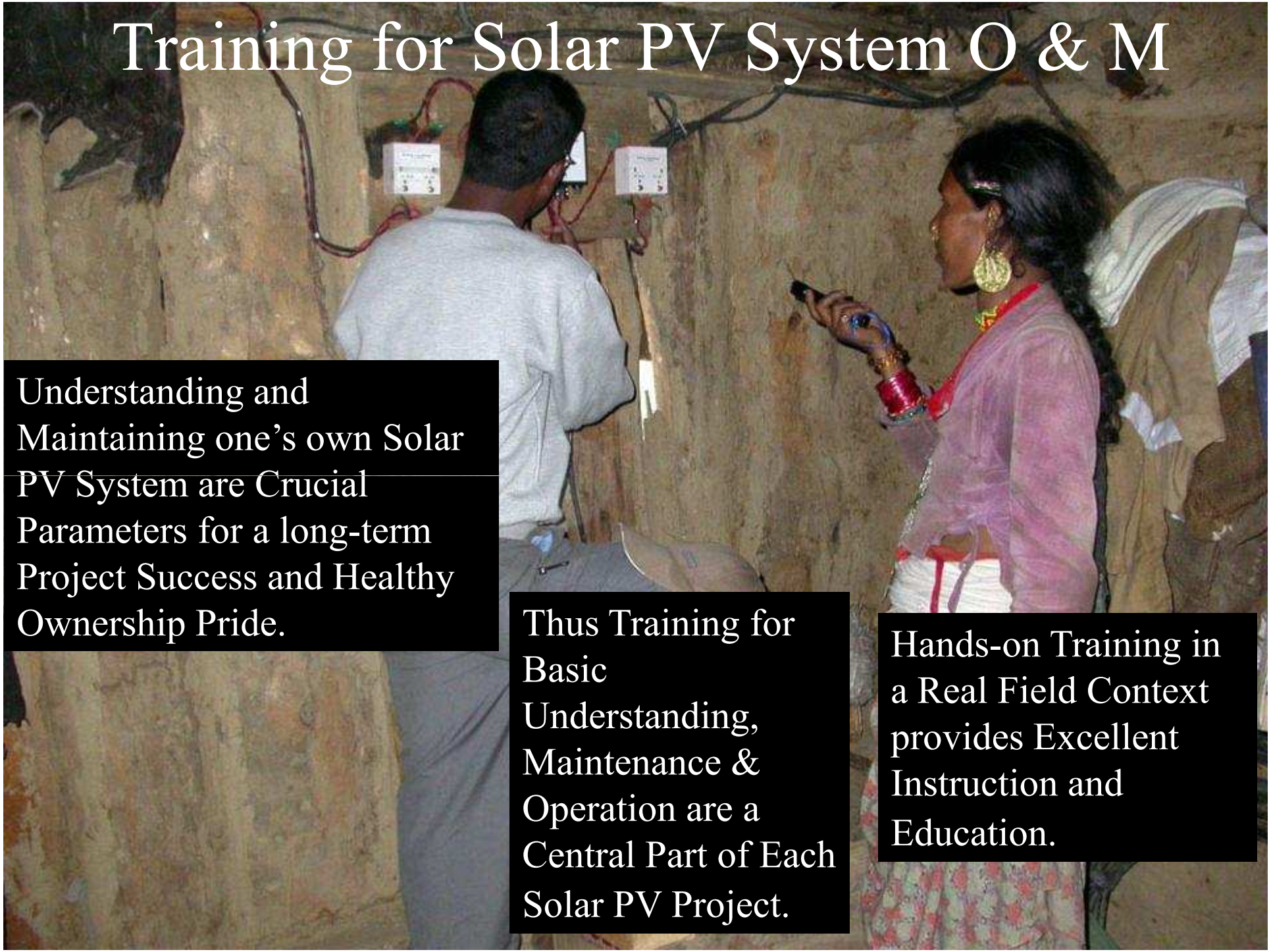
Users are also made aware that unless they do change their open fire cooking habit through a Smokeless Metal Stove, their new Lights will last not very long, . . .

. . . and that the aim is for a long-term Holistic Community Development Project, the so called "Family of 4", including also Pit Latrines and Clean Drinking Water Access for All.

By Demonstrating the Brightness and Illuminence of the WLED Lamps the Users are Introduced to the new Indoor Lighting


Water
Pit Latrine
A Family of 4
Light, Stove,
Pit Latrine,
Water
Light
Stove

Training for Solar PV System O & M

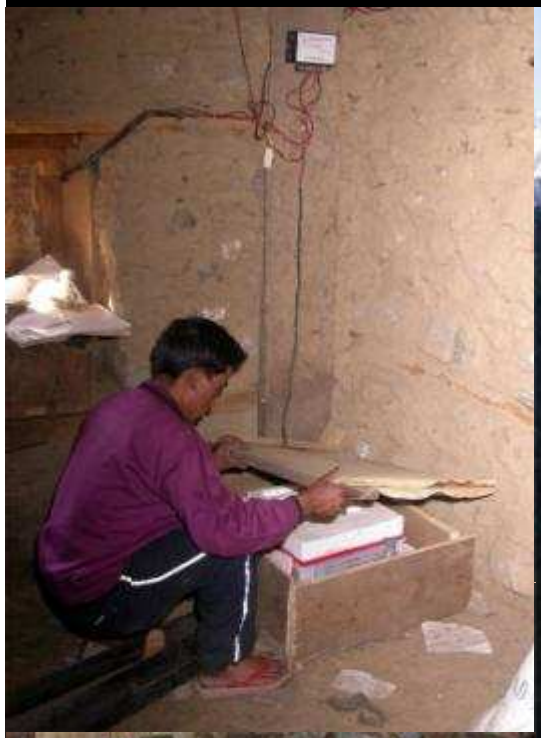


Understanding and Maintaining one's own Solar PV System are Crucial Parameters for a long-term Project Success and Healthy Ownership Pride.

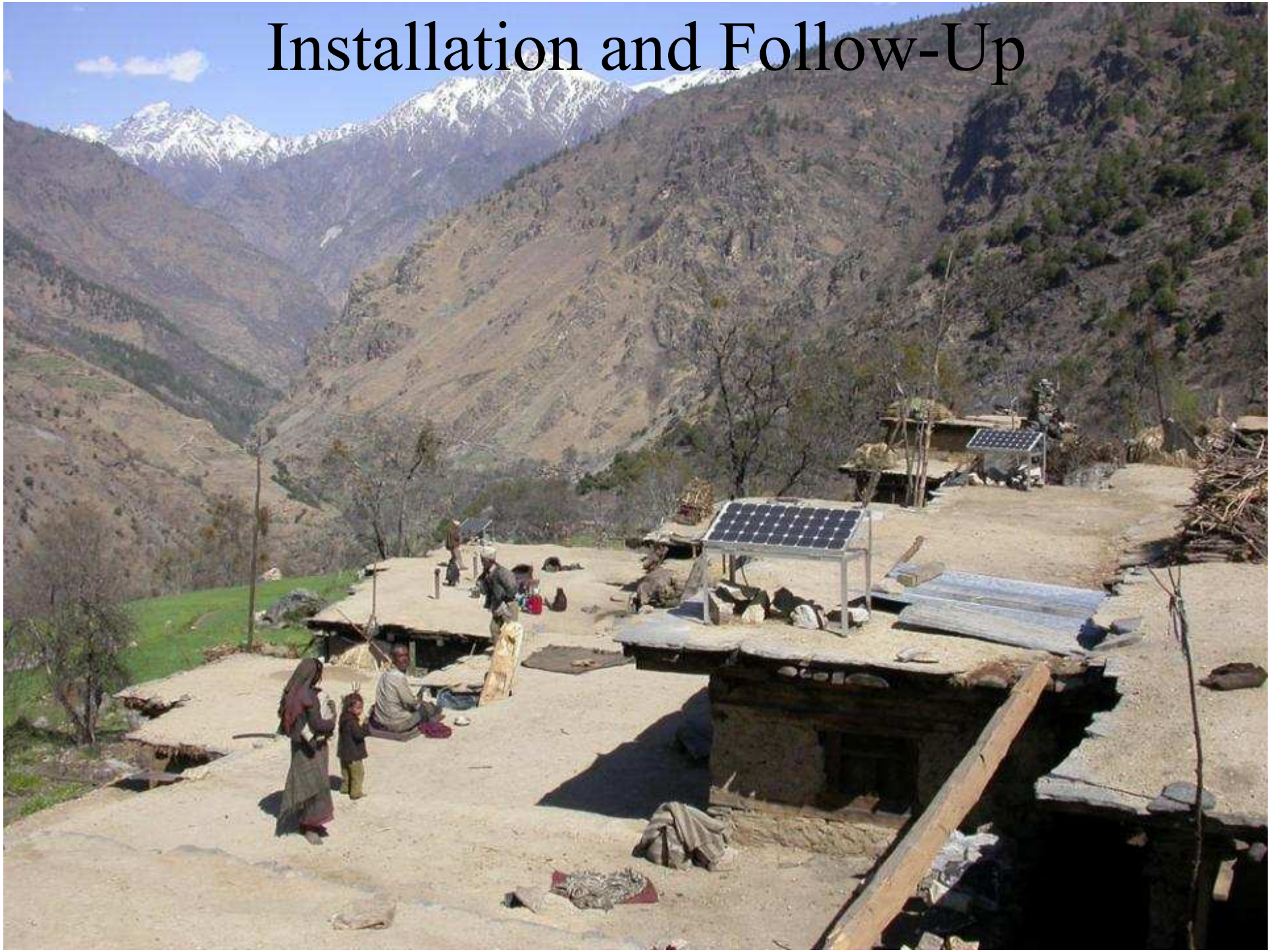
Thus Training for Basic Understanding, Maintenance & Operation are a Central Part of Each Solar PV Project.

Hands-on Training in a Real Field Context provides Excellent Instruction and Education.

Training for Solar PV System O & M



Installation and Follow-Up



Installation and Follow-Up

The RIDS-Nepal Staff Follow-Up Each Installed Solar PV System on a Periodical Basis.

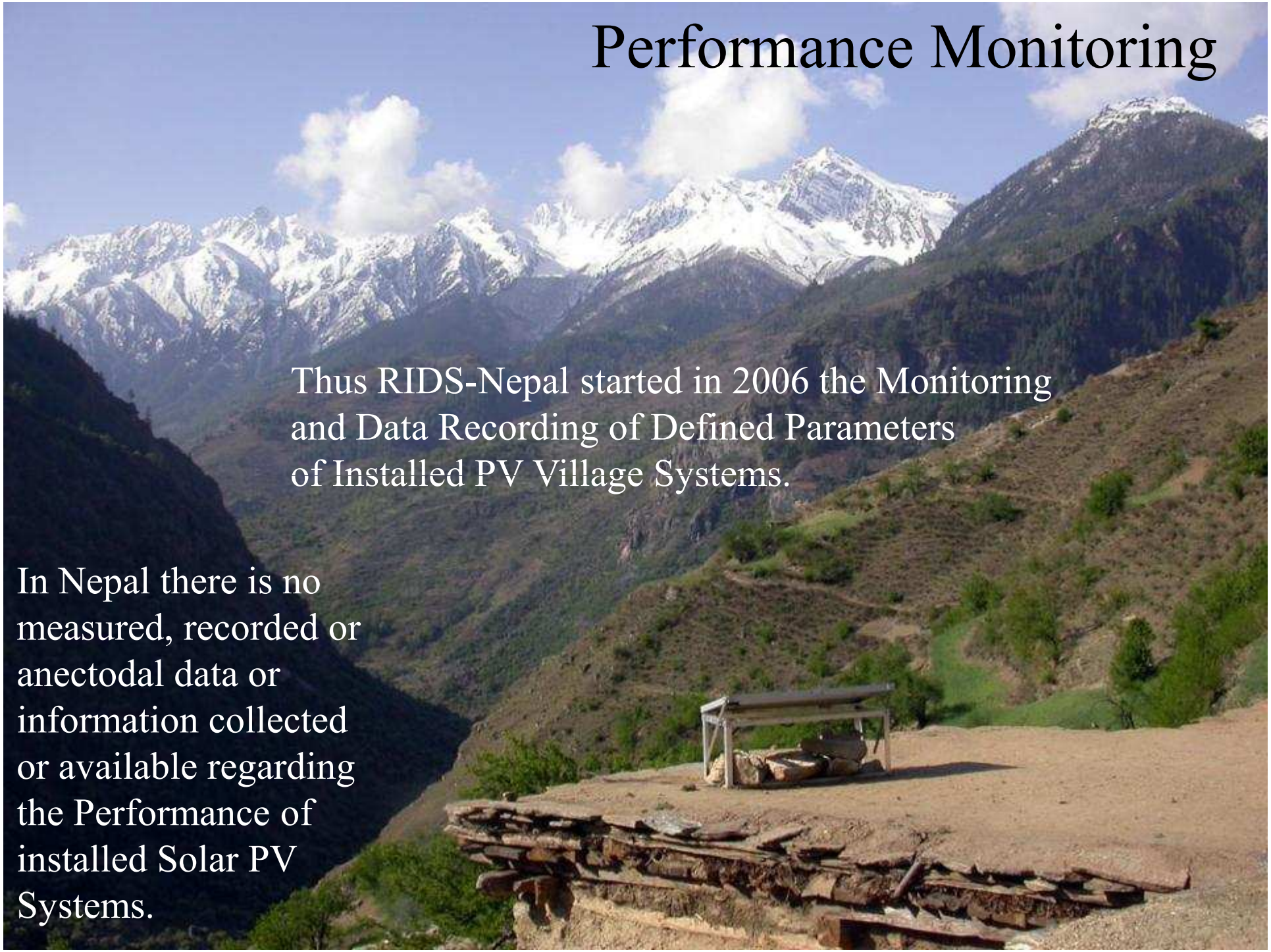
Installation and Follow-Up

With the Basic Solar PV Training Course it is possible for the System Owners to Participate in the System's Installation. That provides the Needed Hands-on Experience and the Village's Respect as the Solar PV Specialist.

Seasonal Adjustments of the Solar PV Frames, Wire Connections and the General Condition of the Installed Solar PV Systems are Part of Periodical Check-Ups and data Collection.

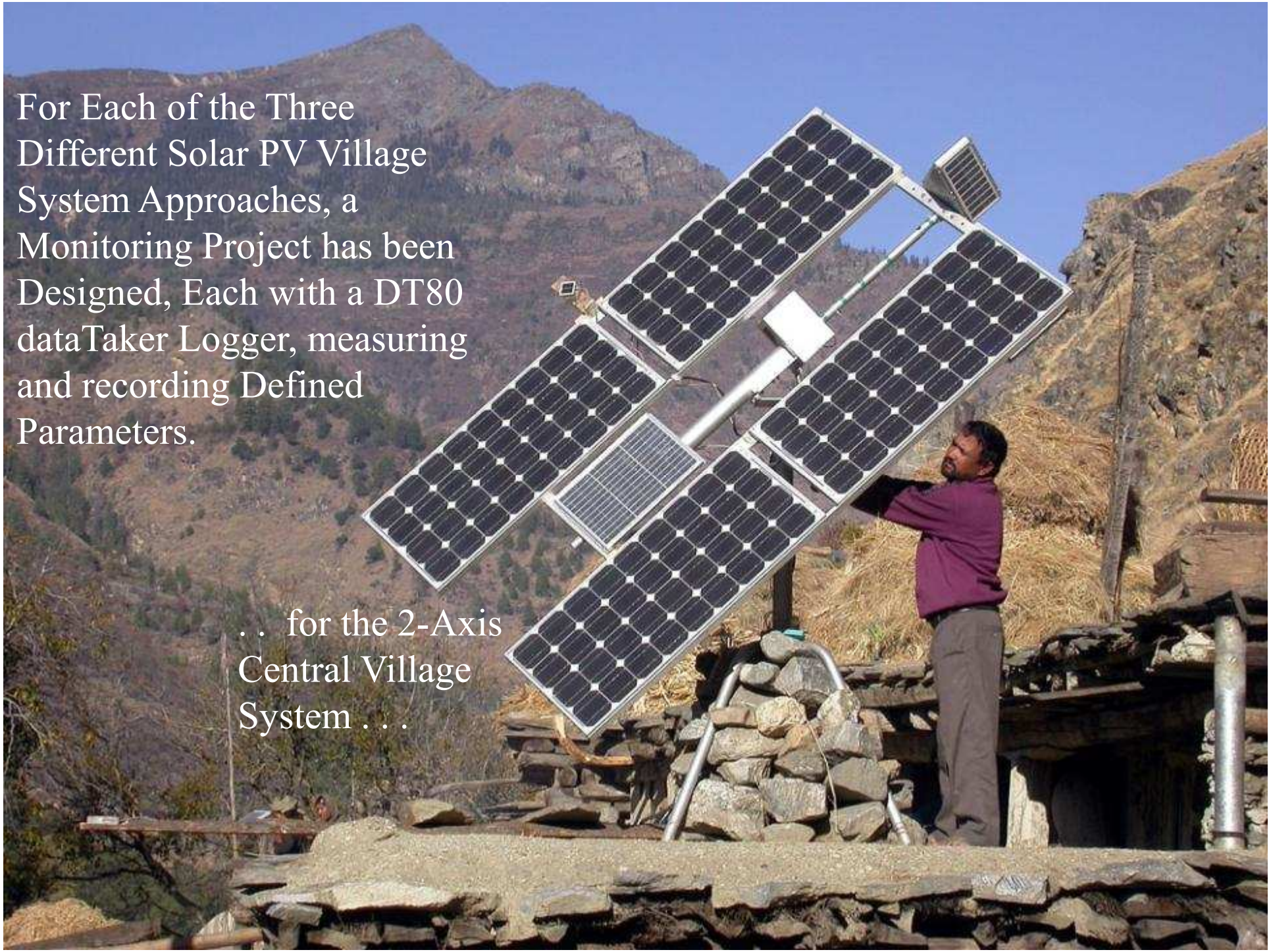
Periodical defined Data Measurements of Each Installed Solar PV System are taken, to Ensure a System's Ongoing Functionality.

Performance Monitoring



Thus RIDS-Nepal started in 2006 the Monitoring and Data Recording of Defined Parameters of Installed PV Village Systems.

In Nepal there is no measured, recorded or anectodal data or information collected or available regarding the Performance of installed Solar PV Systems.


For Each of the Three Different Solar PV Village System Approaches, a Monitoring Project has been Designed, Each with a DT80 dataTaker Logger, measuring and recording Defined Parameters.
. . for the 2-Axis Central Village System . . .


. . . for the
Cluster Village
System


. . . and the
Single Solar
Home System.

dataTaker DT80 Logger

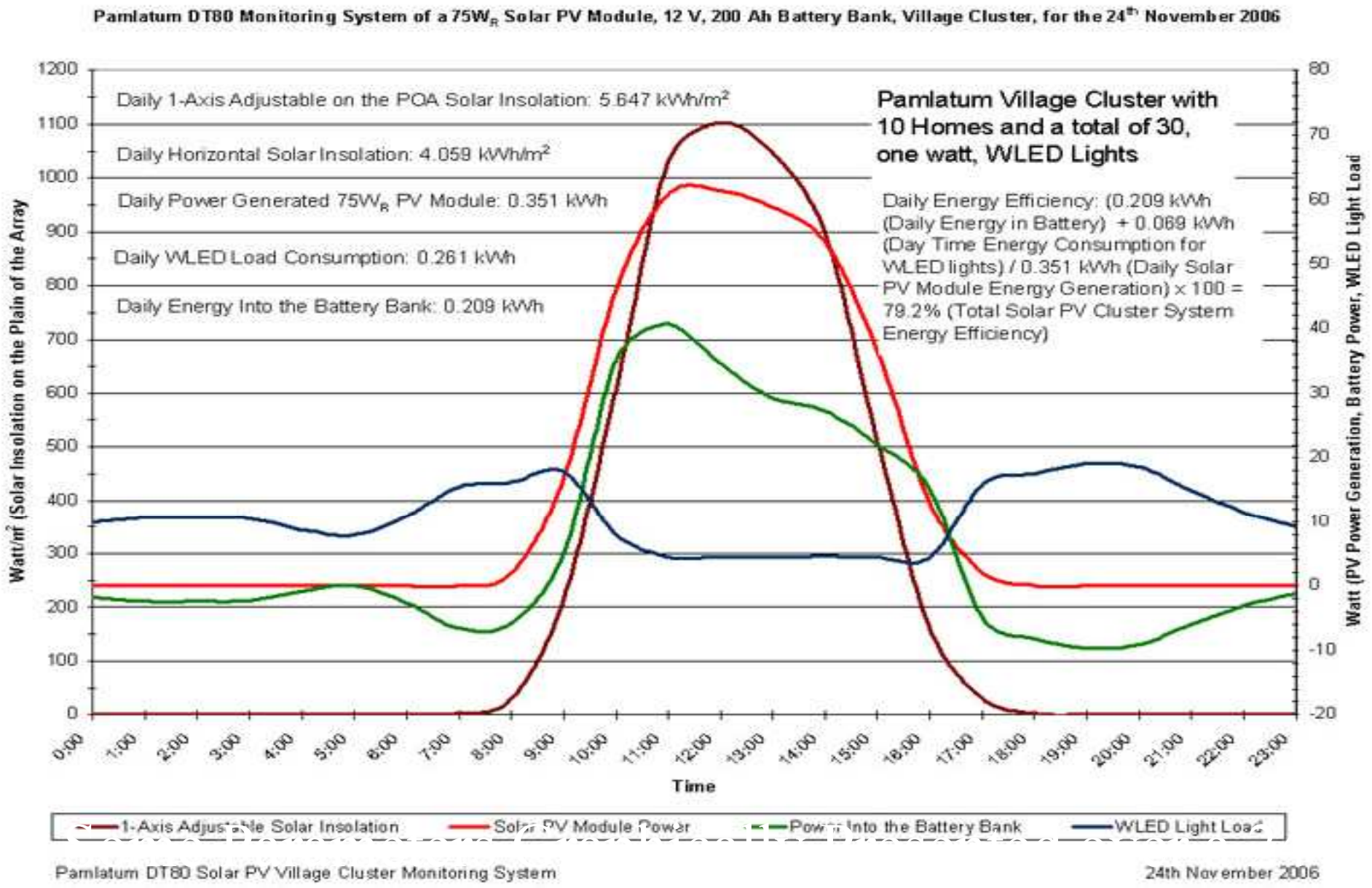
A special, solar PV powered box was designed to contain a DT80 dataTaker Logger for Each PV System Approach Monitoring System.

An individual written Program, to Monitor Each Solar PV System was written for Each of the Three installed DT80 Data Loggers.

Performance Monitoring

A Total of 22 Parameters are Measured, Calculated and Recorded in Each DT80 Data Logger Monitoring System. Some of the Parameters are . . .

- Global horizontal and on the POA Solar Radiation
- Generated solar PV module voltage, current and power output
- Solar PV module efficiency under the measured conditions
- Voltage, current and power flowing from the CC into the battery
- Voltage, current and power flowing from the battery to the WLED lamp load
- Voltage, current and power flowing to the air heater dump load
- Solar PV module, ambient and battery bank temperatures
- Temperature difference between solar PV module and the ambient temperature
- Solar PV module power loss due to increased temperature
- Solar PV module manufacturer's efficiency minus the measured "field" efficiency



Hours Performance Period of a Solar PV Cluster System

Summary

There are many villages in the high elevation areas of the Nepalese Himalaya that will never see the grid reach their community. Solar PV systems, a mature and approved technology, supported by a government subsidy program, allowed a steady growth in solar PV system installations in the remote mountainous communities over the last decade.

Our field experience and observation of other projects has shown that the standard and quality of the majority of the solar PV systems installed are not fulfilling the initial design demands in regard to equipment quality, performance and sustainability.

End users are often left with additional debts from the initial installation, beside their shattered and short-lived dream of improved indoor living conditions through electrification.

Conclusion

There are possible remedies to the identified Technical and NON - Technical problems. It lies with us to be determined and willing to get deeply involved as professionals and friends in the lives of our neighbors . . .

The following recommendations, learned through 10 years practical experience of installed and monitored solar PV systems in the remotest Nepal Himalayan mountain communities, summarize the main lessons learned . . .




Lessons Learned

- A Base-line survey of the community's current living conditions and self-identified needs has to be conducted before a solar PVvillage project is planned
- A solar PV village system project should always be considered as an integrated part of a wider HCD project approach such as the "Family of 4".
- The end users have to take initiative and explicitly express their interest in starting and partnering in a solar PV village system project.
- Prior to the project's planning the intended technologies need to be demonstrated and explained to the end users, with attention paid to services and life cycle costs.
- The end users have to participate in the definition of the systems' load demand, load growth, fee payment and prohibited loads.
- Form solar PV system user committees, responsible for the O & M of the systems, regular fee fee payments etc.
- Professional design of the PV systems, based on actual local geographical, climatic, meteorological and cultural data and conditions, is essential.
- Use and apply locally developed and manufactured equipment whenever possible.
- Equipment has to be checked for appropriate quality and reliability before installation.
- Train the end users in solar PV basics, hands-on system installation and O & M.
- Each PV system is numbered and registered for monitoring in a follow-up program.
- Chose some PV systems for long-term data acquisition and performance monitoring
- Conduct re-surveys after 2, 5 and 10 years of the installation.

For more Info:
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Email: azahnd@wlink.com.np
azahnd@airtelbroadband.in