APN 国際セミナー

地球温暖化と生態系・生物多様性の変化：
変わりゆく生態系にどのように向き合うか？

報　告　書

APN International Seminar

Grobal Warming and Ecosystem/Biodiversity Changes: Facing the Challenge of Changing Ecosystems

平成 20 年 3 月

APN（アジア太平洋地球変動研究ネットワーク）

March 2008

Issued by APN (Asia-Pacific Network for Global Change Research)

目　次
Contents

はじめに

北山　兼弘

ＤＩＷＰＡ（西太平洋・アジア地域の生物多様性ネットワーク）事務局長

京都大学生態学研究センター教授

最近発行されたIPCC第4次評価報告書（2007年IPCC）では、最近の温暖化がすでに、世界の自然の生物系に強く影響を及ぼし始めていると結論付けられている。地球温暖化が生物の種や生態系に及ぼす影響については、6年前に発行されたIPCC第3次評価報告書（2001）に記載されている。しかし現在では、以前より幅の広い生物の種や陸上生態系から集めたより実質的な証拠によって、地球温暖化の影響が強くなっていることが示されている。

20,000件を超える世界中のデータ・セットでは、物理系・生物系で観察されている変化は、人為的な原因による地球温暖化に一致していることが示唆されている。樹木種の開花が早まっていることや、山の樹木限界線が山頂に向かって移動していること、そして氷河が溶けていることなど、様々な証拠が上がっている。生態系の変化はこれまで予想されていたより、驚くべき速い速度で起きているようである。現在における大気中の温室効果ガスの増加速度なら、（社会経済的展開次第では）平均気温が産業革命前の気候と比べると今世紀末には摂氏2.5度から4.5度上昇し、実質的には全生態系が変化してしまう。生態系の変化は地球上の大半の種が絶滅することで最高潮に達する。このような変化は、生態系が回復する能力を上回ると予想される。それは、これらの変化が取り返しのつかないものであることを意味する。地質時代を通じて進化した多くの種が永遠に失われるのである。

自然の生態系は食料、繊維、水、エネルギー、空気など人類に不可欠な原料を供給している。安定した生態系は人間の存続と安全の基盤である。各生態系は、多様な生物や物理的環境で構成され、それらが相互に作用することで、人類にとって生活の糧となる原料が生産される。科学技術によって生態系の悪化傾向は幾分緩和され、食料や繊維などの原料の喪失は解決するかもしれない。だが我々は、生物の種や自然の生態系に美的価値も見出している。実際、文化は気候や自然の生態系に緊密に結びついている。科学技術ではこのような美的価値の代用をすることは出来ない。もし、近い将来に生態系が回復不能なほどに変化したなら、どのようにして健全な社会と文化を維持すればよいのだろう。温室効果ガスの排出量を増やすのを止めたとしても、気温上昇と降雨の変化は長期に渡って続くと考えられている。その意味では、我々は自分たち自身そして子どもたちのためにも、変わりゆく生態系に対する社会的適応力を向上させはじめる責任を負っている。地球温暖化を緩和する取り組みに加えて適応が必要なのだ。

このようにして、このセミナーは生態系の変化へ適応することの重要性を市民に広めるために計画された。

アジア太平洋地域を構成しているのは、様々な諸国、物理系、自然系、文化である。ただし、アジア太平洋地域のいたるところには共通性が見られる。第一に、社会経済的発展はこの地域で最も急激であることが挙げられる。世界経済つまり総生産は、近い将来、幾つかのアジア太平洋諸国によって導かれると予想されているのである。第二に、自然系がアジア太平洋地域の全体に渡り、モンスーン、河川、あるいは海流でつながっていることが挙げられる。第三に、地球温暖化の影響を受けやすい生態系や国がこの地域に多数存在していることが挙げられる。島国や大型デルタなどがその例だ。これらは要するに、ある国における歯止めの利かない開発の影響が私たちの地域の周辺諸国でも感じられるということを意味している。温室効果ガスを制御せずに排出していると、より遠方の諸国の生態系にも影響が出るのである。この機会に、個人個人がどのようにしてアジア太平洋地域全体に持続可能な社会を構築するかを考えるべきである。今後の生態系の変化に関する科学的予想は適応力のある社会を構築するための政策づくりに不可欠であるばかりでなく、市民にメッセージを伝えるためにも役に立つ。

市民にとって、科学者から直接科学的研究の成果を聞く機会が十分にあるとは言えない。このセミナーは市民と科学者をつなぐために計画された。地球温暖化の影響を研究しているアジア太平洋の最も活躍する科学者の数人がこのセミナーに招かれ、平易な言葉で参加者に強いメッセージを送っているのである。

APN国際セミナーの開催にあたって

垣内　秀敏（兵庫県環境担当部長）

ただいまご紹介いただきました兵庫県環境担当部長の垣内でございます。主催者の一員であります兵庫県を代表しまして、一言ご挨拶を申し上げます。本日は、APN 国際セミナーを開催させていただきましたところ、多数のご出席をいただき、誠にありがとうございます。

さて、ご案内のとおり、2008 年 5 月に、ここ神戸において環境大臣会合が開催されます。地球温暖化、生物多様性、３R をテーマに、G8、主要な開発途上国等の各国と、国際機関の首脳が集い、議論が行われます。７月に開催される洞爺湖サミットの主要テーマが地球温暖化であることから、神戸での環境大臣会合は、大変意義深い会合になるのではないかと期待をしております。

環境大臣会合が開催される地元として、この機会を通じて、本県が取り組んでいるコウノトリの野生復帰をはじめ、21 世紀尼崎の森、淡路夢舞台、瀬戸内海の再生などの自然再生プロジェクトや、地球環境保全に関する APN、IGES などの国際機関での研究など、先進的な環境への取り組みを広く内外にアピールしていきたいと考えております。

具体的事業としては、瀬戸内海における自然再生に向けた取組みの研究成果を発表する「瀬戸内海里海シンポジウム」の開催や、コウノトリ野生復帰プロジェクトを発信する「コウノトリ国際シンポジウム」とあわせ、2007 年 10 月から県内の国際機関等が連携し、大臣会合のメインテーマである地球温暖化問題などを取り上げ、リレー形式のシンポジウムを開催しております。本日のセミナーは、その第２回目のリレーシンポジウムとして位置づけております。

これら一連のシンポジウムの総括として「地球環境国際シンポジウム」を開催し、その結果を大臣会合に提言していくこととしております。さらに、環境大臣会合等の成果、県民運動として取り組んでいく地球温暖化対策等推進県民会議の結果を、「ひょうご環境宣言」として、国内外へ発信していきたいと考えております。今後とも、皆様方のご理解とお力添えをお願い申し上げます。

最後になりましたが、本セミナーが有意義なものとなり、その成果がこの兵庫の地から、国内外へ広く発信されますことを心からお祈り申し上げ、簡単ではございますが、私のご挨拶とさせていただきます。

橋詰　博樹（ＡＰＮセンター長）

垣内様、スピーカー及びパネラーの皆様、本当にありがとうございます。

皆様、おはようございます。APN国際セミナーに関心を持っていただいておりますことに感謝申しあげます。

APNという名前をお聞き及びでない方も多いと思いますので、まず、APNについて簡単にご説明させていただきたいと存じます。APNとはAsia-Pacific Network for Global Change Research(アジア太平洋地球変動研究ネットワーク)の略語です。まるでNGOのような名前ですがNGOではなく政府機関です。

最近、地球温暖化、生物多様性の損失、土地利用の変化、砂漠化などの地球規模の変化がマスコミや国際的議題に頻繁に取り上げられています。しかし、地球規模の変化に関する資料、情報、科学者は、特に開発途上国においては非常に限られています。APNは、地球規模の変化に関する研究や研究に関連した能力形成を促進するため、アジア太平洋地域の政府間ネットワークとして1996年に設立されました。1999年からAPNの事務局は神戸に駐在しています。APNは、アジア太平洋地域から提案のあった研究や能力形成プロジェクトに資金提供を行っています。現在、同地域の加盟国は21カ国に上ります。主に兵庫県と日本の環境省、及び米国国立科学財団(NSF)などからAPNに財政的貢献を果たしていただいております。

最近では、「気候変動」という言葉を毎日のようにテレビ番組や新聞紙上で耳にし、目にします。気候変動に関する政府間パネル(IPCC)の第4次評価報告書が今年数回に分けて発行されました。統合報告書は、ほんの数週間前に完成したばかりです。前米国副大統領のアル・ゴア氏はIPCCと共に、気候変動の問題に対する取組でノーベル平和賞を受賞しました。アル・ゴア氏の映画「不都合な真実」では、気候変動問題が最も明白な形で理解しやすいよう紹介されています。2007年は実際、気候変動が大きく報道された年となりました。

過去数年においてAPNは、兵庫県と共に地球規模の変化に関する様々なテーマについての幾つかの国際セミナーを開催しました。昨年には、環境教育に関するセミナーが、今年のはじめには生物多様性に関するセミナーが開催されました。そして本日のテーマは、「地球温暖化と生態系・生物多様性の変化」です。このテーマは、日本の琵琶湖と森林から、モンゴルの草原、東南アジア・太平洋における熱帯降雨林と生態系、ヒマラヤ・チベット高原にいたる様々な分野を網羅しております。

きたる5月には、13人の環境大臣が神戸で会合を行い、気候変動、生物多様性、3R、つまりReduce（ゴミ削減）、Reuse（再利用）、Recycle（再資源化）などについての話し合いが行わ

れます。本日のセミナーでは、この3つの問題のうち2つが検討されます。これは、緊密に関連のある2つの重要な問題について考え、環境大臣会合を歓迎し、間接的ではありますが、環境大臣会合に参画し携わるための実に良いスタートであると確信しています。

最後にもう一度、この会場におられる方全員に対しましてお越しいただいたこと、とりわけ、何年にも渡りAPNと連携し、はるばる海外よりお越しいただいたスピーカー、パネラーの方、及び兵庫県にはAPNへの継続的支援を賜りますことに感謝申しあげます。ご清聴ありがとうございました。

ＡＰＮ国際セミナー概要

趣　旨

温室効果ガスによる地球温暖化が進行し、世界各地の生態系に影響を及ぼしています。温暖化防止の努力を進める一方で、生態系の変化に社会が適応していくことが求められています。

このセミナーでは、温暖化の生態系への影響とその予測に関する最新の研究成果や地域の取組みを紹介することにより、変化する生態系に対して適応できる人間社会をどのように構築すべきか議論を深めます。

日　時

２００７年１２月２日（日）１０：３０～１７：３０

場　所

兵庫県立美術館　ミュージアムホール

主　催

アジア太平洋地球変動研究ネットワーク（ＡＰＮ）、兵庫県

共　催

西太平洋・アジア地域の生物多様性ネットワーク（ＤＩＷＰＡ）

後　援

環境省、(財) 地球環境戦略研究機関 (IGES) 関西研究センター、(財) ひょうご環境創造協会、日本環境教育学会関西支部

プログラム

開　会　　　　　　　　　　　　　　　　　　　　　　１０：３０

主催者あいさつ　兵庫県健康生活部環境担当部長　垣内　秀敏

　　　　　　　　ＡＰＮセンター長　　　　　　　橋詰　博樹

第１部　日本の生態系の現状と将来予測について

◎地球温暖化と琵琶湖の生態系

永田　俊（京都大学生態学研究センター教授）　　　　１０：４０～１１：２０

◎地球温暖化の日本の天然林への影響

田中　信行（森林総合研究所植物生態研究領域環境影響担当チーム長）

１１：２０～１２：００

◎積雪減少と雨水涵養高山湿原の変化

大丸　裕武（森林総合研究所水土保全研究領域山地災害研究室長）

１２：００～１２：４０

＜昼食休憩＞　　　　　　　　　　　　　　　　１２：４０～１３：４０

第２部　日本を取り巻くアジア太平洋諸国の生態系の現状と将来予測について

◎土地利用・土地被覆変化と気候変動への影響

マストゥーラ・マフムッド（マレーシア国民大学社会・人文学部地球観測センター所長）

１３：４０～１４：２０

◎東南アジア熱帯降雨林への土地利用と地球温暖化の影響

北山　兼弘（京都大学生態学研究センター教授）　　　１４：２０～１５：００

◎モンゴルの草原と遊牧文化の気候変動に対する脆弱性：

適応できるのか，破滅的影響を被るのか？

トグトヒン・デュルーン（コロラド州立大学天然資源生態系研究室主任研究員）

１５：００～１５：４０

◎ヒマラヤの氷河および氷河湖に対する気候変動の影響

バサンタ・シュレスタ（国際総合山岳開発センター

山岳環境・自然資源情報サービス部長）

１５：４０～１６：２０

＜休　憩＞　１６：２０～１６：３０

第３部　総合討論　１６：３０～１７：３０

モデレーター；田中　信行（森林総合研究所植物生態研究領域環境影響担当チーム長）

閉　会　１７：３０

国際セミナー　レポート

APN国際セミナー「地球温暖化と生態系・生物多様性の変化：変わりゆく生態系にどのように向き合うか？」が2007年12月2日に神戸で開催された。兵庫県と西太平洋・アジア地域の生物多様性ネットワーク（DIWPA）との共同開催であった。また、このセミナーは、2008年5月に神戸で開催予定のG8環境大臣会合の事前イベントの一つとして開催された。

昨年の2月のAPNの国際セミナーと同様に、このセミナーもおよそ140人の参加者を得て成功をおさめた。地球の温暖化を研究する7人の専門家がスピーカーとして招かれ、一般の人とテーマに関連した最新の科学的成果を共有し、適応の重要性を強く主張した。本セミナーは次の3つの主な講座に分かれる：パート1－日本の生態系の現状と将来予測、パート2－日本を取り巻くアジア太平洋諸国の生態系の現状と将来予測、パート3－総合討論。

日本の生態系の現状と将来予測

京都大学の永田俊博士は、地球の温暖化が琵琶湖の生態系にどのように影響を及ぼしているかが大きな社会的問題になっていると指摘している。日本最大の淡水湖である琵琶湖は、58種類の固有種を含め1,000種類を超える動植物が生息しており、日本は言うに及ばず世界的にも極めて重要である。最近の研究では、地球の温暖化による「全循環」欠損の可能性が予想されている。

「全循環」とは、冬期の湖面冷却によって冷やされた高密度の表層水が沈み込むことで湖水の上下混合（対流）が起こる物理現象である。地球の温暖化による冷却不足は、湖底や深層部の低酸素化や無酸素化を引き起こし、生物の生息地を危険に晒す可能性がある。

また、湖底堆積物からの栄養塩類や有害科学物質の溶出を介して急激な水質悪化や有毒藻類大発生の引き金となる可能性もある。永田博士は、琵琶湖の生態系の将来を科学的データに基づいて予測することの重要性を強く主張している。

地球温暖化の日本の天然林への影響に関する概要は、独立行政法人森林総合研究所（FFPRI）の田中信行博士から発表された。田中博士の発表では、現在と将来の気候条件下での日本の代表的天然林であるブナ林に適する地域（分布適域）の予測に的が絞られた。ある研究では、気候の温暖化のせいでブナの分布域の移動が分布適域の移動（100年に10～50キロメートル）に追いつけないことが明らかされている。それは、氷河期後のブナの分布域の過去の移動速度は、本州や北海道などの地域では100年で23キロメートルであると判断されている

からである。

博士は、多くの樹木種に対する気候変動の悪影響を評価し、影響を受けやすい地域とレフュージアの特定、植林、種の競合の軽減、自然植生地帯の造成などをはじめとする保護管理策など、生物多様性保全のための適応策を提案することの重要性を主張した。

FFPRIから来たもう一人の専門家、大丸裕武博士は、積雪減少と高山湿原に対するその影響に関する発表を行った。大丸博士の報告書では、冬の気候のばらつきが夏季の雪渓の規模に重大な影響を及ぼしていると現在の積雪・融雪過程が示唆しているということが明らかになっている。日本の雪田草原は希少植物種の生息域としてだけでなく、過去の気候記録の保存庫としても重要な価値を持っている。温室効果ガスの増大は日本列島の山地の大部分において、冬季の降雪量の減少と融雪期の気温上昇をもたらすと予想する気候モデルもある。したがって、地球温暖化は雪田草原の著しい縮小や消失をもたらすと考えられる。

日本を取り巻くアジア太平洋諸国における生態系の現状と将来予測

マレーシア国民大学のマストゥーラ・マフムッド博士は、熱帯雨林の伐採と、環境や生活の質に対するその影響について話した。博士は、熱帯雨林の伐採の原因は多変量的であるため、森林伐採問題に対処でき、広く認められた適切な手段の開発が非常に難しくなっていると力説した。さらに、地球温暖化を踏まえ、人類存続に向けた人々と意思決定者の取り組みと意志力を強化することが急務であると述べた。

京都大学の北山兼弘博士による東南アジア熱帯降雨林への土地利用と地球温暖化の影響に関する発表が行われた。北山博士は、世界第3位の面積を誇る島で、東南アジアで最も広い面積で陸続きの熱帯降雨林の存続をかつて支えていたボルネオを東南アジア熱帯地域のモデル系として使い、現在の土地利用における変化と、それらの変化がどのように気候変動と相まって熱帯降雨林に影響を与えているかを説明した。研究では、地球温暖化による深刻な干ばつを伴う持続不可能な伐採が続けば、ボルネオの熱帯降雨林は温暖化ガスの主要な排出源に転じてしまう可能性があり、一旦そうなれば元には戻らない。また、重要な生息地を失ってしまう結果にもなるだろう。

米国のコロラド州立大学のトグトヒン・チュルーン博士は、モンゴルの草原と遊牧文化の気候変動に対する脆弱性に関する報告を行った。博士は、モンゴルにおける「生態系の機能と役目」が気候変動と人間の営みの相互作用によって、いかに突然変化したかを説明した。このような状況では、遊牧民の地域社会、地域行政単位、河川の流域、小区域、国家レベルで、全て

の利害関係者の参画の下、適応策を講じることが求められる。

博士は、地球環境の変化に対するこのような策は、持続可能な開発や中間開発目標に関連させるべきであるとも述べている。

ネパールの国際総合山岳開発センター（ICIMOD）のバサンタ・シュレスタ氏は発表の中で、気候変動がヒマラヤの氷河や氷河湖に影響を与えていることを強調した。

ICIMOD は、地球規模の変化がヒマラヤ山脈に与える影響を理解するための包括的なデータベースを構築した。幾つかの研究によって、ヒマラヤの氷河のほとんどが、ここ数十年で気候変動が原因で加速的に縮小していることが明らかになった。ヒマラヤは氷河が発生する場所であり、アジアの給水塔である。今後、ヒマラヤ地域社会にあらかじめ警告するには適応メカニズムと脆弱性アセスメントが必要である。

課題に向き合う

田中博士による司会で進行されたセミナーの最後の部分では、参加者が発表に対する意見と質問を述べることが出来る公開討論が行われた。生物多様性と生態系という2つの要素は確実に変化を遂げ、地球温暖化はこれらの要素に悪影響を及ぼすほどに進むという問題が取り上げられた。したがって、気候変動と地球温暖化に適応するための行動を起こさなければならない。さらに、専門家と科学者は重要な役割を担っており、自らの研究結果を政策決定者に伝えるべきである。このことは、どうすれば科学がよりよい形で政策、行動、習慣に形を変えることができるのかという新たな課題を指し示すものである。それは、APNが直面している課題である。

パネラーは、気候変動は人類が直面する深刻な問題の一つであり、人が共同で考え、何が人間によって誘発された影響で何が自然の影響かを判断し、それに応じて行動する時期が来ているということに同意した。

APNは、兵庫県、DIWPA及び日本国環境省、地球環境戦略研究機関（IGES）関西研究センター、（財）ひょうご環境創造協会、日本環境教育学会関西支部など、セミナーへのご支援に対して感謝の意を表したい。

講演アブストラクト

地球温暖化と琵琶湖の生態系

永田　俊（京都大学生態学研究センター）

我が国最大の淡水湖である琵琶湖は、世界有数の古代型湖沼であり、その形成時期は約４００万年前と推定されている。

大きく発達した沖合や深底部（最大水深 104 m）と、それを取り囲む複雑な湖岸は、広大で豊かな生息環境を提供し、多様な生物の共存を可能にしている。５８種の固有種を含め、１０００種を超える動植物種が記載されている湖は、我が国はいうにおよばず世界的にも貴重であり、まさに、淡水生物多様性のホットスポットということができる。

近年、この多様な生物群集にとっての「生命維持装置」ともいうべき、冬期「全循環」が、温暖化の影響によって不活性化し始めている可能性が指摘されている。全循環とは、冬期の湖面冷却によって冷やされた高密度の表層水が沈み込むことで湖水の上下混合（対流）が起こり、それによって湖の全深度に溶存酸素が供給される物理現象である。温暖化（冷却不足）による全循環の欠損や不全は、湖底や深層の低酸素化・無酸素化をひきおこし、そこに生息する生物の絶滅につながる危険がある。

また、湖底堆積物からの栄養塩類や有害化学物質の溶出を介して急激な水質悪化や有毒藻類大発生の引き金となる可能性もある。琵琶湖の湖底にしのびよる、温暖化の「見えざる影響」は、社会的にも大きな関心を集めている。

琵琶湖はどうなるのか？１２００万人の飲料水を供給し、わが国の全淡水資源の３４％もの水量を湛える巨大な水がめでもある琵琶湖生態系の将来を、科学的な根拠に基づいて予測することが強く求められている。

地球温暖化の日本の天然林への影響

田中　信行（独立行政法人　森林総合研究所）

日本の代表的天然林であるブナ林に適する地域（分布適域）を現在と将来の気候条件で予測した。ブナ林の分布確率を環境要因から予測する分類樹モデルを構築した。分類樹モデルでは、目的変数をブナ林の実際の分布とし、ブナ林や他の天然林の分布情報として第３回自然環境保全基礎調査による３次メッシュ植生データ(MVDB)を用いた。説明変数を４気候変数（暖かさの指数、最寒月最低気温、夏期降水量、冬期降水量）と５土地変数（表層地質、地形、土壌、斜面方位、斜面傾斜度）とし、現在の気候には３次メッシュ気候値を、将来の気候には2100年の気候変化シナリオCCSR/NIESとRCM20を、土地変数には国土数値情報を用いた。分類樹モデルによると、ブナ林の分布を規定する要因の影響力を示す分離貢献度は、冬期降水量、暖かさの指数、最寒月最低気温の順に高かった。夏期降水量の貢献度は４気候変数の中では最低で、土地変数の貢献度は低かった。また、ブナ林の分布確率の高い地域と低い地域の気候条件が明らかになり、分布の限界を規定する気候変数と閾値が地域間で異なることが示された。ブナ林の分布適域を予測精度判定に基づいて分布確率0.5以上の地域とすると、その面積は現在の気候下では26,220km^{2}である。温暖化後の分布適域の面積は、CCSR/NIESシナリオでは9%に、RCM20シナリオでは37%に減少すると予測される。両シナリオとも、九州、四国、本州太平洋側の分布適域はほとんど消滅し、分布適域の広い東北でもその面積が大きく減少する。分布適域から外れるブナ林は、100年程度の時間をかけて衰退すると考えられる。欧米では、気候変化の潜在分布域への影響予測が多くの植物種について行われている。日本でも多種について影響予測を実行し、温暖化の種多様性への影響評価と適応策の検討が必要である。

積雪減少と雨水涵養高山湿原の変化

大丸　裕武（独立行政法人　森林総合研究所）

日本の山地の雪田草原は極域と共通する多くの希少種の分布域となっている。

山地における多量の積雪の集積は植物の生育期間を制限することで、本来高山帯を分布域とする植物が山地帯や亜高山帯の気候条件で生息することを可能にしている。このように、日本の雪田草原は高山植物にとって重要なレフュージアとなっている。日本の積雪山地の土壌層に記録された情報は、過去の気候変動が夏季の雪渓の規模を変化させたことを物語っている。とくに、ヒプシサーマル期や中世温暖期などの温暖な時代には、夏季の雪渓の規模が著しく縮小した。現在の雪渓において積雪の涵養過程と消耗過程を観察すると、とくに冬の気候条件が雪渓の規模に大きく影響することがわかる。したがって、雪田草原は希少種の生息域としてだけでなく、過去の気候記録の保存庫としても重要な価値を持っている。気候モデルによると、温室効果ガスの増大は日本列島の山地の大部分において、冬季の降雪量の減少と融雪期の気温上昇をもたらすとされている。結果として、地球温暖化は雪田草原の著しい縮小や消失をもたらすと考えられる。

土地利用・土地被覆変化と気候変動への影響

シャリファ・マストゥーラ S.A. / マストゥーラ・マフムッド
（マレーシア国民大学）

1990年代前半、土地利用・土地被覆変化は地球環境変化の研究における重要な課題として認識されていた（1990年ターナー他、1994年ターナーおよびマイヤー、1999年ランバン他、1999年ガイスト、1997年シャリファ・マストゥーラ）。土地利用・土地被覆変化は人間による地表面の重大な改変であるとされてきた。自然の力ではなく人間の活動が昨今の生物圏の状態および循環における変化の第一原因であり、微量ガス排出、生物多様性損失、土地劣化、アルベド変化、微気候変動、水循環の変化といった、他の二次的な影響の第一原因なのである。

したがって土地利用・土地被覆変化およびそれらを促進する要因について理解することは、地球環境変化を理解し、シミュレーションや予測を行う上で最も重要なことである。そうした知識は、人間の利益となるよう地球環境変化を建設的な手段を用いて管理・対応する上で利用することができる。

土地利用・土地被覆変化が重要な課題であることは、地球圏－生物圏国際協同研究計画(IGBP)、地球環境変化の人間社会側面に関する国際研究計画(IHDP)、アジア太平洋地球変動研究ネットワーク(APN)、米航空宇宙局(NASA)などが行っているさまざまな国際的な地球変動研究プログラムに高額な研究助成金が支給されていることからもうかがえる。この論文では、マレーシア国民大学(UKM)地理学科の地球観測センターの科学者による土地利用・土地被覆変化プロジェクトの一環として行われている、東南アジアを中心とした熱帯林破壊の原因究明に焦点を当てる。森林の減少の原因究明には複合科学を含めた幅広い分野の研究が必要であるが、ここでは本題に関係の深い要素についてのみ論じることとする。森林破壊が環境に与える最終的な影響についてもいくつか論じるが、主に生物多様性損失、侵食、堆積要因、森林火災の際の温室効果ガス排出について論じる。

東南アジア熱帯降雨林への土地利用と地球温暖化の影響

北山　兼弘（京都大学生態学研究センター）

東南アジアの赤道熱帯地域は温暖化による温度上昇率が他地域に比べてそれほど高くなく、このため温暖化による熱帯林生態系への影響は比較的小さいと考えられてきた。

しかし、温暖化に伴うエル・ニーニョ干ばつの拡大や土地利用の波及効果を加えると、生態系影響はかなり大きくなる可能性がある。ここでは、ボルネオを例に現在の土地利用パターンを紹介し、さらに気候変化と土地利用の相互作用がどのような効果を東南アジア熱帯降雨林に与えるのかについて考察したい。ボルネオは面積的に世界第3位の大きな島で、東南アジアで最も広い面積の熱帯降雨林が存在していた所である。しかし、農用地開発、森林伐採、大規模森林火災によって過去数十年で、森林面積が40～60%減少した。現在の森林被覆率は40%程度と見積もられているが、その大部分は伐採後に放置された二次林と考えられている。択伐と呼ばれる、商業的に価値の高い樹木の抜き切りは、無秩序に行われると、50%以上のバイオマスを森林から奪ってしまう。従って、抜き切りは火災などに対する森林の脆弱性を高める効果をもたらす。生態系モデルを使い、熱帯降雨林が今後どのように変化していくのかを、特に森林バイオマスに着目して予測してみた。その結果、2050年までに想定される程度の温度上昇だけでは、温度上昇の正の効果と負の効果が釣り合って、バイオマスには大きな変化が生じなかった。温度上昇に加えて、樹木の枯死を引き起こすような干ばつと激しい伐採の効果を与えたところ、森林の回復率は著しく低下し、現在期待されているような「持続的な森林利用」は不可能になることが示された。このモデルによれば、ボルネオの熱帯降雨林は想定される程度の温度上昇自体には大きな反応を示さないが、干ばつを伴う温暖化と伐採には脆弱であり、回復は望めないことから、温暖化ガスの主要な排出源に転じてしまう可能性がある。また、多くの野生生物が生息場所を失ってしまう結果にもなるだろう。

モンゴルの草原と遊牧文化の気候変動に対する脆弱性：適応できるのか、破滅的影響を被るのか？

トグトヒン・チュルーン（コロラド州立大学）

過去60年間モンゴルの地表気温は1.8度上昇しており、その変化は冬に最も顕著に現れている。この数値は地球全体の数値の2.5倍である。気温の上昇と降水量の減少によりモンゴルでは春にますます乾燥するようになってきている。ゴビ砂漠、乾燥草原、アルタイ・ハンガイ両山脈の南側斜面の境界地域では、植物の生育が一ヶ月遅れる傾向が見られている。この数十年の気温の上昇と降水量の減少に伴って植物の生育期前半は乾燥が続く傾向にあり、家畜の出産期、成長期という重要な時期に飼料が減ってしまう結果となっている。さらに、モンゴルでは1999年、2000年、2001年、2002年の夏に最悪の干ばつが発生し、国土の50%～70%が影響を受けた。こうした干ばつは観測史上最も深刻な「ゾド(zud)」をもたらした。「ゾド」とは家畜がエサを掘り起こすことができないほど大量の積雪のことである。陸上で何らかの支援を届けるのはほぼ不可能で、前述の干ばつに続いて発生した3年連続の「ゾド」の間に、1,200万頭の家畜が死亡した。長期にわたる乾燥期はモンゴル国内の水源にも影響を与えている。モンゴル自然環境省による2003年の「地表水に関する全国調査」によると、水域の約15%(5,565本の河川うちの683本、9,600箇所の泉のうちの1,484箇所、4,196箇所の湖と池のうちの760箇所)が前回1995年に行われた調査以降に消失してしまっていた。水および飼料となる資源の減少により、モンゴル国内の牧畜体制は気候変動の影響を受けやすい状態となっている。砂漠化につながる深刻な土地の劣化、気候の変化や人間活動による水源の減少は破滅的な結末の一例である。

遊牧文化は多様性に富んだ気候や地形をもつ乾燥地や半乾燥地に出現しており、伝統的な牧畜社会のネットワークに気候変動によるリスクに対処できる人間の適応能力を向上させるよう発展してきた。広大な地形は「ゾド」や干ばつなどの極端な事象を伴う気候変動の影響を弱めるのに非常に重要である。

しかし、現在の地球環境の変化のスピードは、それに対処するための自然資本や文化資本の能力を超えつつある。気候変動への適応は破滅的な結末を回避する唯一の方法であるが、この気候変動に適応する能力を開発する上で最大の障害となっているのが貧困である。モンゴルの牧畜業者の約60%は所有家畜数が100頭に満たない非常に貧しい人々である。その貧しい牧畜業者の大半が以前に比べ移動の頻度が減少しており、水源や居住地付近での過放牧が起こっている。このようにモンゴルの生態系と遊牧文化は破滅的影響を被るのか、適応できるかの分岐点に立っている。

ヒマラヤの氷河および氷河湖に対する気候変動の影響

バサンタ・シュレスタ（国際総合山岳開発センター）

地球温暖化に直面する中、ヒマラヤ氷河の大部分は年間で数メートルから数十メートルの範囲まで後退しており、その結果、氷河湖の数も表面積においても増大し、これに伴い、氷河湖決壊洪水（GLOF）の脅威が増してきている。このような気候変動は、下流区域に住む山岳住民の生命や財産に最悪の影響をもたらしている。地球温暖化の人的活動への影響については現在も激しく議論が交わされているが、ヒマラヤの氷河の後退は、気候変動に対する対策が必要であることの確固たる証拠となっている。

ブータン、ネパールおよびパキスタンにある（33,340平方キロメートルの表面積に相当する）約15,000の氷河と9,000の氷河湖並びに中国とインドにある選び出された河川流域について、ICIMOD（国際総合山岳開発センター）、UNEP（国連開発計画）およびアジア太平洋地球変動研究ネットワーク（APN）によって、これまで基礎研究が報告書にまとめられている。最近では21件のGLOF災害がネパール領内に甚大な被害をもたらし、これまでに200超の危険性が予測される氷河湖がヒマラヤ地域において報告されている。このような事実から、氷河および氷河湖を継続的に監視し、脆弱性評価を行い、緩和・適応手段を実行に移し、更には、氷河湖決壊洪水（GLOF）の早期警報システムを構築することによって、氷河環境についての科学的知識を向上させるための緊急の必要性が明確に示されている。また、気候変動により発生したと思われる影響に関連する国境を越えた問題に対処することを目的として、組織的戦略を構築するための地域間の協力も必要である。

この研究では、ヒマラヤの氷河活動の2つの危険地域であるネパールのDudh Koshi（ドゥードコシ）下流地域とブータンのPho Chu（ポーツウ）下流地域における氷河および氷河湖に対する気候変動の影響に焦点を当てる。これら双方の流域では、ここ最近、悲惨なGLOFの災害に見舞われている。この研究で議論される科学的モデル構築法および経験的方法のどちらにおいても、他のヒマラヤの危険地域に関するこのような調査の精密化および拡大に有益な最初の一歩が必要なのである。現在必要とされているのは、手遅れになる前に、気候変動の結果に対する更なる科学的理解の構築を支援し、矯正的措置および予防的措置を取るにあたっての国際社会による緊急対策である。

講師略歴

永田　俊（ながた　とし）

学歴：

1983 年　京都大学大学院理学研究科修士課程修了

1987 年　京都大学大学院理学研究科博士課程修了（理学博士）

職歴：

1989 年　デラウェア大学海洋学部研究員

1991年　名古屋大学水圏科学研究所助手

1995 年　東京大学海洋研究所海洋生化学部門助教授

2000 年　京都大学生態学研究センター教授（現在に至る）

田中　信行（たなか　のぶゆき）

学歴：

1980 年　東京大学大学院農学系研究科修士課程修了

1983 年　東京大学大学院農学系研究科博士課程単位取得退学

職歴：

1991年　タイ国王室林野局へ派遣（タイ国造林研究訓練計画：国際協力事業団）

1993 年　森林総合研究所生産技術部更新機構研究室

2005 年　森林総合研究所植物生態研究領域チーム長（現在に至る）

大丸　裕武（だいまる　ひろむ）

学歴：

1988 年　北海道大学大学院環境科学研究科修士課程修了

職歴:

2000 年　森林総合研究所九州支所山地防災研究室長

2005年　森林総合研究所チームリーダー（災害危険地判定）

2006年　森林総合研究所山地災害研究室長（現在に至る）

マストゥーラ・マフムッド

学歴：

バーミンガム大学博士課程修了

現職：

マレーシア国民大学社会・人文学部地球観測センター所長

北山　兼弘（きたやま　かねひろ）

学歴：

1983 年　東京農工大学自然保護学科修士課程修了

1992 年　ハワイ大学植物学科博士課程修了

職歴：

2000 年　京都大学生態学研究センター助教授

2001 年　京都大学生態学研究センター教授（現在に至る）

※西太平洋・アジア地域の生物多様性ネットワーク（DIWPA）事務局長

トグトヒン・チュルーン

学歴：

1977 年　ハリコフ州立大学修士課程修了

1991 年　モスクワ州立大学博士課程修了

職歴：

1977 年　モンゴル科学アカデミー主任研究員

1991 年　コロラド州立大学天然資源生態系研究室研究員

2002 年　モンゴル国立大学教授（現在に至る）

現在、コロラド州立大学天然資源生態系研究室主任研究員

バサンタ・シュレスタ

学歴：

1989 年　アジア工科大学院大学情報科学修士課程修了

現職：

国際総合山岳開発センター　山岳環境・自然資源情報サービス部長

Introduction

Kanehiro Kitayama

(Secretary General,DIWPA, Center for Ecological Research,Kyoto University)

The recently published Fourth Assessment Report of IPCC (IPCC 2007) concludes that recent warming is already strongly affecting natural biological systems of the world. The influences of global warming on species and ecosystems had been described in the Third Assessment Report of IPCC (2001), which was published six years ago. However, there is now more substantial evidence from a wider range of species and terrestrial ecosystems than before to suggest the stronger impacts of global warming. More than 20,000 data sets worldwide indicate that observed changes in physical and biological systems are consistent with global warming of anthropogenic origin. The evidence ranges from earlier flowering of a tree species to the upward sift of timberline on a mountain to melting glaciers. It appears that ecosystem changes are occurring at an alarming rate than ever expected. With the current rate of the increase of green house gases in the atmosphere, mean air temperature will increase by 2.5-4.5□ in the end of this century compared with the pre-industrial climate (depending on socio-economic scenarios) and virtually all ecosystems will change. Ecosystem changes will culminate in the major extinctions of species around globe. It is predicted that such changes exceed the resilient capacity of ecosystems, meaning that these changes are irreversible. We will lose forever many species that evolved through geological time.

Natural ecosystems provide human beings with such essential material as food, fiber, water, energy and air. Stable ecosystems are the basis for human subsistence and security. Each ecosystem consists of diverse organisms and physical environments, and their interactions produce subsistence materials for human beings. Technology may partly alleviate deteriorating ecosystems and resolve the loss of such materials as food and fiber. However, we also find many aesthetic values in species and natural ecosystems. In fact, culture is closely associated with climate and natural ecosystems. Technology cannot substitute such aesthetic values. If ecosystems irreversibly change in the near future, how can we maintain our healthy society and culture? It is believed that temperature rise and precipitation change will continue for an extended time even if we stop increasing the emission of green house gases. In this sense, we are charged to begin raising societal adaptability for changing ecosystems for ourselves and for our children. Adaptation is needed in addition to the efforts to mitigate the global warming. This seminar was thus planned to disseminate the importance of adaptation for ecosystem changes among citizens.

The Asia and Pacific region consists of diverse countries, physical and natural systems and cultures. However, there are some commonalities across the Asia and Pacific region. Firstly, socio-economic development is most rapid in this region. World economy or gross production is expected to be lead by some of the Asia-Pacific countries in the near future.

Secondly, natural systems are connected throughout the region with the monsoon, rivers or ocean currents. Thirdly, many vulnerable ecosystems or countries to global warming exist in this region. Island countries and some large deltas are such an example. These altogether mean that the consequences of uncontrolled developments in a country will be felt in the surrounding countries in our region. Uncontrolled emission of green house gases will affect the ecosystems of more remote countries. In this opportunity, each of us should think how we develop sustainable society throughout the region. Scientific predictions on future ecosystem changes are not only essential to make policies for developing adaptive societies but also useful to send messages to citizens. There are not enough opportunities for citizens to hear scientific findings directly from scientists. This seminar was planned to link citizens and scientists. Some of the most active Asian-Pacific scientists who study the influences of global warming were invited to this seminar and send strong messages to the participants with plain words.

Welcome Address

Hidetoshi Kakiuchi (Chief Executive Officer for the Environment,Hyogo Prefectural Government)

My name is Hidetoshi Kakiuchi, Chief Executive Officer for the Environment, Hyogo Prefectural Government. On behalf of our prefecture, one of the organizers of this Seminar, I would like to start with a welcome address to you. I am very grateful to have this great number of attendants at the APN International Seminar today.

As announced earlier, the Environment Ministers Meeting 2008 will be held here in Kobe next May. At the Meeting, leaders of the Group of eight (G8) and major developing countries will gather to discuss three agendas: climate change, biodiversity, and 3Rs. We are expecting the Meeting in Kobe to be a very meaningful and significant one, because the Meeting will be held before the G8 Hokkaido Toyako Summit in July, the main theme of which is global warming.

Taking this current opportunity when Hyogo will serve as the venue of the Environment Ministers Meeting 2008, both at home and abroad our prefecture would like to further promote our advanced environmental efforts including our natural environment regeneration projects such as releasing storks into the wild, the 21st Amagasaki no Mori, the Awaji Yumebutai, and the regeneration of the Seto Inland Sea, as well as undertaking researches in international institutes like the Asia-Pacific Network for Global Change Research (APN) and the Institute for Global Environmental Strategies (IGES).

Here I introduce our activities more specifically. From October we organized the Setonaikai Satoumi Symposium to deliver the research results of efforts made to regenerate the natural environment of the Seto Inland Sea, and the Stork International Symposium that disseminates activities designed to release storks into the wild. Along with such events, we planned and held a series of symposia to discuss topics including global warming, one of the main agendas of the Environment Ministers Meeting 2008, by collaborating with international institutes and other organizations in Hyogo. Today's seminar is regarded as the second meeting of this series of the symposia.

As a conclusion to the series of symposia, we will organize a Climate Change Symposium, and propose the results obtained from the Symposium at the Environment Ministers Meeting 2008, and then, as "The Hyogo Environmental Declaration," we would like to disseminate the results of the Meeting and Hyogo Prefectural Promotion Meeting on global warming and other issues we are addressing as prefectural initiatives. Concerning these matters we hope for your general understanding and continued support.

I will close my brief greeting by sincerely wishing that this seminar is a meaningful one and that its results will be widely disseminated from Hyogo to the rest of Japan and the world.

Opening Remarks

Hiroki Hashizume (Director of the APN Secretariat)

Thank you very much, Mr. Kakiuchi, distinguished speakers and panelists. Good morning, ladies and gentlemen. Thank you very for your interest in this APN International Seminar.

Let me start with briefly explaining what is the APN because many of you may have not heard of us, I am afraid. APN stands for the Asia-Pacific Network for Global Change Research. It may sound like an NGO, but it is not. It's governmental.

These days, global change such as global warming, loss of biodiversity, change in land use, desertification, is frequently appearing in media and on international agenda. However, data and information and scientists on global change are very much limited particularly in developing countries. The APN was established in 1996 as a network of governments in the Asia-Pacific region in order to promote research and research related capacity building on global change. Since 1999, the Secretariat has been stationed in Kobe. The APN funds research and capacity building projects proposed from the Asia-Pacific region. Now, we have 21 member countries in the region. Hyogo Prefectural Government as well as Japanese Ministry of the Environment and US National Science Foundation are the major financial contributors to the APN.

Recently, we find the term "climate change" on newspapers and TV programmes everyday. The 4th Assessment Report of Inter-Governmental Panel on Climate Change (IPCC) was published volume by volume this year. Just a few weeks ago, the synthesis report was finalized. Al Gore, the former US Vice President, together with the IPCC got the Nobel Peace Prize for the efforts to cope with climate change. Al Gore's movie "An Inconvenient Truth" most notably presented the issue of climate change in easy way to understand. The year 2007 has really become a year of great publicity on climate change.

In the past few years, the APN organized several international seminars on various topics of global change with Hyogo Prefecture Government, last year on environmental education, early this year on Biodiversity. And today, we picked up "Global Change and Ecosystem/Biodiversity Changes" as the topic. It will cover variety of areas, from the lake Biwa and Forests in Japan to Mongolian Steppe, tropical forests and ecosystem in Southeast Asia and the Pacific and Himalayan-Tibetan Plateau.

13 Environmental Ministers will get together in Kobe in next May and discuss on climate change, biodiversity and 3R's or Reduce, Reuse and Recycle of Waste. Today's seminar discusses two of those three issues and I am sure this is really a good start for us to think about those two important closely-related issues as well as to welcome and to be involved and participate, indirectly though, in the Environment Ministers Meeting.

Lastly but not least, let me again thank all of you in this hall for coming, particularly the speakers and the panelists, who have been working with the APN for years and come all the way from abroad, and Hyogo Prefecture government for the continuing support to the APN. Thank you very much.

Outline of the APN International Seminar

Background

Global warming, due to the emission of greenhouse gases, is progressing and affecting ecosystems all over the world. Natural ecosystems provide human beings with essentials such as food, fibre, water, energy and air. Thus, stable ecosystems are the basis for human subsistence and security. Each ecosystem consists of diverse organisms and physical environments, and their interactions produce subsistence materials for human beings. Climate determines the distribution of organisms and regulates the magnitude of the biological-physical interactions.

How does global warming affect ecosystems? How do we face the challenges of changing ecosystems? It is believed that temperature rise and precipitation change will not stop even if we moderately reduce greenhouse gases. We need to begin raising societal adaptability for changing ecosystems in addition to the efforts to mitigate global warming. In this seminar, Asia-Pacific scientists who study the influences of global warming will speak on the latest scientific results and point out the importance of adaptation.

Date

02 December 2007, Sunday

Time

10:30-17:30

Venue

Museum Hall, Hyogo Prefectural Museum of Art

Organized by

Asia-Pacific Network for Global Change Research (APN),
Hyogo Prefectural Government

Co-organised by

DIVERSITAS in Western Pacific and Asia (DIWPA)

Supported by

Ministry of the Environment, JAPAN
Institute for Global Environmental Strategies (IGES), Kansai Research Centre
Hyogo Environmental Advancement Association
The Japanese Society of Environmental Education, Kansai Branch

Programme

Welcome Address (10:30-10:35)
Mr.Hidetoshi Kakiuchi, Chief Executive Officer
for the Environment , Hyogo Prefectural Government

Opening Remarks (10:35-10:40)
Mr.Hiroki Hashizume,Director, APN Secretariat

Part 1
The Current Situation and Projetion of Ecosystems in Japan

Dr. Toshi Nagata,Center for Ecological Research,Kyoto University,
"Does Global warming Impact the Lake Biwa Ecosystems?" (10:40-11:20)

Dr. Nobuyuki Tanaka,Department of Plant Ecology,
Forestry and Forest Products Research Institute
"Impact of Global Warming on Natural Forests in Japan" (11:20-12:00)

Dr. Hiromu Daimaru,Hillslope Conservation Laboratory,Department of Soil and Water Conservation,Forestry and Forest Products Research Institute
"Snow-cover Decrease and its Impact on a Mountain Wet Meadow" (12:00-12:40)

<Lunch Break> (12:40-13:40)

Part 2
The current situation and Projection of Ecosystems in Asia and the Pacific

Dr. Mastura Mahmud,Head,Earth Observation Center,
Faculty of Social Sciences and Humanities,Universiti Kebangsaan Malaysia
"Land Use and Land Cover Dynamics and its Impact on Climate Change"
(13:40-14:20)

Dr.Kanehiro Kitayama,Center for Ecological Research,Kyoto University
"Influence of Global Warming and Land-use on the Tropical Rain Forests of Southeast Asia" (14:20-15:00)

Dr. Chuluun Togtohyn,Natural Resource Ecology Laboratory,
Colorado State University

"Vulnerability of the Mongolian Steppe and Nomadic Culture to Climate Change:Adaptation or Catastrophe?" (15:00-15:40)

Mr. Basanta Shrestha, Mountain Environment and Natural Resources'Information Systems, International Centre for Integrated Mountain Development
"Impacts of Climate Change on Himalayan Glaciers and Glacial Lakes"

(15:40-16:20)

<Break> (16:20-16:30)

Part 3
Discussion

Moderator: *Dr. Nobuyuki Tanaka,* Department of Plant Ecology, Forestry and Forest Products Research Institute (16:30-17:30)

Seminar Report

The APN International Seminar "Global Warming Ecosytem/Biodiversity Changes: Facing the Challenge of Changing Ecosystems" convened in Kobe , Japan , 02 December 2007. It was co-organised by the Hyogo Prefectural Government and the DIVERSITAS in Western Pacific and Asia (DIWPA). The seminar was also held as one of the pre-events for the upcoming G8 Environment Ministers Meeting to be held in the same city, next May.

Similar to the international seminar that APN organised last February, this recently concluded seminar was also a resounding success, and attracted around 140 participants. Seven experts who study the influence of global warming were invited as speakers to share with the public the latest scientific results related to the theme and to stress the importance of adaptation. The Seminar was divided into three main sessions: Part 1 - The Current Situation and Projection of Ecosystems in Japan; Part 2 - The Current Situation and Projection of Ecosystems in Asia and the Pacific; and Part 3 - Discussion/Open-forum.

The Current Situation and Projection of Ecosystems in Japan

Dr. Toshi Nagata, Kyoto University , Japan , pointed out how global warming affects the Lake Biwa ecosystem causing great social concern. Lake Biwa is the largest freshwater lake in Japan and home to 58 indigenous species and more than 1,000 animals and plants which are essential not to Japan alone but to the world. Recent studies predicted the possibility of deficient 'total circulation' due to global warming.

'Total circulation' is a physical phenomenon where winter cooling of highly dense surface water sinks causes the lower layer of water and the upper layer of water to mix (convention). The insufficient cooling caused by global warming brings about low oxygen or no oxygen at all to the lakebed and deeper layers of the lake, thus potentially endangering the biological habitat. Elution of nutrient salts and hazardous chemical substances from the lakebed sediments could also trigger a sharp decline in water quality or outbreak of algae. Dr. Nagata stressed the importance of forecasting the future ecology of Lake Biwa based on scientific data.

An overview of the impacts of global warming on natural forests in Japan was presented by Dr. Nobuyuki Tanaka, Forestry and Forest Products Research Institute (FFPRI), Japan . His presentation focused on predicting suitable habitats under current and future climate conditions for Buna (Fagus crenata) forests, a typical Japanese natural forest. A study revealed that migration of Buna cannot keep up with the shift of suitable habitats (10-50km/100yr) due to climate warming because the past migration speed of Buna after the last glacial period was estimated to be 23km/100yr in some areas like Honshu and Hokkaido.

He asserted the importance of assessing the adverse impacts of climate change on many plant species and proposing adaptation measures for conserving biodiversity such as determining vulnerable areas and refugia, planting, reducing species competition, making corridors of natural vegetation, and taking other protective management measures.

Another expert from FFPRI, Dr. Hiromu Daimaru, gave a presentation on snow cover decrease and its impact on a mountain wet meadow His report showed that present snow accumulation and snowmelt processes indicate that fluctuations of winter climate significantly influence the dimensions of summer snowpatches. Snowpatch grasslands in Japan are valuable not only as habitats for rare plant species, but also as records of past climates. Some climate models predict that increases in greenhouse gases will bring about decreased snowfall in winter and increased warming in the melt season in Japanese mountains. Global warming, therefore, will lead to extreme shrinkage or extinction of snowpatch grasslands.

The Current Situation and Projection of Ecosystems in Asia and the Pacific

Dr. Mastura Mahmud, University Kabangsaan, Malaysia , talked about tropical deforestation and its impact on the environment and quality of life. She emphasised that the multivariate causes in tropical deforestation make it extremely difficult to develop a widely accepted and applicable policy that can manage the issues of deforestation. She further noted that it is imperative that commitment and willpower of the people and decision-makers be reinforced for the survival of humans in the light of global warming.

A presentation on the influence of global warming and land-use on the tropical rain forests of Southeast Asia was given by Dr. Kanehiro Kitayama, Kyoto University , Japan . He used Borneo, the third largest island in the world, which used to support the biggest area of contiguous tropical rain forest in Southeast Asia , as a model system of the Southeast Asian tropics to demonstrate present land-use changes and how these changes may interact with climate change to influence rainforests. Studies showed that if unsustainable logging continues, coupled with severe droughts due to global warming, the tropical rain forests of Borneo might irreversibly become the major source of carbon, which may lead to the loss of important habitats.

Dr. Chuluun Togtohyn, Colorado University , U.S.A. , reported on the vulnerability of the Mongolian steppe and nomadic culture to climate change. He explained how 'ecosystem function and services' in Mongolia change abruptly due to interacting climate change and human activities. This situation demands the implementation of adaptation strategies at pastoral community, local administrative unit, river basin, sub-regional and country levels, with participation of all stakeholders. He also mentioned that these strategies to global environmental change should be linked to the Sustainable Development and Medium Development Goals

In his presentation, Mr. Basanta Shrestha , International Centre for Integrated Mountain Development (ICIMOD), Nepal , underscored the impact of climate change on Himalayan glaciers and glacial lakes. ICIMOD developed a comprehensive database to understand the impact of global change in the Himalayas and several studies revealed that most glaciers in Himalaya have been shrinking at accelerated rates in recent decades due to the impact of climate change. Himalaya is the womb of ice glaciers and the water tower of Asia ; hence, adaptive mechanisms and vulnerability assessment are necessary to forewarn the community.

Facing the Challenge

The last part of the seminar, moderated by Dr. Tanaka, was an open discussion wherein the participants were given the chance to comment on the presentation and ask questions. It was raised that two elements of biodiversity and ecosystems, will definitely undergo changes and that global warming will proceed to an extent that poses negative effects on these elements. Therefore, action must be taken in order to adapt to climate change and global warming. Further, experts and scientists play an important role and they should communicate their research results to policy-makers. This points to another challenge in how science can be better translated into policy, action and practices – a challenge that APN is also facing.

The panellists agreed that climate change is one of the serious problems being faced by humankind and that the time has come for people to think collectively; determine what the human-induced impacts and natural impacts are, and then act accordingly.

The APN would like to thank the Hyogo Prefectural Government, DIWPA and the following institutions for their support in the success of the Seminar: Ministry of the Environment, Japan ; Institute for Global Environmental Strategies (IGES), Kansai Research Centre; Hyogo Environmental Advancement Association, and the Japanese Society of Environmental Education, Kansai Branch.

Abstract

Does Global Warming Impact the Lake Biwa Ecosystem?

Toshi Nagata(Center for Ecological Research, Kyoto University)

Lake Biwa, the biggest freshwater lake in Japan, is one of the most famous ancient lakes in the world, supposedly formed nearly 4 million years ago. Its large and developed offshore area, deep layer (the deepest point is 104 m deep), and complex coastline that surrounds the lake provide a large habitat and rich environment that enables diverse animals to live together. The area is home to 58 indigenous species, and more than 1,000 animals and plants live in the lake, which is valuable not only to Japan but to the world. It could be considered a "hot spot" for its diversity of freshwater plants and animals. Total circulation in winter is a life-support system for the diverse biological community in Lake Biwa. In recent years, however, it has been pointed out that there is possibility of total circulation in winter shutting down due to global warming. "Total circulation" is a physical phenomenon where winter cooling of highly dense surface water sinks causing the lower layer of water and upper layer of water to mix (convection). This mixing provides dissolved oxygen to all the layers of lake water. Deficient or incomplete total circulation caused by global warming (insufficient cooling) brings about low oxygen or even no oxygen to the lakebed and deeper layers of the lake, which might endanger the biological habitat. Furthermore, elution of nutrient salts and hazardous chemical substances from the lakebed sediments could trigger a sharp decline in water quality or outbreak of toxic algae. The invisible influence of global warming, which is sneaking up on Lake Biwa's bed, is causing great social concern. What will happen to Lake Biwa? The lake provides water for 12 million people and like a giant cistern, accounts for 34% of freshwater resources in Japan. It is strongly recommended that the future ecology of Lake Biwa be forecast based on scientific data.

Impact of Global Warming on Natural Forests in Japan

Nobuyuki Tanaka(Forestry and Forest Products Research Institute)

Suitable habitats for buna (*Fagus crenata*) forests, a typical Japanese natural forest type, were predicted under the current and future climate conditions. The occurrence probability of buna forests was predicted by tree-based models. In the models, the response variable was presence/absence data on actual distribution of buna forests derived from the Third Mesh Vegetation Database (MVDB). Predictor variables comprised four climatic ones, *i.e.*, the Warmth Index (WI), the mean minimum daily temperature of the coldest month (TMC), the precipitation in the warm season (PRS) and that in the cold season (PRW); and five non-climatic variables, *i.e.*, topography, surface geology, soil, slope aspect and inclination. According to the models developed, DWS values, which evaluate the contribution of each predictor variable to a model, were the highest for PRW, followed by WI and TMC. They were low for PRS as well as for the non-climatic variables. The models showed climatic conditions for varying occurrence probability for buna forests, indicating that the variables controlling buna forest distribution and their thresholds vary among regions. Suitable habitats for buna forests, defined as the areas with over 0.5 in occurrence probability, cover 26,220 km^2 under the current climate. The area of suitable habitats is predicted to decrease to 9% of the current area under the CCSR/NIES climate change scenario and 37% under the RCM20 scenario. Under both scenarios, suitable habitats disappear in Kyushu, Shikoku and the Pacific Ocean side of Honshu, and decline greatly even in the Tohoku area of northern Honshu with the most extensive suitable habitats. Buna forests in the areas which become unsuitable after climate change may gradually decline along with the death of the buna trees. Much research on predicting the impact of climate change on potential distributions of many wild plants has been conducted in Europe and the United States. It is necessary to assess the impact of climate change on many plant species in Japan and to propose adaptation measures for conservation of biodiversity.

Snow-cover Decrease and its Impact on a Mountain Wet Meadow

Hiromu Daimaru(Forestry and Forest Products Research Institute)

Snowpatch grasslands on snowy mountains in Japan contain many rare species that are common in arctic areas. Accumulation of extremely deep snow shortens the snow-free period in snowpatches and allows many alpine plants to survive in subalpine or mountain climates. Snowpatch grasslands are important refuge areas for alpine plant species. Historical records preserved in soil profiles on Japanese snowy mountains indicate that past climatic changes have changed the dimensions of summer snowpatches. Especially in past warm periods, such as the hypsithermal and medieval warm periods, some snowpatches were significantly smaller than those at present. Present snow accumulation and snowmelt processes indicate that fluctuations of winter climate significantly influence the dimensions of summer snowpatches. Consequently, snowpatch grasslands in Japan are valuable not only as habitats for rare plant species, but also as records of past climates. Some climate models predict that increases in greenhouse gases will bring about decreased snowfall in winter and increased warming in the melt season in Japanese mountains. Therefore, global warming will lead to extreme shrinkage or extinction of snowpatch grasslands.

Land Use and Land Cover Dynamics and its Impact on Climate Change

Sharifah Mastura S.A and Mastura Mahmud(Universiti Kebangsaan,Malaysia)

In the early 1990's land use and land cover (LUCC) dynamics have been recognised as a key research imperative in global environmental change research (Turner et al 1990, Turner and Mayer 1994, Lambin et al 1999, Geist 1999, Sharifah Mastura 1997). LUCC has been blamed for causing serious modification of the land surfaces by mankind. Human activities rather than natural forces are the primary source of most contemporary changes in the state and flow of the biosphere, and other secondary impacts such as trace gas emission, biodiversity loss, land degradation, albedo alteration, microclimate change and hydrological cycles.

Understanding LUCC and the factors that drive them are thus of utmost importance for understanding, modelling and predicting global environmental change. This knowledge can be utilised in managing and responding to the change in a most positive way that would benefit mankind.

The importance of LUCC is seen by the large research grants made available to various international global change research programmes such as undertaken by the International Geosphere Biosphere Programme (IGBP), International Human Dimensions Programme (IHDP), Asia Pacific Network (APN) and National Aeronautics and Space Administration (NASA). This paper focuses on the understanding of the causes of tropical deforestation especially in Southeast Asia, which is part of the LUCC project, undertaken by the scientist at the Earth Observation Centre, Department of Geography, University Kebangsaan Malaysia (UKM). The driving forces that cause forest to deplete encompass wide field of research involving multidisciplinary sciences, however, only the pertinent factors will be discussed here. Downstream impacts of deforestation on the environment are also selectively discussed and mainly concentrated on biodiversity loss, erosion, sedimentation factors and greenhouse gas emission during episode of forest fire.

Influence of Global Warming and Land-use on the Tropical Rain Forests of Southeast Asia

Kanehiro Kitayama(Center for Ecological Research, Kyoto University)

The Southeast Asian humid tropics are generally considered one of the regions which will be least affected by global warming because the rate of temperature rise is lower than the other regions (IPCC 2007). However, the combined effects of warming, the droughts associated with El Nino, and land-use changes may severely influence the tropical rain forest ecosystems of this region. I will use Borneo as a model system of the Southeast Asian tropics to demonstrate the present land-use changes and how the land-use changes may interact with climate changes to influence rain forests. Borneo is the 3rd largest island in the world and used to support the largest area of contiguous tropical rain forests in Southeast Asia. Borneo rapidly lost forest cover by 40 - 60% in the past several decades due to agricultural development, logging, and large-scale forest fire. Approximately only 40% of Borneo is currently covered by "forests," most of which are degraded secondary logged-over forests. Selective logging has removed more than 50% of biomass in most forests and the thinned forests are vulnerable to fire and further degradation. I used an ecosystem model to simulate the future changes of a tropical forest in terms of biomass. Global warming alone does not change the live biomass of the forest during 2000-2050 because positive effects of warming offset negative effects. However, the inclusion of the effects of severe droughts (that are likely to occur in this region) and severe selective logging demonstrates that the recovery from the loss of biomass is extremely slow and logging is not sustainable anymore. The tropical rain forests of Borneo may not be susceptible to warming per se but are vulnerable to logging and droughts. If unsustainable logging continues, the tropical rain forests of Borneo may irreversibly become the major source of carbon. It is highly likely that wildlife may lose important habitats.

Vulnerability of the Mongolian Steppe and Nomadic Culture to Climate Change: Adaptation or Catastrophe?

Chuluun Togtohyn (Natural Resource Ecology Laboratory,Colorado State University)

Over last sixty years, surface air temperature in Mongolia has increased by 1.80C, most notably in winter. This figure is 2.5 times more than the figure for the globe as a whole. In Mongolia, spring is becoming increasingly dry by the warmer temperature and decreased precipitation. Plant growth trend shows delay by a month in the boundary zone of the Gobi and dry steppe and southern slopes of the Altai and Khangai mountains. A drying trend during early growing season linked with higher temperatures and decreased precipitation over the past decades has resulted in reduced forage for livestock during critical calving and growth periods. Furthermore, Mongolia experienced its worst droughts in summers of 1999, 2000, 2001 and 2002, which affected 50-70% of its territory. These droughts caused the most severe zud in recorded history. Zud is massive accumulation of snow where livestock are unable to dig up food. Sending any form of assistance on land is nearly impossible. During the three consecutive years of zud that followed aforementioned droughts, 12 million livestock died. The long-lasting dry period has also affected water resources in Mongolia. According to the National Survey for Surface Water conducted in 2003 by the Ministry for Nature and Environment, about 15% of water objects (683 rivers out of 5,565 rivers, 1,484 springs out of 9,600 springs, and 760 lakes and ponds out of 4,196 water bodies) had disappeared since the last survey in 1995. Reduced water and forage resources is making the Mongolian pastoral systems very vulnerable to climate change. Serious land degradation leading to desertification and shrinking water sources due to both climate change and human activities are examples of catastrophic consequences.

Nomadic culture emerged in arid and semi-arid lands with highly variable climate and diversity of landscapes. Traditional pastoral networks evolved to increase human adaptive capacity to cope with climatic risks. Spatially large landscape is critical to offset climate variability with extreme events such as zud and droughts. However, the speed of current global environmental changes is exceeding the natural and cultural capital's capacity to cope with them. Adaptation to climate change is the only way to prevent catastrophic results, but poverty is the largest barrier to developing this capacity to adapt to climate change. About 60% of the Mongolian herdsmen are very poor, owning less than 100 livestock. Majority of the poor herders have become less mobile, causing overgrazing near water sources and human settlements. Thus, the Mongolian ecosystems and the nomadic culture are at the diverging point: catastrophe or adaptation.

Impact of Climate Change on Himalayan Glaciers and Glacial Lakes

Basanta Shrestha(International Centre for Integrated Mountain Development)

In the face of global warming, most Himalayan glaciers have been retreating at a rate that ranges from a few metres to several tens of metres per year, resulting in an increase in the number and size of glacial lakes and a concomitant increase in the threat of glacial lake outburst floods (GLOFs). Such climate changes have ultimate effects on the life and property of the mountain people living downstream. While the effect of human activity on global climate is still being hotly debated, the retreat of glaciers in the Himalaya is compelling evidence of the need for action on climate change.

Approximately 15,000 glaciers (covering an area of 33,340 sq.km), and 9000 glacial lakes throughout Bhutan, Nepal and Pakistan, as well as selected river basins in China and India were documented in a baseline study conducted earlier by ICIMOD, UNEP, and the Asia Pacific Network for Global Change Research (APN). Twenty-one GLOF events have adversely affected Nepalese territory in the recent past and to date over 200 potentially dangerous glacial lakes have been documented across the Himalayan region. These facts underline the urgent need to enhance scientific knowledge of glacier environments by continuously monitoring glaciers and glacial lakes, carrying out vulnerability assessments, implementing mitigation and adaptation mechanisms, and developing a glacial lake outburst flood (GLOF) early warning system. Regional co-operation to develop a coordinated strategy to deal with trans-boundary issues related to the impacts which can occur as a result of climate change is also required.

This study focuses on the effects of climate change on glaciers and glacial lakes in two hotspots of glacial activity in the Himalaya: the Dudh Koshi sub-basin of Nepal and the Pho Chu sub-basin of Bhutan. Both these basins have witnessed devastating GLOF events in the recent past. The scientific modelling approaches and the empirical methods discussed in the study are both needed first steps that will be valuable in refining and scaling up this type of investigation to other Himalayan hot-spots. What is needed now is urgent action by the international community to help develop even better scientific understanding of the consequences of global climate change and to take the corrective and precautionary measures before it is too late.

Lecturer Profiles

Toshi Nagata

Education:

1987 D.S.,Zoology,Kyoto University

1983 M.S.Zoology,Kyoto University

Professional Career:

2000-present Professor, Center for Ecological Research,Kyoto University

1995-2000 Associate Professor, Ocean Research Institute,The University of Tokyo

1991-1995 Assistant Professor,Institute of Hydrospheric-Atmospheric Sciences,Nagoya University

1989-1991 Postdoc,College of Marine Studies,U.Delaware

Nobuyuki Tanaka

Education:

He graduated from the Tokyo University of Agriculture and Technology in 1977,and studied the habitat and regeneration of *Fagus crenata-Abies mariesii* forests for his Doctoral degree at the University of Tokyo.He specialized in forest ecology and tropical silviculture.

Present position:

The leader of the Research Project"Impact of climate change on forests and vulnerability assessment(2005-2009),Forestry and Forest Products Research Institute

Hiromu Daimaru

Education:

1988 M.A.Graduate School of Environmental Science,Hokkaido University

Professional Career:

2006-present Chief of Hillslope Conservation Laboratory,FFPRI

2005-2006 Team leader(Disaster prevention),FFPRI

2000-2005 Group Leader of Hillslope Conservation

Group,Kyushu Research Center.FFPRI

Mastura Mahmud

Education:

B.Sc.Physics and Meteorology,University of Reading,United Kingdom

PhD.,University of Birmingham,United Kingdom

Present Position:

Head,Earth Observation Center,Faculty of Social Sciences and Humanities,Universiti Kebangsaan Malaysia

Kanehiro Kitayama

Education:

1992 PhD.in Botany:Department of Botany,University of Hawaii at Manoa

1983 M.Sc.Ag.: Environmental Sciences and Nature Conservation,Tokyo University of Agriculture&Technology

Professional Career:

2001-present Professor,Center for Ecological Research,Kyoto University

2000-2001 Associate Professor,Center for Ecological Research, Kyoto University

※Secretary General,DIWPA(DIVERSITAS in Western Pacific and Asia)

Chuluun Togtohyn

Education:

1991 Ph.D. Moscow State University,USSR

1977 B.S.&M.S.,Kharkov State University

Professional Career :

Senior Researcher,Natural Resource Ecology Laboratory,Colorado State University

2002-present Professor, National University of Mongolia

1991-present Research Scientist,Natural Resource Ecology Laboratory,CSU

1977-1991 Senior Research Scientist,Mongolian Academy of

Sciences

Basanta Shrestha

Education:

1989 Masters of Engineering in Computer Science from the Asian Institute of Technology,Thailand

1985 Bachelors of Engineering in Electrical and Electronic Engineering from Madras University,India

Present Position :

Division Head,Mountain Environment and Natural Resources Information Systems(MENRIS)

International Centre for Integrated Mountain Development(ICIMOD)

講演資料
Presentation Materials

地球温暖化と琵琶湖の生態系

永田　俊
（京都大学生態学研究センター）

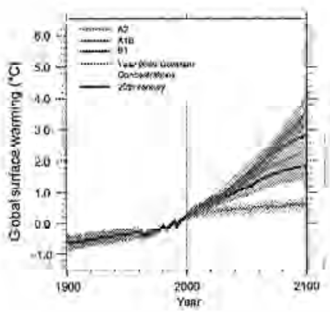
1

概要

- 世界各地で顕在化する湖への温暖化影響
- 琵琶湖生態系の危機？
- 楽観的ではない将来

2

IPCC　2007



2100年までに平均気温が0.5－4 °C上昇する

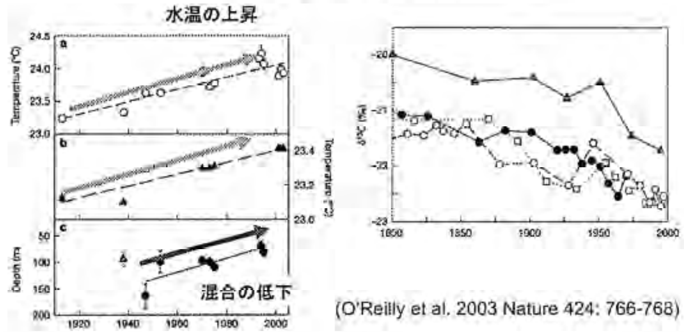
3

淡水生態系へ影響予測(IPCC第四次報告書から)

- 水温上昇の直接影響　：　魚類の分布、微生物活性の増大、プランクトン組成の変化（有毒シアノバクテリアの大発生）
- 混合パターンの変化　：　深水層酸素濃度の低下、堆積物からのリン溶出（富栄養化）、栄養供給の低下（貧栄養化ー漁業資源の低下）
- UVーB照射と夏期降水量の増大　：　溶存有機炭素（DOC）の増加、生物地球化学循環への影響
- 二酸化炭素濃度の上昇による一次生産上昇（湿地）：　メタン発生量の増大（温暖化に対する正のフィードバック）

4

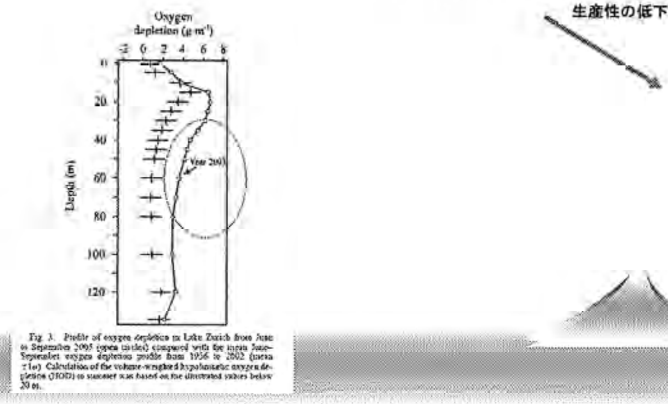
タンガニーカ湖における一次生産の低下



(O'Reilly et al. 2003 Nature 424: 766-768)

5

欧州を襲った2003熱波によるチューリヒ湖の溶存酸素枯渇



6

琵琶湖においても生態系に対する温暖化影響が懸念されはじめています

7

琵琶湖の貴重な生物相

- 世界有数の古代型湖沼(約400万年前に形成)
- 広大な水域と複雑な湖岸環境
- 61種の固有種を含む1，000種以上の動植物の生息場所(生物多様性のホットスポット)
- 地域の食文化や芸術・文芸の糧

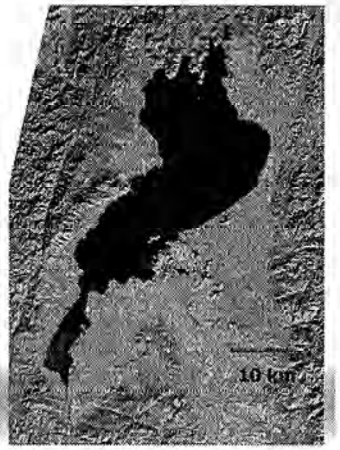
湖の … 速度が飛躍的に増大した

Jankowski et al. (2006) Limnology and Oceanography 51: 815-819)

8

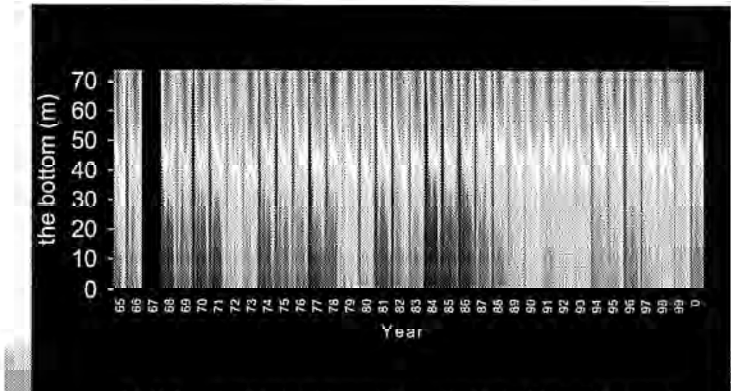
1,400万人の水源

- 水質管理の重要性
- 集水域（人口120万人）での人間活動：年間6900トンの窒素負荷
- 富栄養化問題：80年代以降、赤潮、アオコの発生などの問題
- CODの増加傾向



9

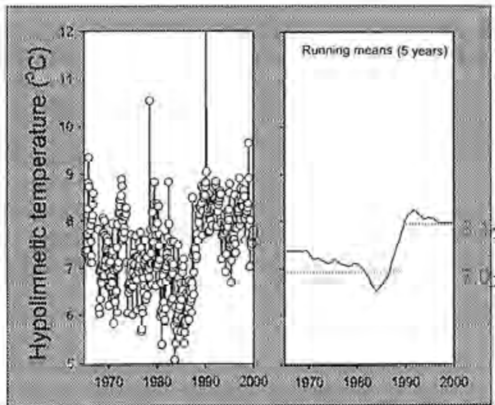
琵琶湖の水温の長期変化



データ元　京都大学生態学研究センター（旧大津臨湖実験所）定期観測

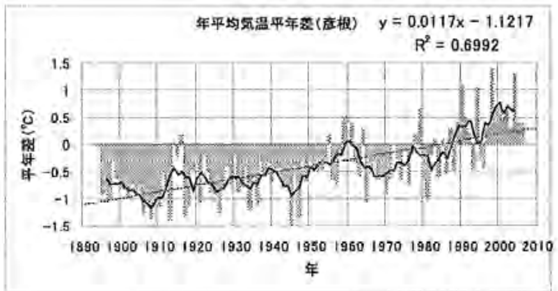
10

深層水温の移動平均



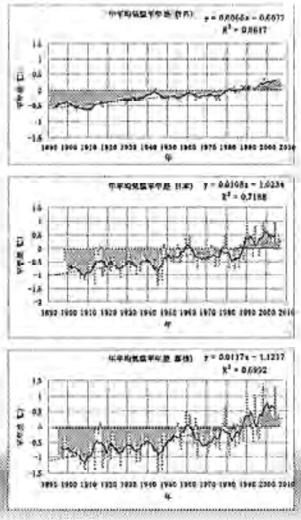
11

滋賀県（彦根）の気温



気象庁のデータをもとに滋賀県琵琶湖環境科学研究センター
熊谷道夫博士が作成

12

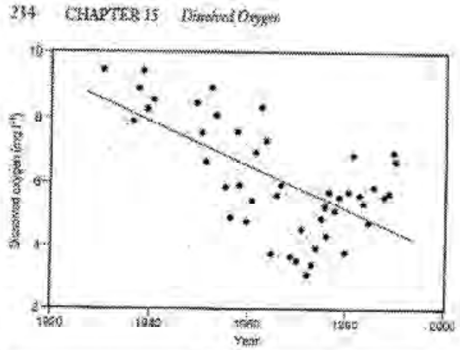


日本平均と比べて上昇スピードが速い

滋賀県琵琶湖環境科学研究センター
熊谷道夫博士が作成

13

長期的な傾向
（年間最低溶存酸素濃度）



Jacob Kalff 著 "Limnology" (2002年刊)
京都大学および滋賀県のデータなどをもとにKalff博士が作成

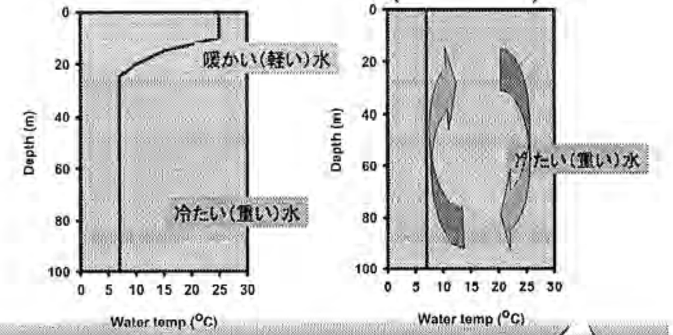
14

- 温暖化と、湖の水質（溶存酸素）や生産性はどのように関係するのでしょうか？

15

水温の鉛直分布

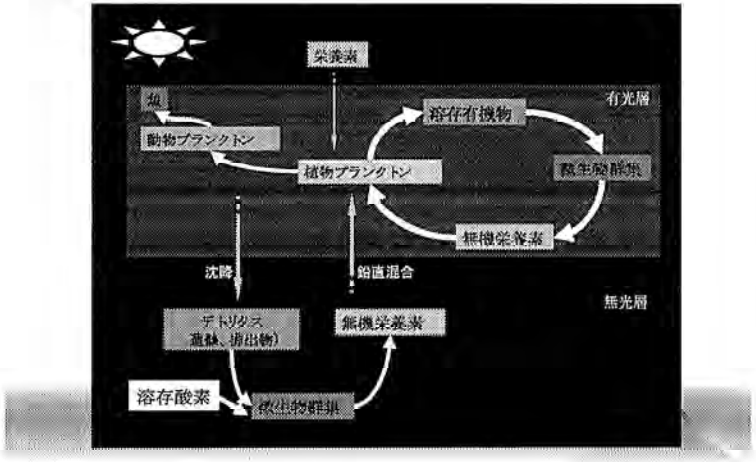
成層期 (stratification)　　循環期 (circulation)



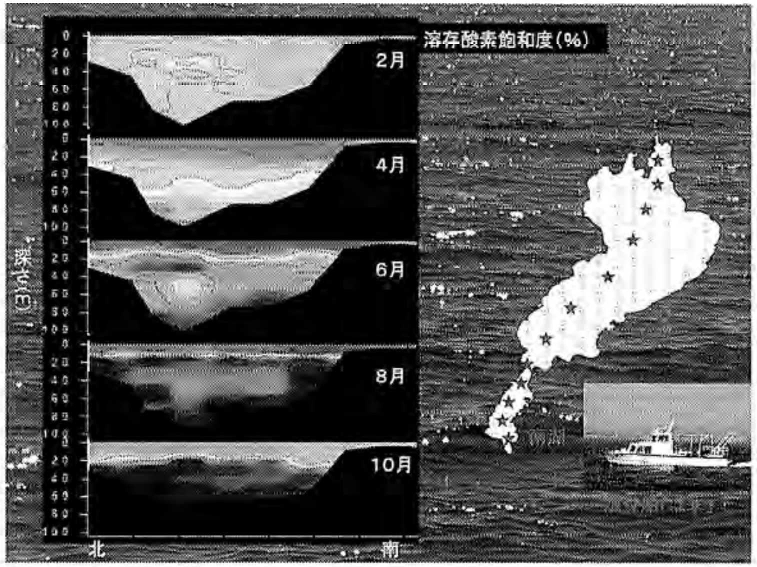
夏 (summer)　　冬 (winter)

16

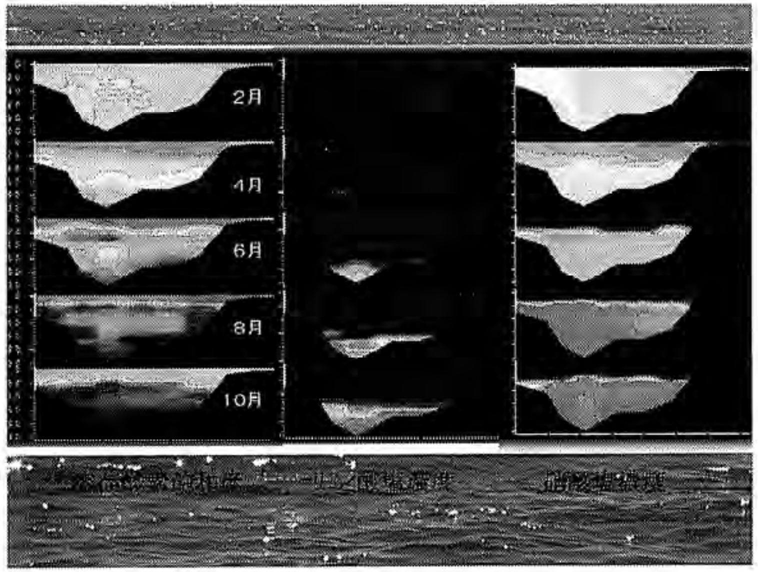
琵琶湖生態系の骨格構造



17

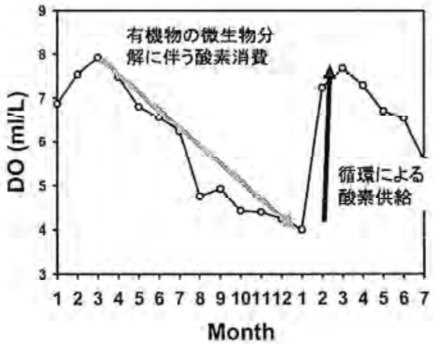


18



19

湖底付近の溶存酸素濃度の季節変化



データ元　1991-1992 京都大学生態学研究センター

20

富栄養化と温暖化の相乗効果

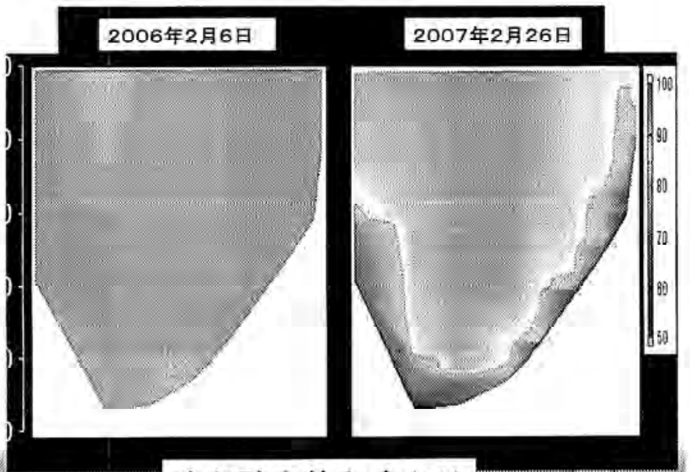
- 富栄養化　　酸素消費を促進
- 温暖化　　　酸素供給を阻害

21

2007暖冬

- 2007年の冬は記録的な暖冬でした
- このことが琵琶湖の生態系に大きな影響を与えた可能性があります

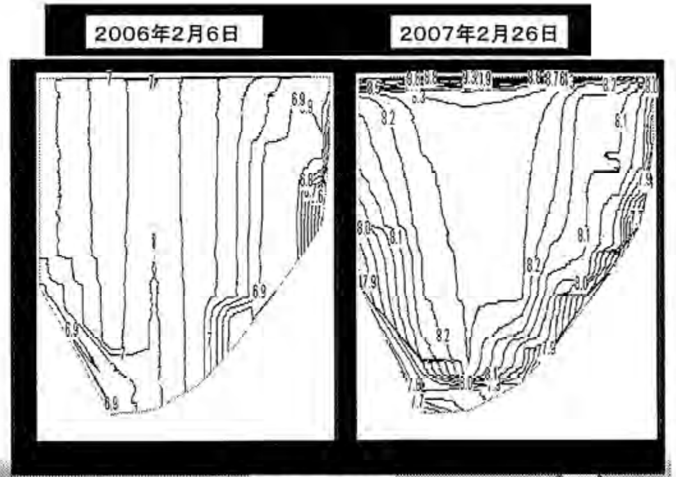
22



溶存酸素飽和度（%）

データ元　京都大学生態学研究センター

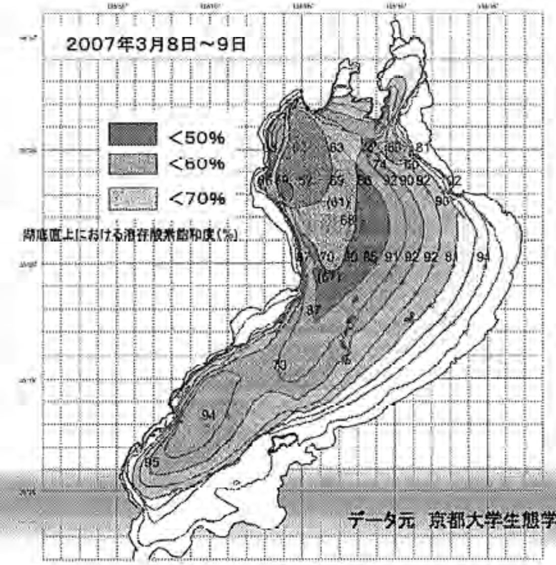
23



水温（°C）

データ元　京都大学生態学研究センター

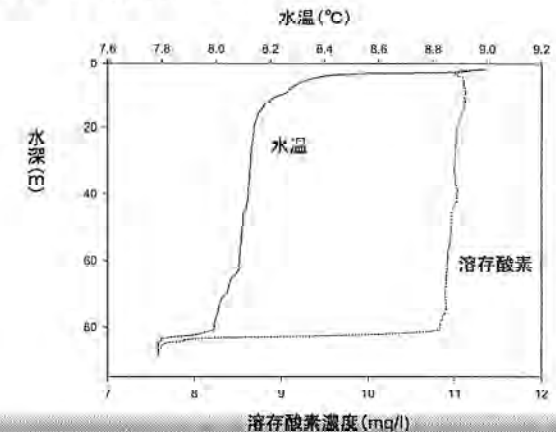
24



データ元　京都大学生態学研究センター

25

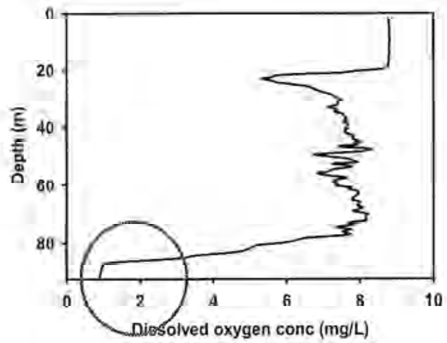
平成19年3月22日　今津沖



データ元　京都大学生態学研究センター

26

今年の酸素環境は観測史上最悪か



データ元　京都大学生態学研究センター（Sta.B3, 2007年11月1日）

27

2007暖冬（まとめ）

- 深層における溶存酸素の回復（飽和度80%以上）が3月の下旬にずれこんだ。これは、例年よりも1－2ヶ月遅い。琵琶湖観測史上初めて。
- 溶存酸素の回復の程度が例年に比べて不十分であった可能性がある。
- 深層および堆積物の状態を注意深く監視する必要がある。

温暖化の進行とともに、今後、慢性化（あるいは悪化）することが懸念される

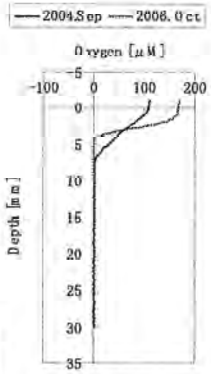
28

低酸素化・無酸素化がもたらすもの

- 魚類は貝類への直接的影響 （絶滅あるいは生息場所の縮小）
- 物質循環への影響 （リンの溶出、硫化水素などの有毒物質の発生）

29

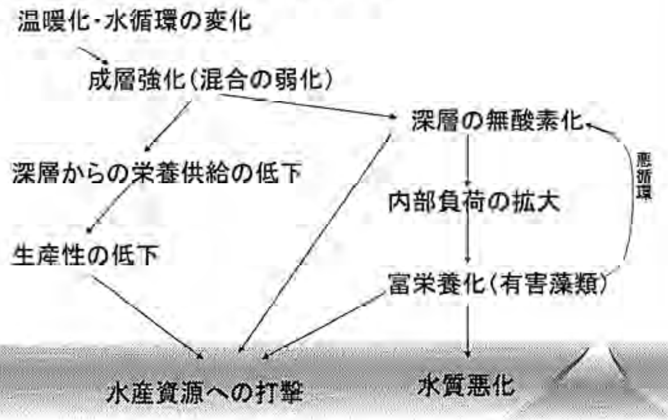
堆積物環境



微小電極で測定した堆積物中の溶存酸素濃度の鉛直プロファイル

30

琵琶湖における温暖化影響評価の複雑性



32

重要な事項

- 地球温暖化（IPCC）シナリオ下での琵琶湖生態系の応答予測（循環を考慮した高精度な生物地球化学・生態系モデルの構築）→効果的な適応策の早期提案
- 重要なプロセスに関して機構解明型の研究を早急に進める必要がある
  - 全循環のメカニズム
  - 物質循環系の応答（水中・堆積物）
  - 生物への影響（低酸素、高水温、脆弱性）

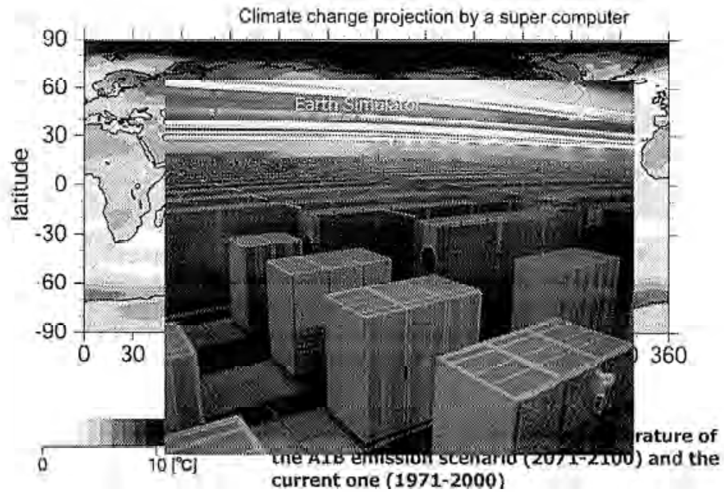
32

Impact of global warming on natural forests in Japan

Tanaka Nobuyuki

Forestry and Forest Products Research Institute (FFPRI), Tsukuba

1

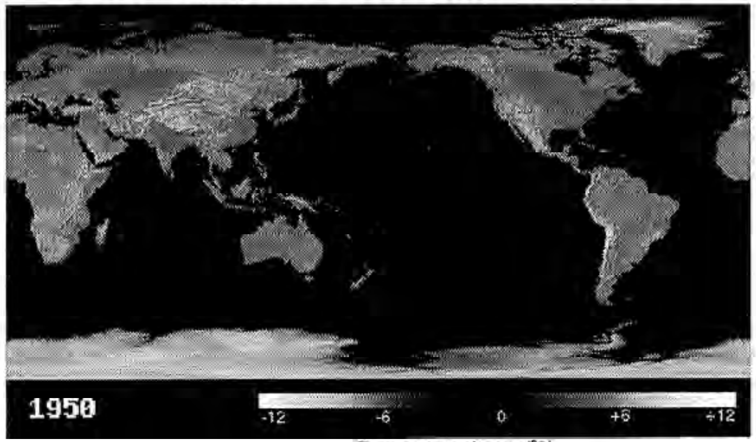


...rature of the A1B emission scenario (2071-2100) and the current one (1971-2000)

出典：国立環境研/東大気候システムセンター/海洋研究開発機構

2

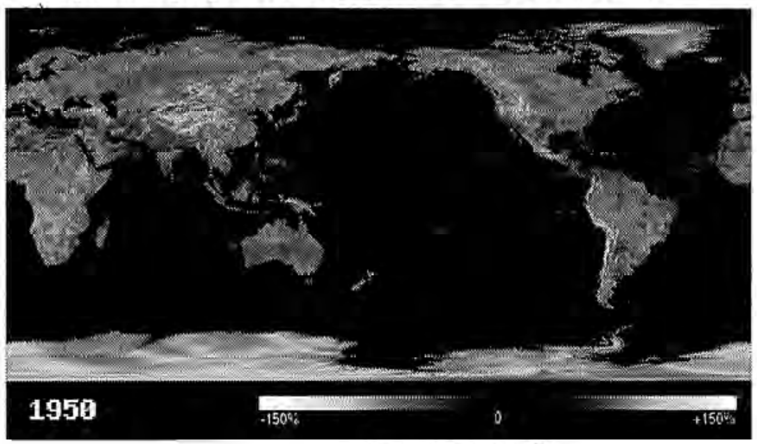
Temperature projection based on a GCM （１９５０－２１



出典：国立環境研/東大気候システムセンター/海洋研究開発機構

3

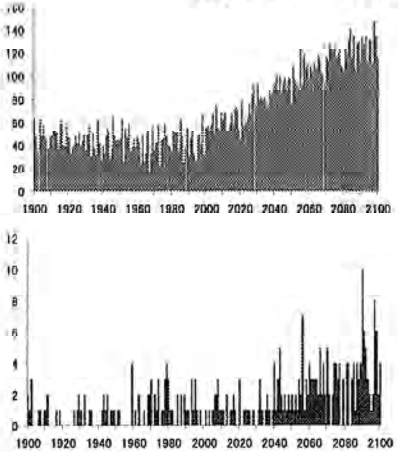
Precipitation projection based on a GCM （１９５０－２１０



出典：国立環境研/東大気候システムセンター/海洋研究開発機構

4

Increase of hot days and heavy rain days with climate warming

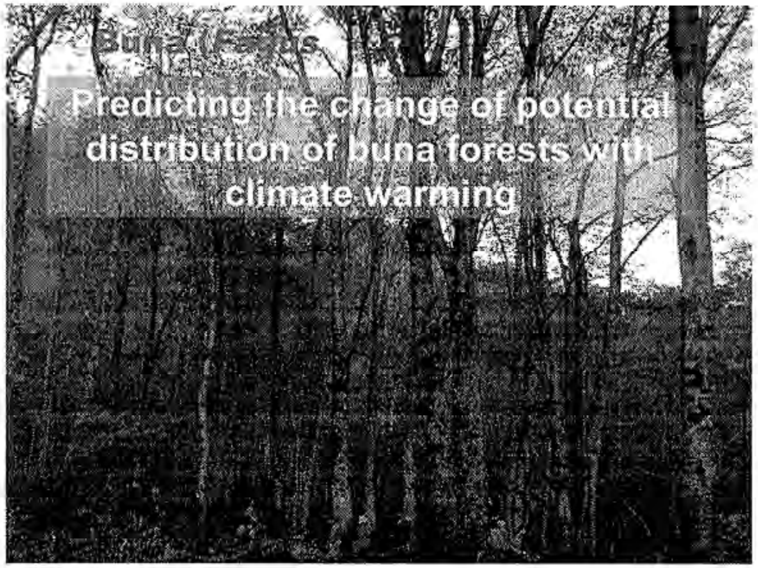


Change of no. of days with max temperature > 30℃ (1900～2100)
Counted by days of >30 ℃ for all cells (ca. 100km × 100km) covering Japan

Change of no. of days with daily rainfall > 100mm in June, July and August (1990～2100年)

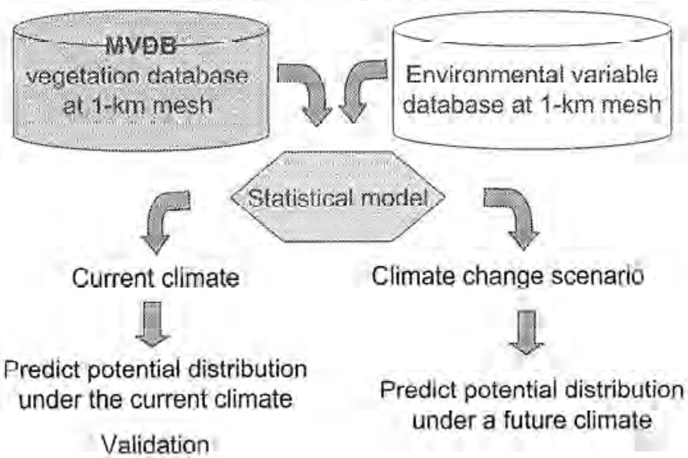
出典:国立環境研/東大気候システムセンター/海洋研究開発機構

5



6

Data and Methods



7

Data

Vegetation data

1-km mesh vegetation data (MVDB)

- Natural vegetation: 156,804 cells
- Buna forests: 23,432 cells

Environmental data

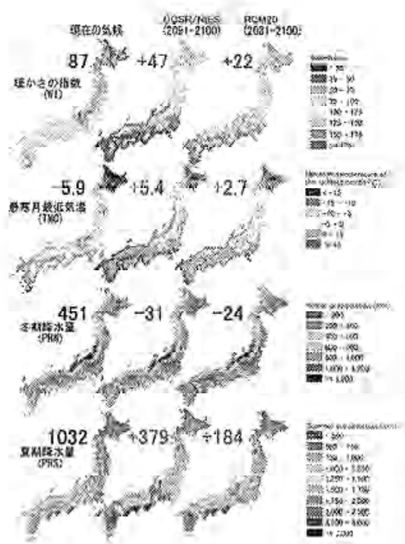
1-km mesh climate normals (Japan Meteorological Agency)

- WI: warmth index
- TMC: mean minimum daily temperature of coldest month
- PRW: winter precipitation (Dec. to March)
- PRS: summer precipitation (May to September)

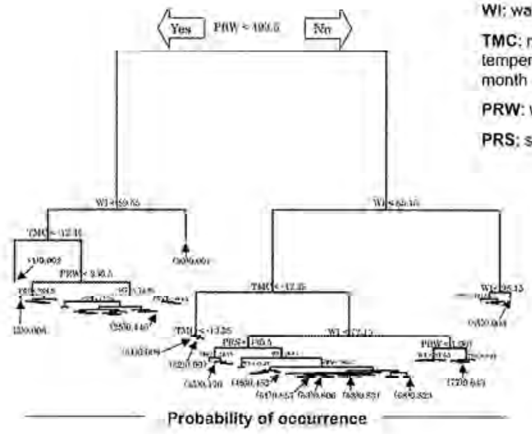
8

Climate change scenarios

Distribution of four climatic variables under the current climate and CCSR/NIES scenario (2091-2100) and RCM20 scenario (2081-2100)



9



WI: warmth index

TMC: mean minimum daily temperature of the coldest month

PRW: winter precipitation

PRS: summer precipitation

Classification tree model for buna forests

10

What is the influential variables of climate?

Deviance weighted score (DWS) in the model shows

PRW>WI>TMC>PRS

11

Where are the most suitable habitats for buna forests?

Areas with high probability of occurrence (>0.8)

The Sea of Japan side of northern Honshu and the southern Hokkaido

High winter precipitation (PRW: 600 to 1400mm)

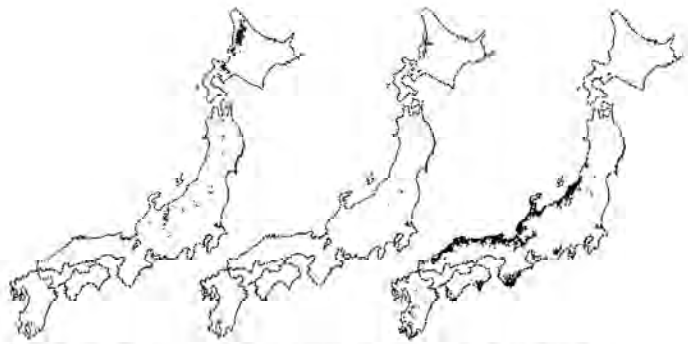
Moderate WI (WI: 55 to 75)

Moderate coldness in winter (TMC: -9.0 to 0 °C)

12

Areas with low probability of occurrence (<0.01)

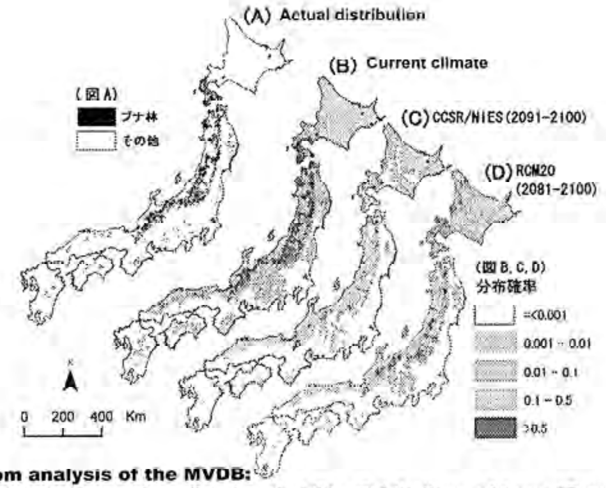
13



Areas with low probability of occurrence (<0.01)

(continued)

14

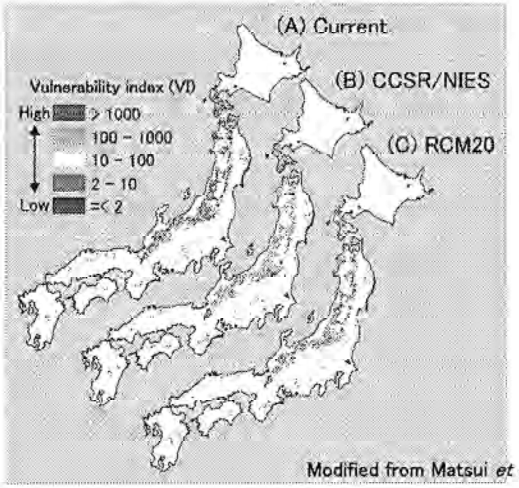


Results from analysis of the MVDB:
(A) Actual distribution and predicted probability distributions of buna (*Fagus crenata*) under (B) the current climate and the climate change scenarios of (C) CCSR/NIES and (D) RCM20 (modified from Matsui et al. 2004).

15

Vulnerability Indices for buna forests (VI)

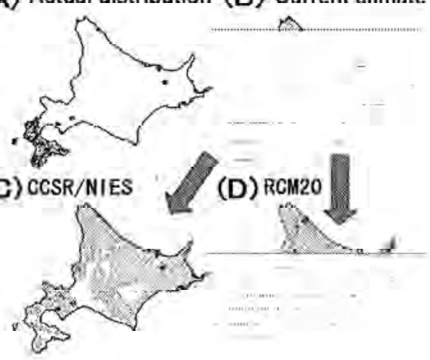
VI = 1 / Probability



Modified from Matsui *et al.* (2004)

16

Shift of suitable habitats in Hokkaido

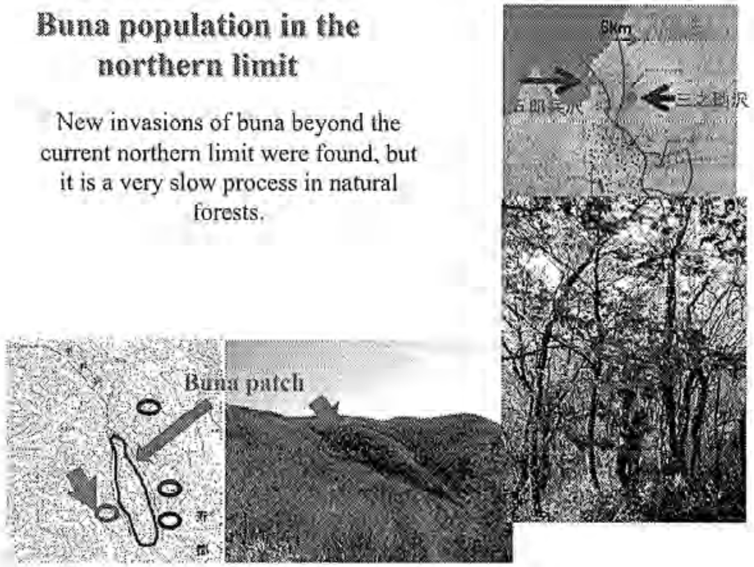


Migration of buna can not catch up with the shift of suitable habitats (10-50 km/100yr) with climate warming because the past migration speed of buna after the last glacial period was estimated to be 23km/100yr in Honshu and 1-2km/100yr in Hokkaido.

17

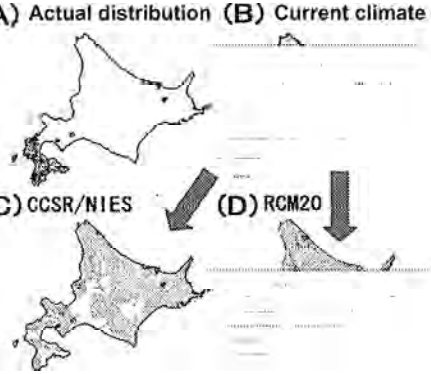
Buna population in the northern limit

New invasions of buna beyond the current northern limit were found, but it is a very slow process in natural forests.



18

Shift of suitable habitats in Hokkaido

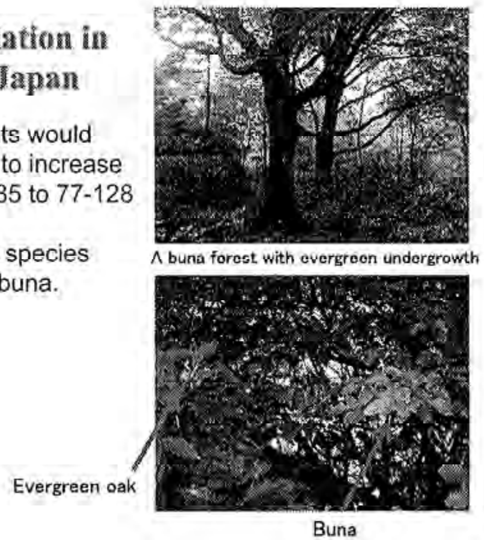


Migration of buna can not catch up with the shift of suitable habitats (10-50 km/100yr) with climate warming because the past migration speed of buna after the last glacial period was estimated to be 23km/100yr in Honshu and 1-2km/100yr in Hokkaido.

19

Buna population in Western Japan

- Suitable habitats would disappear due to increase of WI from 45-85 to 77-128
- Evergreen oak species would replace buna.



20

A declining buna forest on top of Mt. Tsukuba

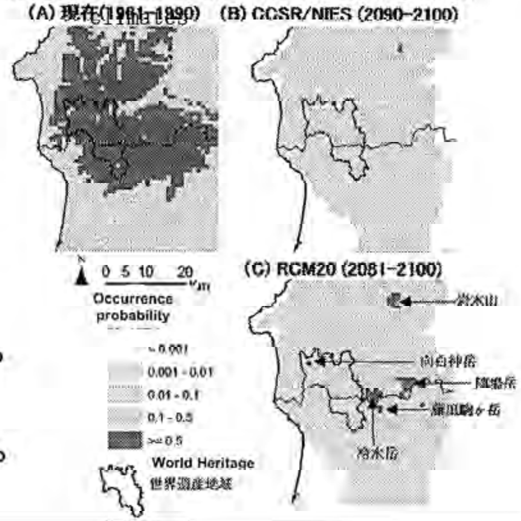
21

Prediction of occurrence probability of buna forests in Shirakami World Heritage area under current and future

Analysis with ca. 1km² cells

Suitable habitats (area with >0.5 in probability)

- **CCSR/NIES scenario (+4.5℃): disappear**
- **RCM20 scenario (+2.5℃): decrease to 3%**



22

Impact of warming on buna forests in Mts. Shirakami

- Lower limit:
  Buna would be replaced by deciduous trees such as oak and chestnut
- Upper limit:
  Buna would invade to bush vegetation

Buna in the lower limit of distribution

Buna in the upper limit of distribution

23

Adaptation: action to reduce the adverse impacts of climate warming

A case of buna and other plant species

Determining vulnerable areas and refugia by studies

⇩

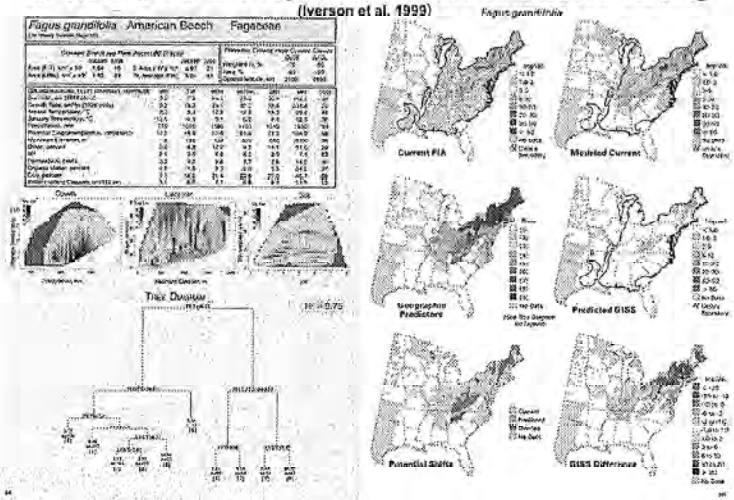
Deciding whether to take protective management or not

⇩ Protective measures such as planting(?), reducing species competition, making corridors of natural vegetation

⇩ Observation of the natural change

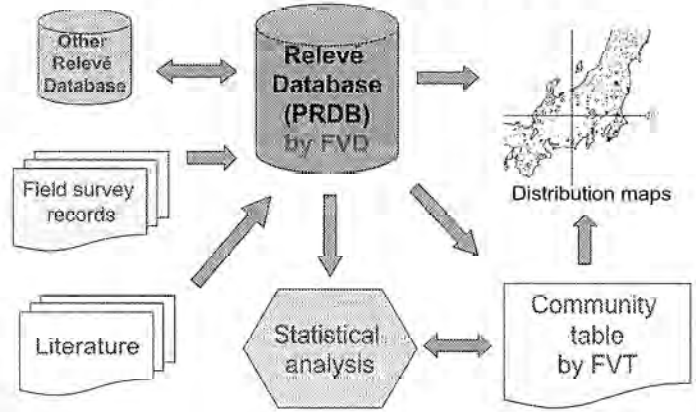
24

Prediction of potential distribution for 80 tree species in eastern USA and impact assessment of climate warming
(Iverson et al. 1999)



25

Phytosociological Relevé Database (PRDB) operated by FVD and FVT



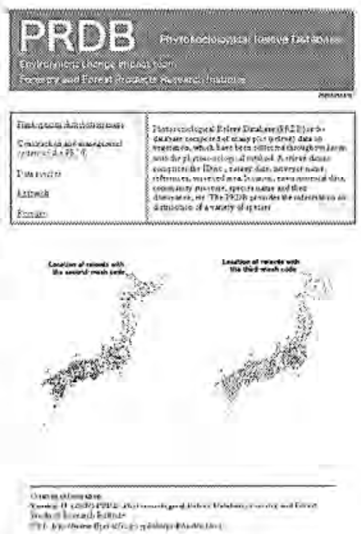
26

A relevé data sheet of PRDB operated by FVD

27

Web site

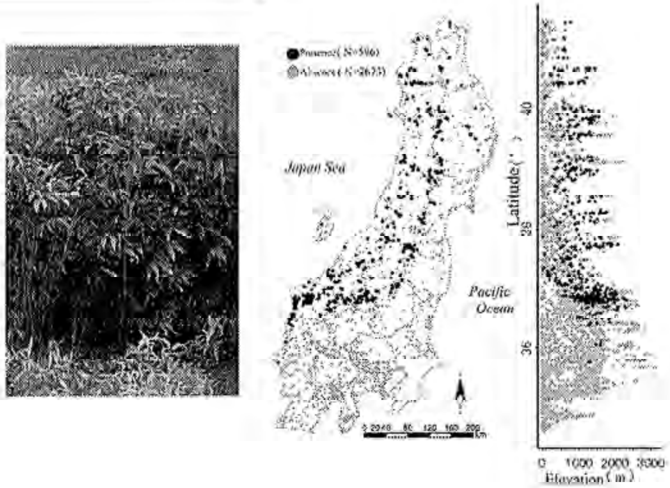
http://www.ffpri.affrc.go.jp/labs/prdb/index.html



When the PRDB is fully constructed, ca. 6,000 vascular plant species native to Japan can be analyzed with distribution models

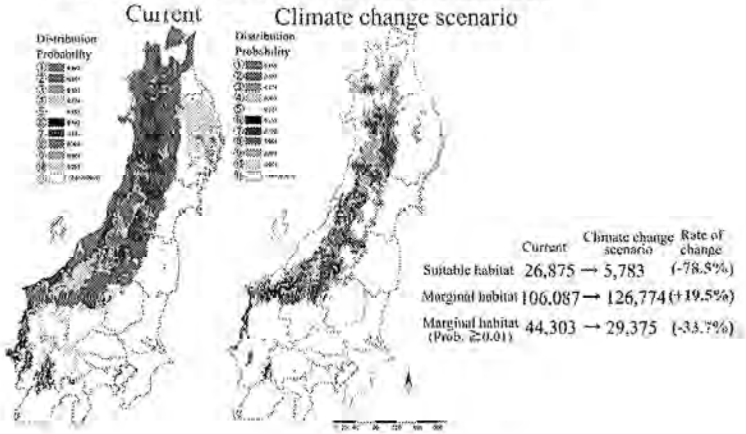
28

Distribution of *Sasa kurilensis* in eastern Honshu

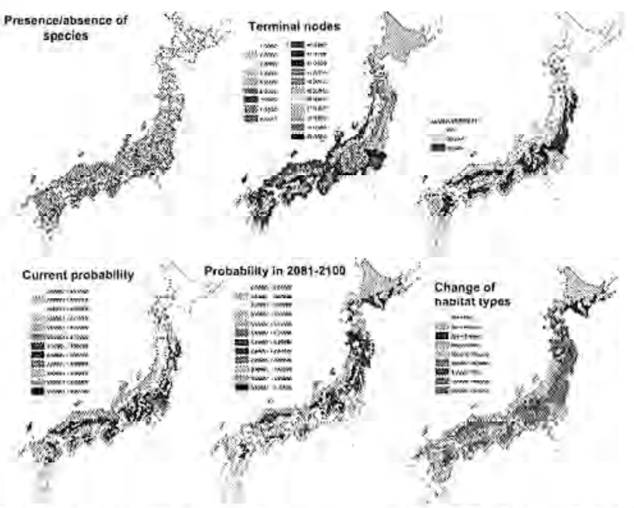


29

Predicted probability distributions of *Sasa kurilensis* under the climate change scenario



30



Prediction of distribution based on PRDB; Abies firma

31

Conclusion

- Tree model using MVDB and four climatic variables can predict the potential distribution of buna forests types on the nation-wide scale.
- Winter precipitation (PRW) is most influential on the buna forest distribution, followed by warmth index (WI), minimum temperature in the coldest month (TMC) and summer precipitation (PRS).
- Tree model showed conditions of suitable and unsuitable habitats, suggesting that factors limiting the buna forest distribution are different among regions.
- The area of suitable habitats of buna forests decrease into 1/10 under CCSR/NIES scenario in 2090s. Buna forests in Pacific side of Honshu, Shikoku, Kyusyu will be most vulnerable to the anticipated climate change.
- MVDB is in lack of information on plant species distribution. In order to predict the potential distribution of a variety of species, it is necessary to compile a database on plant species distribution such as the PRDB.
- **Based on studies on impact assessment, adaptation to conserve natural vegetation and biodiversity should be considered.**

32

共同研究者

松井哲哉・八木橋勉・中谷友樹・
垰田宏・津山幾太郎・堀川真弘・
中園悦子・小川みふゆ・小川有
子・ 島田和則・大丸裕武・吉永秀
一郎

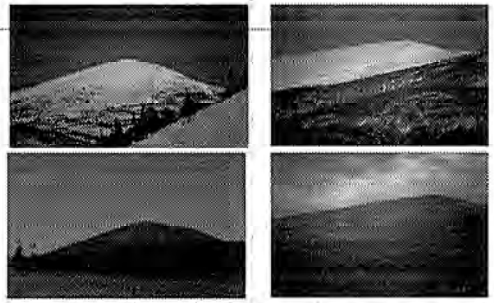
33

積雪減少と雨水涵養高山湿原の変化

大丸裕武(独立行政法人森林総合研究所)

Snow-cover decrease and its impact on montane wet meadow

Hiromu Daimaru (FFPRI)

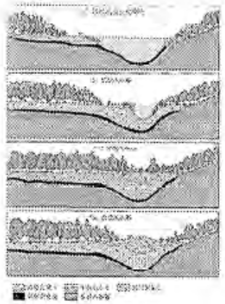


1

湿原(泥炭地;peatland)とはどういう空間か？

・植物遺体の堆積量が分解量を上回るために泥炭となって堆積して出来た景観。

・寒冷気候による植物遺体の分解の抑制、平坦な地形条件による過湿な水分環境、旺盛な植物遺体生産(熱帯の泥炭地)などが成因として重要である。



陸化型泥炭地の形成過程(佐久間, 1994)

・欧米で典型的とされる湖沼が陸化して形成されたタイプのもの以外にも、様々なタイプのものが存在する。

典型的な陸化型泥炭地・日光の小田代ヶ原

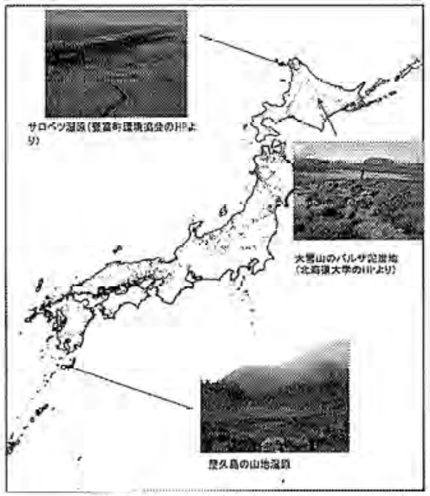
2

泥炭地の分布

Distribution of peatland in Japan

・平野部では潟湖(lagoon)が陸化して出来たものが多いが現在では農地化が進む

・山岳地では、平坦な火山地形や地すべり地形によって排水が悪い場所に形成されることが多い。



湿原の分布(環境省の自然環境GISより作成)

3

山岳地の泥炭地

南八甲田の平坦地に出来た湿原

南八甲田の傾斜地に出来た湿原(傾斜泥炭地)

・日本海側の山地では、多量の積雪が原因となって形成されたものが多い

・平坦地だけでなく排水の良い傾斜地にも泥炭地が見られる → なぜなのか？

・雪が遅く(6～8月)まで残る斜面に泥炭地が形成される

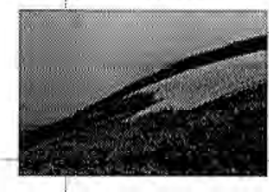
4

傾斜泥炭地は稜線部の風下側で冬に雪が厚く吹きだまる場所に形成される

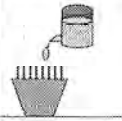
Snowbanks form peatland on mountain slopes

5

雪田草原(snowpatch grassland)



奥羽山地の傾斜泥炭地
(snow patch grassland)



灌水装置付のプランター

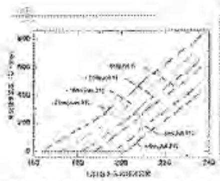
尾瀬ヶ原
(Ozegahar Moor: backmarsh type)

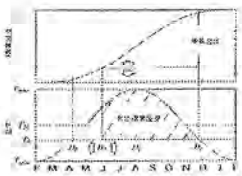
- 傾斜地に見られる泥炭地(傾斜泥炭地)のほとんどは雪解けの遅い場所に形成される雪田草原(snowpatch grassland)である
- 夏の間じゅう融雪水が供給されるため、湿性の高山植物が多くみられる(残雪という灌水装置付のプランター)
- 残雪量の変動をダイレクトに受けるため、気候変化にとても敏感！

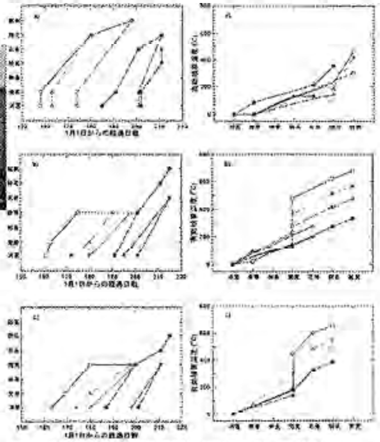
→ 温暖化の影響は、まず雪田草原に現れるはず！

6

残雪は植物の生育期間を支配する Snowpatch controls snow-free period

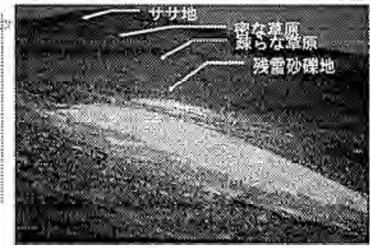






7

雪どけの季節に沿った植生と土壌の同心円状分布
Zonation of vegetation and soil produced by snowmelt



現在のコケスギランの分布(Heusser and Igarashi, 1994)

コケスギラン

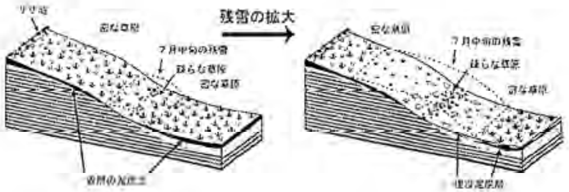
短い生育期間に適応した高緯度地域と共通する要素も多い

→希少種の避難地

(refuge area of rare plants)

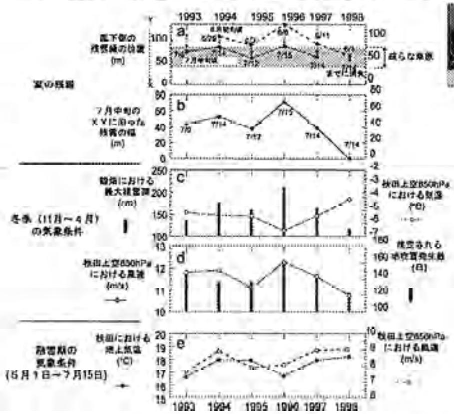
8

気候変動による雪渓の変動と埋没泥炭土の形成（岩手県焼森山）
Climate change and buried peat layer



9

残雪規模の経年変化と気象条件
Year to year change of snowpatch



→冬季の積雪量の変動が大きく影響している！

10

気候変動と氷河 Climate change and Glacier

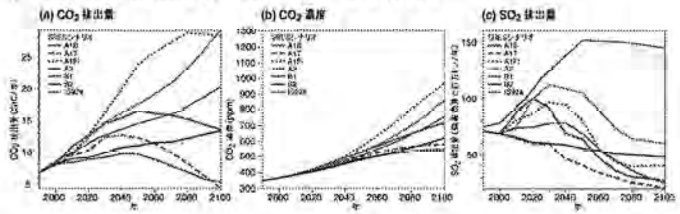
氷河の末端から現れた約900年前のヒョウの遺体（水野, 1994）

チンダル氷河の後退と植生遷移（水野, 1994）

11

温暖化予測シナリオ

排出シナリオ(SRES シナリオ)



（気象庁HPより引用）

・共通的な温暖化物質の排出シナリオが作成され、これを元に将来の気候シミュレーションが行われる

・わが国で用いられることが多い気象庁の地域気候シナリオはこの中のA2シナリオが用いられている

12

気候モデルによる降雪量の変化
Snawfall change predicted by GCM

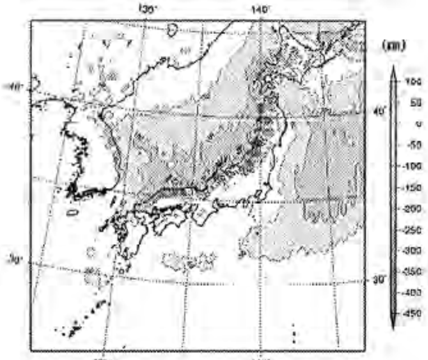


図 RCM20を用いた年降雪量の変化量（単位：cm）
2081～2100年平均値と1981～2000年平均値との差。

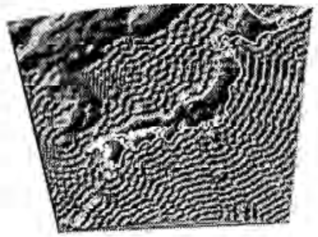
・オホーツク海を除いた全ての地域で減少が予測される。

・現在降雪量の多い北海道から山陰にかけての日本海側での減少が大きく、多いところで年間400mm（水換算）程度の減少が予測されている。

（気象庁HPより引用）

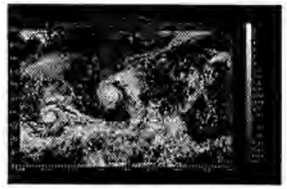
13

気候モデルによる積雪環境予測
Topographic data is too crude for prediction of snowfall



RCM20に用いられる地形モデルのtin

・降雪現象に大きな影響を与える複雑な地形の効果は再現出来ていない

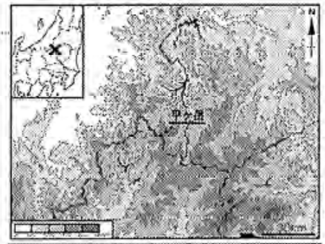


・地球シミュレーターによる温暖化予測精度向上の努力が続けられている

14

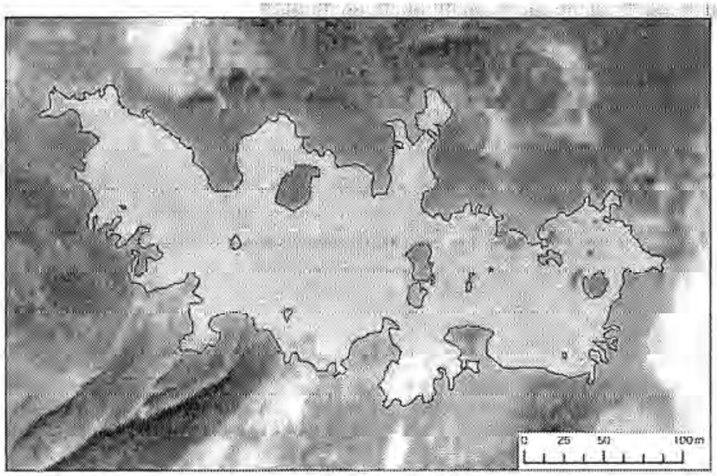
積雪変動による湿原の縮小はすでに始まっている？
ー 上越山地平ヶ岳の事例 ー

Shrinkage of mountain moor?



安田ほか(2007)

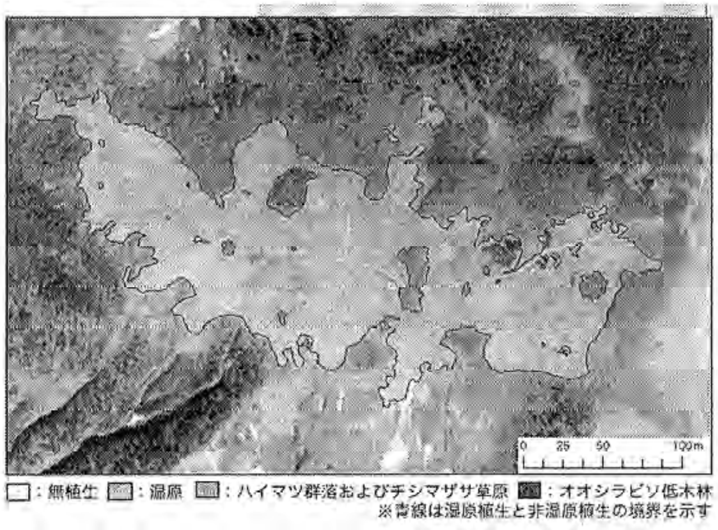
15



□：無植生 □：湿原 □：ハイマツ群落およびチシマザサ草原 ■：オオシラビソ低木林
※赤線は湿原植生と非湿原植生の境界を示す

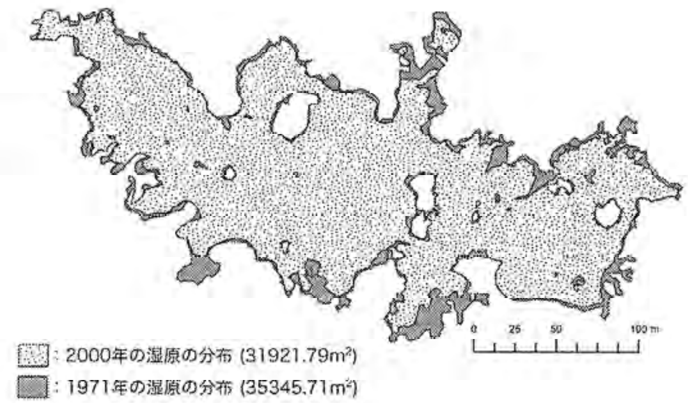
1971年の湿原分布（安田ほか，2007による）

16



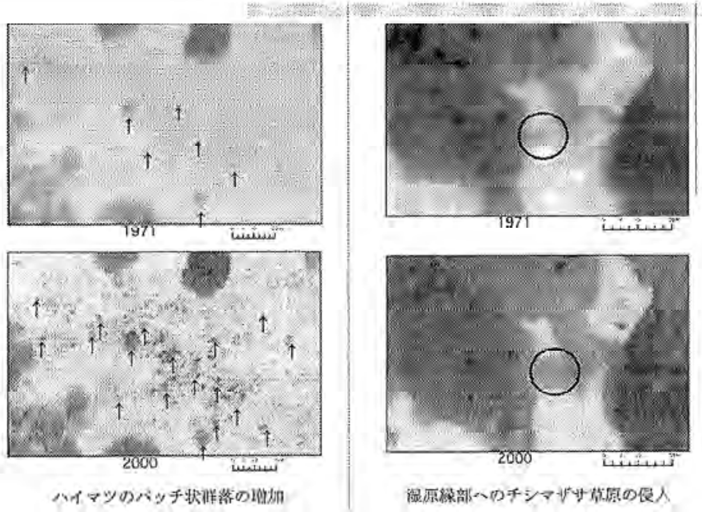
2000年の湿原分布（安田ほか，2007による）

17



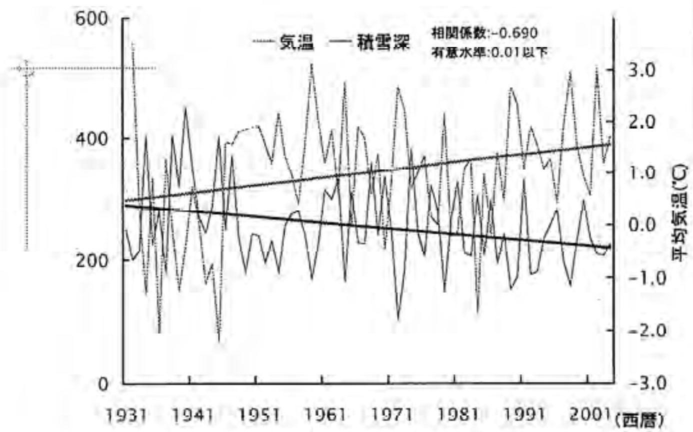
1971年と2000年の湿原の範囲

18



植生変化の様子（安田ほか，2007による）

19



只見の年最大積雪深と冬期平均気温経年変動
（安田ほか，2007による）

20

まとめ

1）日本の山地湿原の中でも傾斜泥炭地（雪田草原）に気候変化の影響が現れやすい

2）傾斜泥炭地の土壌層の中には過去の気候変動の痕跡が記録されている

3）過去数10年間の空中写真の比較から、一部の山地においては、湿原の縮小が認められ、積雪深の減少の影響が疑われる。

→ただし、地域的な減少か、地球温暖化と関係するのか、については今後の研究によって明らかにする必要がある

21

TROPICAL DEFORESTATION AND ITS IMPACT ON ENVIRONMENT AND QUALITY OF LIFE

Sharifah Mastura Syed Abdullah
& Mastura Mahmud
Earth Observation Centre
National University of Malaysia

1

Presentation Outline

- Importance and conservation of tropical forests
- Causes of deforestation in Southeast Asia
  - Rate of deforestation
  - Drivers of deforestation
- Case study of deforestation in SEA
  - Research by SEARRIN
- Impacts of deforestation
- Conclusion

2

2

Introduction

- In the 1990's land use and land cover (LUCC) dynamics have been recognised as a key research imperative in global environmental change research.
- LUCC has been blamed for causing serious modification of the land surfaces on earth.
- Understanding LUCC and the factors that drive them are thus of utmost importance for understanding, modelling and predicting global environmental change. This knowledge can be utilised in managing and responding to the change in a most positive way that would benefit mankind

3

3

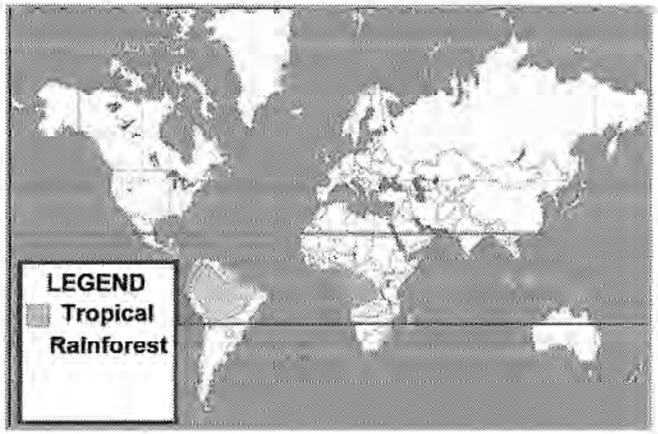
Importance of tropical forests

- Tropical forests are homes to almost 50% of the world's species
- Forests help mitigate the impacts of global warming
- Forests are important as they play a role in the water recycle process and help balance the oxygen amount
- Many thousands of plants have been identified possessing anti-cancer properties
- Tropical forests provide precious wood for furniture, lumber and firewood; and
- Forests provide jobs and income for the people who live around them.

4

4

The extent of global tropical forests



5

Conservation of Tropical Forests

- Tropical forests are rich in biodiversity with unique and endangered species which are alive with the sounds of birds and animals.
- Tropical forests also play crucial roles for humans. They provide water, food, medicines, shelter and sources of livelihood for the communities that live in and around them.
- The forests also provide important environmental services for the planet. For instance, they function as temperature regulators by absorbing and storing carbon dioxide, and helps mitigate the impacts of global warming.
- Unfortunately, the fragile tropical ecosystem is under threat from deforestation, improper agricultural practices, tourism, development and forest fires.

6

The Tropical Rainforest

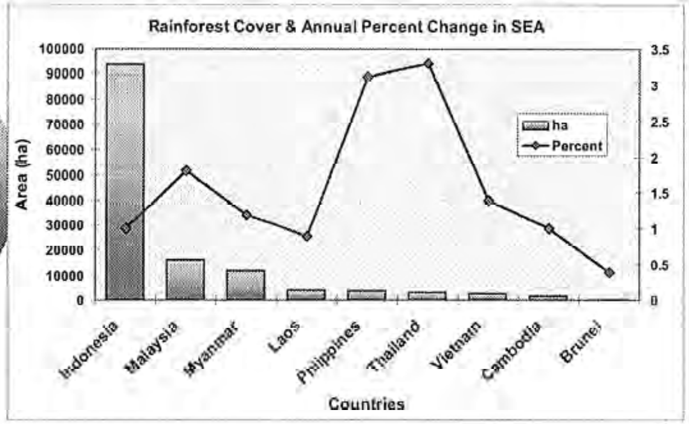
- Rainforest in its natural state or dynamic equilibrium comprise a mosaic of aging trees, clearing caused by storms, landslides, lightning or human activity with regenerating seedlings and area of mature and immature trees.
- They are genetically far more diverse with 50 to 200 or more tree species per hectare.
- Southeast Asia, with only 0.5% of the earth's total land area probably has 10% of all the plant species.
- The fast pace of tropical deforestation occurring in Southeast Asia has challenged the very existence of the forests in the future if no serious efforts are taken to combat them.

7

Extent of Tropical Deforestation

- The estimates of rainforest cover in nine countries in South East Asia (WRI, 1999):
- Indonesia with the largest land area of 181.16 million ha, recorded 94 million ha of rainforest cover and subjected to 1% annual change rate from 1981-1990.
- Malaysia has 16 million ha of rainforest but recorded higher change rate of 1.8%.
- Philippines and Thailand recorded highest annual change rate of 3.1% and 3.3% respectively.
- For the other countries the annual change rate of forest range from 0.4% to 1.4%.

8



9

9

Satellite data analysis of forest areas and the rate of deforestation in Southeast Asia

Country	Forest Area in 1973	Forest Area in 1985	Forest Area Change	% Change	Deforestation Rate Per Year
Cambodia	5.25	3.98	1.27	24	0.11
Laos	18.28	16.52	1.76	10	0.15
Thailand	22.56	16.74	5.81	26	0.49
Vietnam	19.92	16.15	3.77	19	0.31
Myanmar	48.71	44.82	3.88	8	0.32
Total	114.70	98.21	16.49	14	1.37

10

10

Discrepancies of forest statistics

- Problems in documenting rainforest statistics differ in different countries. United Nation bodies also derive their data from government statistics which in many cases register larger areas of forest.
- There is obviously lack of geographically reference data at high spatial resolution and derived from a single consistent method for the whole of Southeast Asia.
- Other areas of data difficulties include, distinguishing rates of new deforestation, abandonment and regrowth.
- Currently, the best method is via the use of satellite remote sensing method as it can resolve discrepancies in data output and spatial variations in rainforest cover statistics.

11

11

Tropical Deforestation

- Definition of deforestation

Mather *et al* (1998) summarise it as:

- '...The study of the causality of trend in forest cover...does not readily yield the simplicity and elegance of explanation that would reward the ideal scientific endeavour. In the real word of human-driven change in land and land cover there are numerous problems and difficulties that confound such an endeavour. The field cannot be successfully tilled as a disciplinary preserve, and neither reductionism nor holism alone seems to offer the approach necessary for success'.

12

12

Tropical Deforestation

- Tropical deforestation includes both quantitative loss of woody vegetation as well as qualitative changes such as loss or reduction in species biodiversity.
- There are various degrees of tropical deforestation ranging from reductions in vigour and/or species diversity to a decline in regeneration, in the changes such as in species diversity, thinning altered regeneration or resistance to pest, diseases and invasion of undesirable species.
- Among the impacts of tropical deforestation are the altered local or regional hydrology, altered climate and serious environmental problems such as flood damage and siltation.

13

Annual Rate of Deforestation

Country	National Land Area Covered By Forest (%)		Annual Deforestation Rates (1,000 ha/yr)	
	1980	1990	1976-80	1981-90
Kampuchea	70	69	15	131
Indonesia	61	61	550	1,212
Laos	58	57	125	129
Malaysia	63	54	230	396
Burma	47	44	96	401
Vietnam	30	26	65	137
Thailand	33	28 1988	333	515
Philippines	26	24 1987	101	316

14

15

Drivers of Deforestation

- Understanding the drivers of tropical deforestation is not a straightforward case. For example in LUCC research, key questions have been to seek answers to what seems to be simple questions.
- These questions are:
  - ➢ How much forest is lost in the study area over 10 year time period?
  - ➢ What are the factors that cause forest to change to other land uses?
  - ➢ What is the trend of future changes?

16

Continue

- The causes attributed to deforestation are multivariate in nature, interrelated and differ at local, national as well as regional scale.
- The drivers of tropical deforestation can be summed up as complex socio-economic processes that are impossible to isolate a single cause.
- It consists of a complex of social, political, economic, technological and cultural variables that constitute initial conditions in the human-environmental relations that are structural (or systematic) in nature.
- In terms of spatial scale, underlying drivers may operate directly at local level or indirectly from the national or global level.

17

17

Actions and factors in deforestation

3 clusters are involved in deforestation are:

a) Proximate causes: Agricultural expansion
Wood extraction
Expansion of infrastructure

b) Underlying causes: Demographic
Economic
Technological
Policy/ institutional
Cultural or socio- political factors

18

18

Continue

c) Other factors (land characteristics, biophysical drivers, and social trigger events)

Land characteristics
Biophysical environment
War
Health and economic crisis
Government policy failures

19

19

(i) Population pressures

Past and Projected population and land area in Southeast Asia

Country	Population (million)				Land (10^5 ha)	Per Capita Land (ha/person)			Per Capita Crop Land, 2000
	1950	2000	2025	2050		2000	2025	2050	
Indonesia	79.54	206.5	275.2	318.3	181.16	0.88	0.6	0.57	0.16
Kampuchea	4.34	10.7	16.9	21.4	17.65	1.64	1.04	0.83	0.39
Laos	1.76	5.3	10.2	13.9	23.08	4.31	2.26	1.66	0.19
Malaysia	6.11	21.4	31.6	38.1	32.86	1.53	1.04	0.86	0.39
Myanmar	17.83	47.6	67.6	80.9	65.76	1.38	0.97	0.81	0.23
Philippines	20.99	72.1	105.2	130.5	29.82	0.41	0.28	0.23	0.14
Thailand	20.01	59.6	69.1	72.9	51.09	0.86	0.74	0.70	0.35
Vietnam	29.95	77.0	110.1	129.8	32.55	0.42	0.30	0.25	0.09

20

20

(ii) Improved infrastructure and utilities network

- Analyses of land use and road maps in the Philippines and Malaysia show that the closer the forest to the road the higher the rate of deforestation.
- 78% of the 2.1 million ha of forest within 1.5 km from the roads in 1934 was removed by 1988. On the other hand only 39.5% of forest between 15.0 and 16.5 km from the road were lost.
- In Malaysia, LUCC study showed that a kilometre increase in the distance of a pixel from a road network reduces the odds of forest clearing by a factor of 0.68.
- This means that access to road network increases the probability of land being cleared for other uses. Lambin and Giest (2001) showed that extension of infrastructure in combination with other proximate causes explained 110 out of 152 cases of deforestation (72%).

21

21

(iii) Land settlement scheme

- In Malaysia, land development scheme entails the conversion of forest into smallholdings. The scheme was carried out to alleviate poverty, overdependancy on rubber, ethnic and rural-urban disparity.
- The government implemented a drastic scheme to provide public assistance to the poor so that they are directly involved and benefit from the exploitation and development of the resources of the country.
- Between 1971-1980, 866,058 ha of forestland were cleared for agriculture. In 1980's a further 647,374 ha were cleared for land development.
- A further 180,750 ha were cleared up to year 2000 (EPU 2000, 6th Malaysia Plan). The large conversion of forestland to agriculture has generated financial and economic returns and socio-economic benefits to the country. Poverty was reduced drastically at the expenses of the rainforest.

22

22

(iv) Large scale commercial agriculture

- In Southeast Asia, 80% of forest conversion is to agriculture.
- In 1980's, 30% of the cultivated land area in the Philippines was converted to cash crop production for export of mainly bananas, pineapples and sugar cane.
- In the island of Negros, forest decreases by 20,000 ha which is gained by sugar estate that produce 68% of the Philippines sugar crop.
- In Thailand, between1973-1982, cassava exports to EEC rose from 1.5 million tons to 8 million tons. Other major plantations include oil palm, peanuts, rubber and soybeans.
- In Peninsular Malaysia, between 1966-1990, plantation agriculture increased from 2.7 million ha to 4.7 million ha. All agricultural gains were at the expense of forest land.

23

23

(v) Commercial logging, demand for timber, woodchips, pulps and forest products

- In Malaysia, from 1986-1990, the annual felling rate of log increased by 5.8% to reach 41 million cu m in 1990, 43.5 million cu m in 1992 and 35 million in 1995 (a drop of 20% production in 3 years).
- Export of wood and wood based products in 1991 was RM 9.3 billion and 43% of it was logwood. Malaysia is the largest exporter of tropical hardwood logs in 1991. Sarawak accounted for 15.7 million cu m of log exported and the remaining was from Sabah.
- The government of Malaysia has banned export of logs. Downstream processing of wood based industry was encouraged. This is an attempt to reduce deforestation and damage due to the tropical rainforest. In Indonesia in 1985, 40% of the forestland was leased to timber companies for economic purposes.

24

24

(vi) Other factors

- Shifting cultivation, which is associated to poverty is the primary agent that brought about 40% to 95% of forest loss.
- Poverty represents demographic, economic, technological policy and institutional meanings namely resource-poor farming, survival economies, insufficient food production, chronic food deficit, limited land endowment, land scarcity, landlessness, low living standard, joblessness, social deprivation, and marginalization.

25

25

- In Southeast Asia poverty is an underlying social process of deforestation in 42% of the cases.
- As proximate factors, about half of the poverty-driven cases are associated with traditional and shifting cultivation, permanent small holder and subsistence farming.
- 80% of the poverty-driven cases are related to human factor under the sections of population dynamics and land scheme policy.

26

26

Example: hydroelectricity dams

- The forest is also under increasingly threat as Southeast Asian countries build hydroelectricity dams in rainforest areas such as the Kenyir and Bakun Dam (69, 500 ha) in Malaysia.
- No mitigating measures and reforestation programmes taken could compensate for the loss of pristine tropical forest.
- The net downstream impacts include degradation of the forest, erosion, water pollution and reduction on aquatic life, habitat fragmentation, reduction of habitat diversity and loss of regional biodiversity.
- Two totally protected species, 68 protected species of plant, 1,230 species of significant plants were lost. It is estimated that an annual cost of displacement of forest resources ranges from RM10 to 22 billion.

27

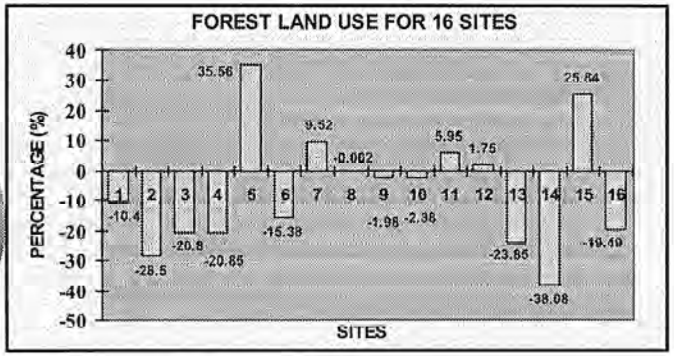
27

DEFORESTATION IN SOUTHEAST ASIA: LUCC CASE STUDY

- Southeast Asia Regional Research Network (SEARRIN) had involved in land use and land cover change research since 1976. Among the research activities are:
  - Developing case studies to determine deforestation dynamics.
  - Determining whether annual rates of deforestation have been significantly different from the decadal mean rate over 16 selected study areas
  - Developing diagnostic models of the deforestation process to better understand and quantify the deferential controls on the rate of deforestation and abandonment .

28

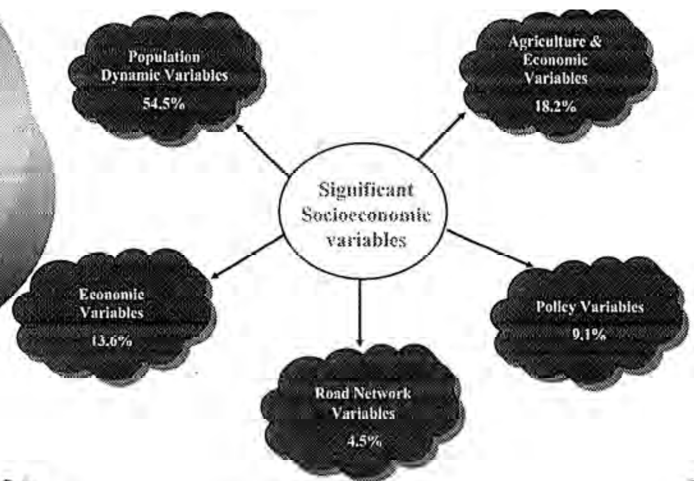
28



Site:

1.	Klang-Langat (10 yrs)	9. Mae Chaem (9 yrs)
2.	Kayan-Sempadi (10 yrs)	10. Lin Thin (11 yrs)
3.	Citarum (12 yrs)	11. Phusithan (10 yrs)
4.	East Kalimantan 1 (5 yrs)	12. Eastern Forest (11 yrs)
5.	East Kalimantan 2 (5 yrs)	13. Ao Sawi (11 yrs)
6.	Jambi (6 yrs)	14. Tamdao (24 yrs)
7.	Magat (9 yrs)	15. Kg. Cham (13 yrs)
8.	Puerto Princesa (10 yrs)	16. Nam Thuen (3 yrs)

29



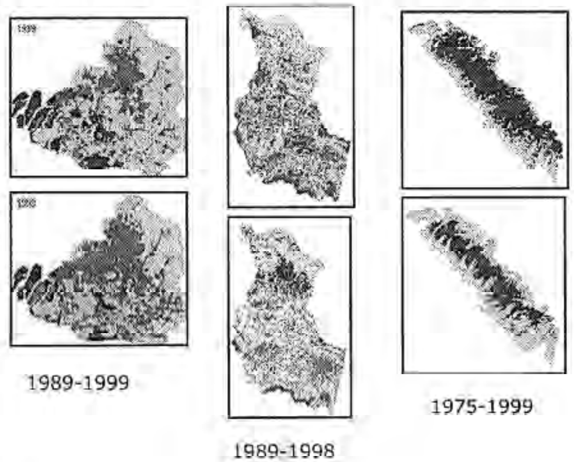
30

Driving Forces of Change

Country	Variable
Malaysia	• Road distance from forest areas • Land classes suitability • Population density • Agricultural employment • Forest reserve and non reserve areas
Indonesia	• Rate growth in the number of school going children • Change in the total number of school going children • Number of industrial establishments
Philippines	• Number of households using charcoal as fuel • Number of households using wood as fuel • Farm size • Literacy rates • Areas planted with permanent crop • Rural population • Areas planted with temporary crops • Woodland and forest in farm areas
Thailand	• Population structure • Population age • Number of households with pick up trucks • Number of shops • Number of rice mills • Number of households practising agriculture

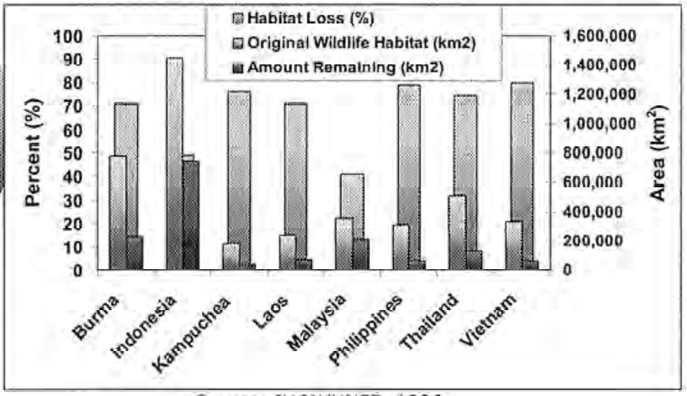
31

Land use changes in Malaysia, Indonesia, Vietnam



32

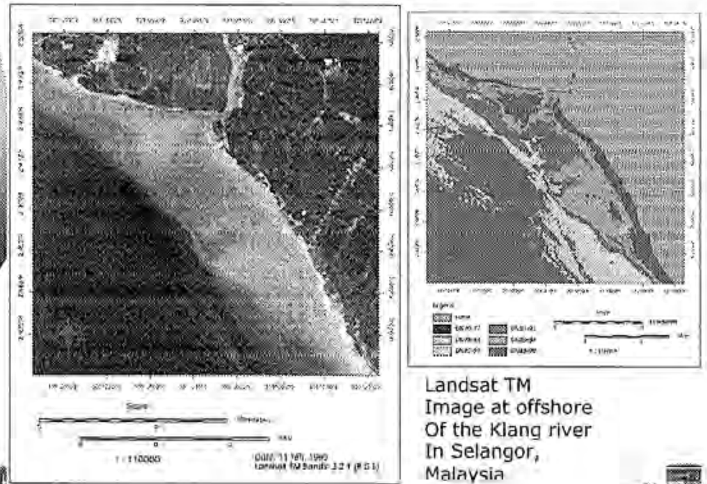
Impact of tropical deforestation



Source: IUCN/UNEP, 1986

33

Soil erosion and sedimentation



Landsat TM Image at offshore Of the Klang river In Selangor, Malaysia

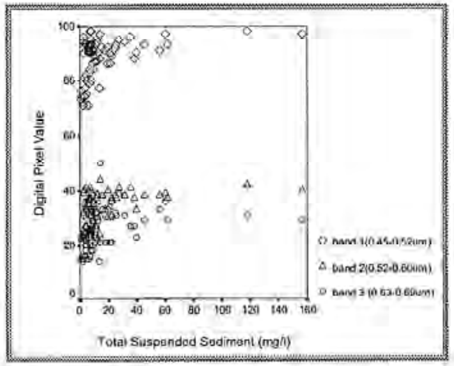
34

Soil erosion and sedimentation

Satellite analysis on suspended sediments at the Klang river in Selangor, Malaysia.

Landsat TM bands 1,2, 3 showed 2 clusters: Bands 1 and 2 & 3.

High DN values Correspond to high Total suspended Sediments.



35

- Excessive depositions of sediments in rivers and offshore can smother bentic organisms and cause shallowing effects.
- In the case of Klang and Langat rivers in Malaysia, depositions reduced storage capacity due to bottom deposition. Expensive dredging or frequent removal of the sediment were done.
- The river beds of lower reaches of Klang-Langat would be raised gradually and increase the frequency of downstream flooding.
- Approximately 1000,000 m^3 sediments have been removed in the upstream reaches of Klang River.
- About 200,000 m^3 and 400,000 m^3 of silt have been removed from Batu River and Gombak River respectively. It was estimated that the silt removed from major tributaries of the Klang River amounted to approximately 300,000 m^3 per annum.

36

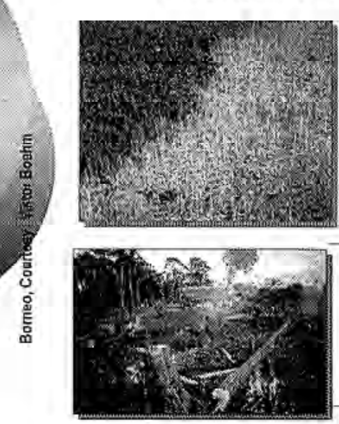
Deforestation and the greenhouse effect

- Deforestation and carbon emission effects have been extensively documented.
- Forest absorbed carbon dioxide but deforestation adds considerable quantities of carbon dioxide to the atmosphere.
- Deforestation contributes between one 25% to 50% of the five billion tons released from burning of fossil fuel.
- The release of carbon attributed to land cover conversion is a major biogenic source of carbon in Southeast Asia.
- The current net flux of carbon from land cover conversion in the tropics is expected to rise if deforestation issues are not abated

37

37

Anthropogenic C Emissions: Land Use Change



Tropical deforestation

13 Million hectares each year

2000-2005	
Tropical Americas	0.6 Pg C y^{-1}
Tropical Asia	0.6 Pg C y^{-1}
Tropical Africa	0.3 Pg C y^{-1}
	1.5 Pg C y^{-1}

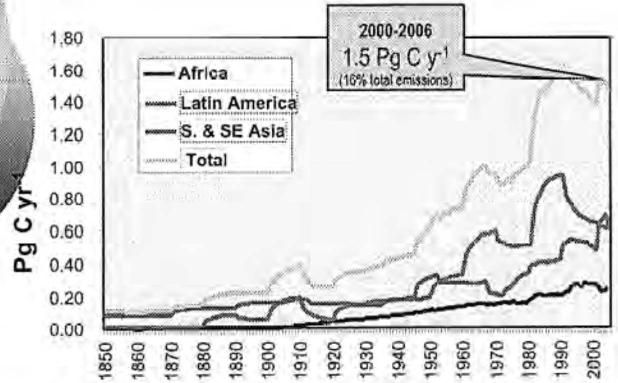
Source: FAO-Global Resources Assessment 2005; Canadell et al. 2007, PNAS

38

38

Anthropogenic C Emissions: Land Use Change

Carbon Emissions from Tropical Deforestation



Source: FAO-Global Resources Assessment 2005; Canadell et al. 2007, PNAS

Houghton, unpublished

39

39

Forest fires & transboundary haze

- In Southeast Asia, uncontrolled burning from the large-scale land clearing processes can result in transboundary haze, poor visibility and the degradation of the local air quality between the neighbouring countries.
- The haze events appear to be an annual event during the burning season, which occur from June to October.
- The 1997 haze caused by the forest fires in Indonesia was one of the notable events that caught the world's attention due to its magnitude and its coincidence with the dry major El Nino event.

40

40

41

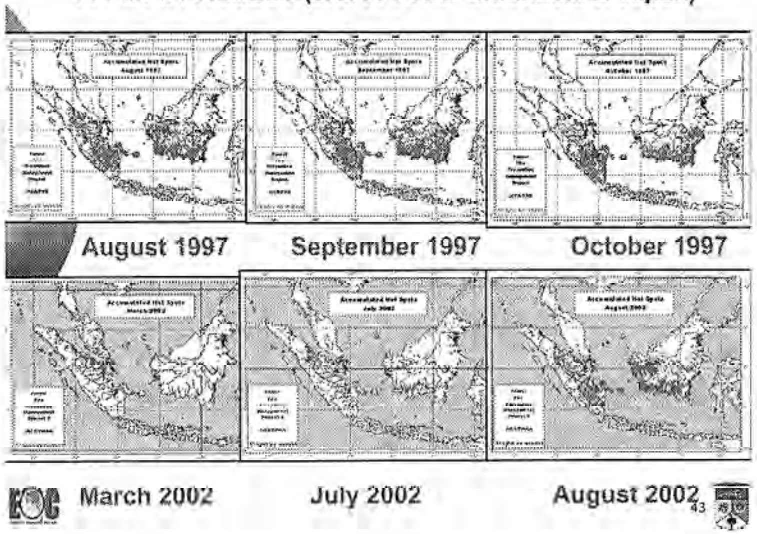
Greenhouse gas emitter

- Indonesia is rated as the world's top three greenhouse gas emitters in the world from land use change and deforestation, significantly by the release of carbon dioxide from deforestation.
- Deforestation and land conversion are the largest sources of emissions of the greenhouse gases, with forest fires accounting for 57% of the contribution.
- Indonesia has maintained its position as one of the top twenty emitters of greenhouse gases from land-use, land use change and forestry since 2000.
- This is due to the very large stock of carbon stored in the vegetation and soil that amounted to approximately 24 billion tons, and where deforestation accounts for 85% of the annual emissions of GHG in Indonesia.

42

42

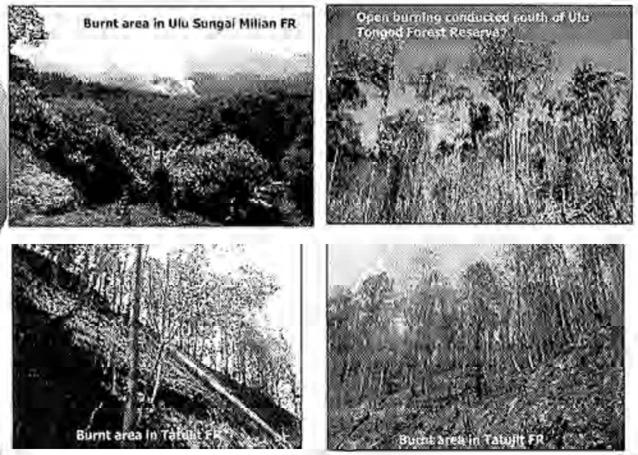
FFPMPII PROJECT (JICA-PHKA: Indonesia & Japan)



43

43

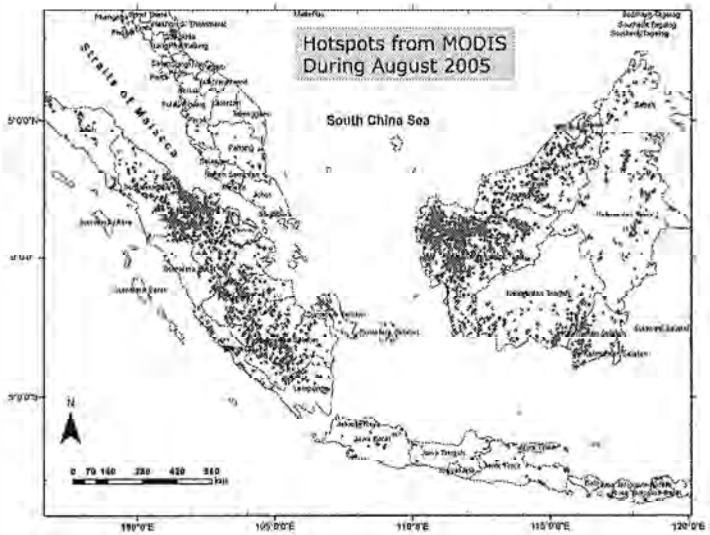
FOREST FIRE IN SABAH



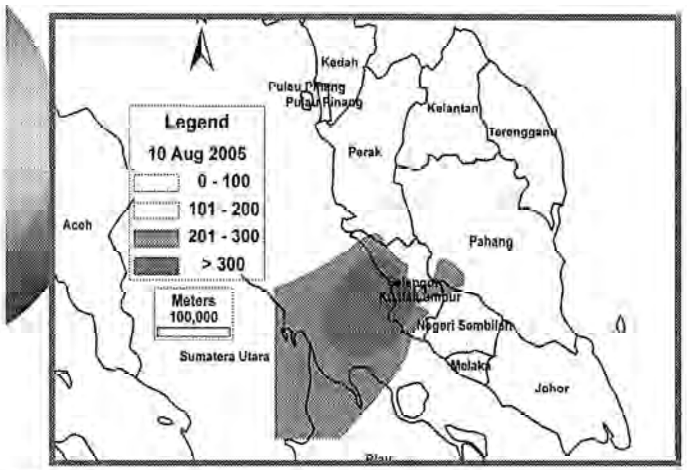
SOURCE :http://www.sabah.gov.my/hutan

44

44

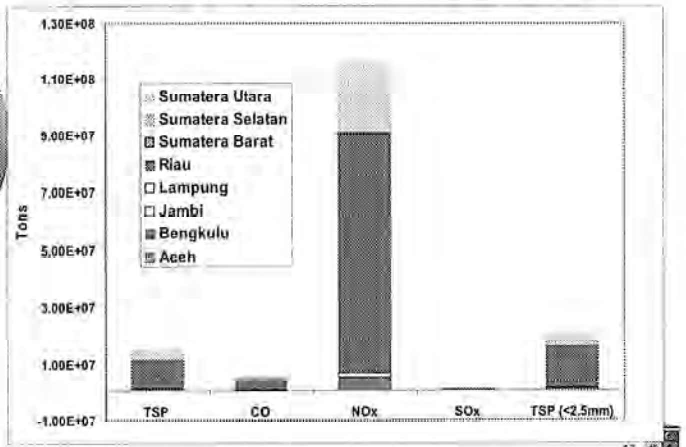


45



46

Estimates of gases and particulates in Aug 2005



47

Conclusion

- The dynamics of tropical deforestation are very complex. It is multivariate in nature that are made up of interrelationship between proximate as well as underlying factors.
- The multivariate causes in tropical deforestation make it extremely difficult to develop a widely accepted and applicable policy that can manage the issues of deforestation.
- Current policies introduced to manage deforestation are often simplistic on the drivers of change or only understood part of the process.
- Therefore, any attempt to control and manage deforestation must be prepared to invest on the understanding of the causal factors.
- It is imperative that commitment and willpower of the people and decision makers be made for the survival of humans in the light of global warming.

48

49

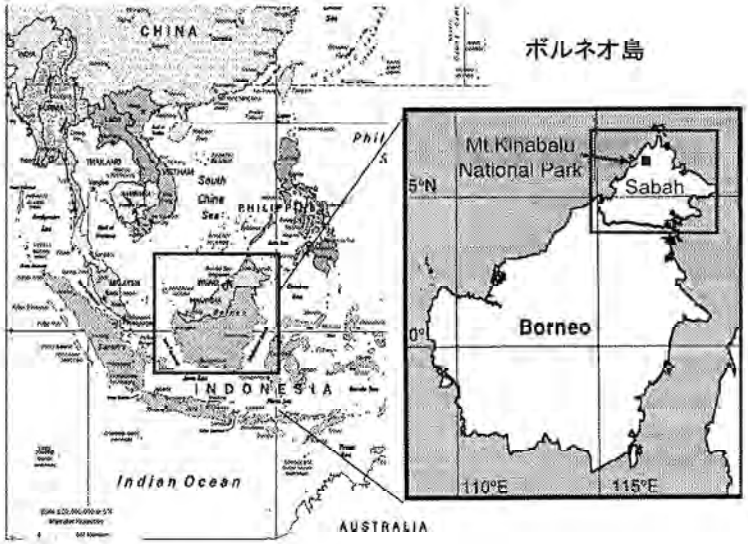
APN国際セミナー 2007/12/2

東南アジア熱帯降雨林への
土地利用と地球温暖化の影響

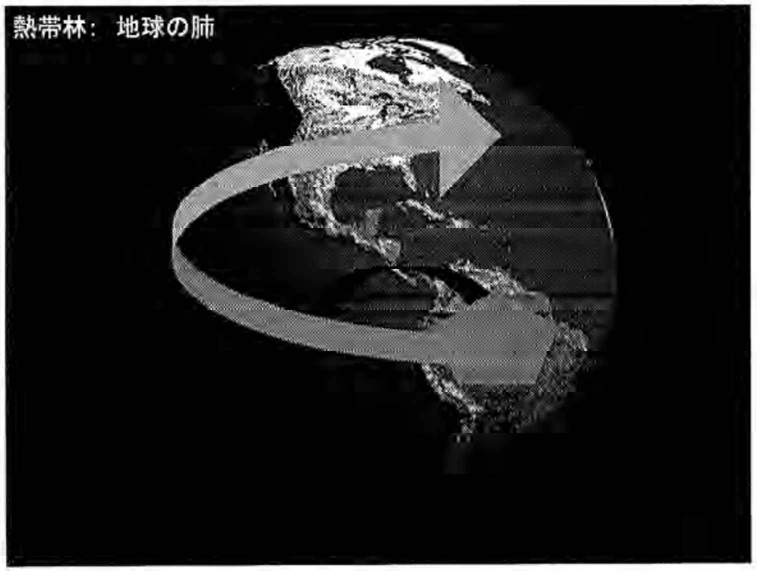
京都大学・生態学研究センター
北山兼弘

1

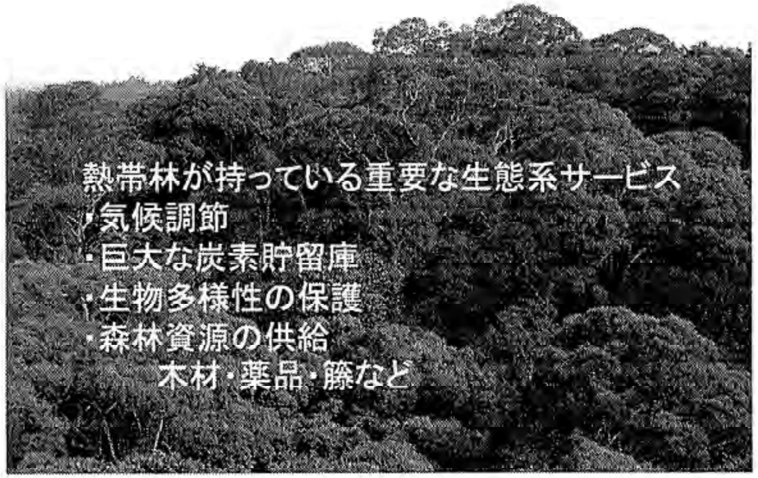
ボルネオ島



2



3



4

まず、IPCCは熱帯生態系をどのように捉えているのか？

気候変動に関する政府間パネル
の4次報告から

5

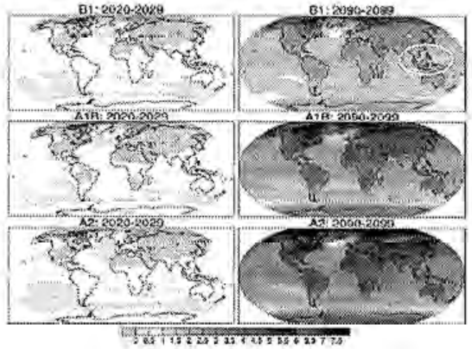
Higher confidence in projected patterns of warming

SRES Emissions Scenario

B1: "low"
環境優先社会

A1B: "medium"

A2: "high"
経済優先社会

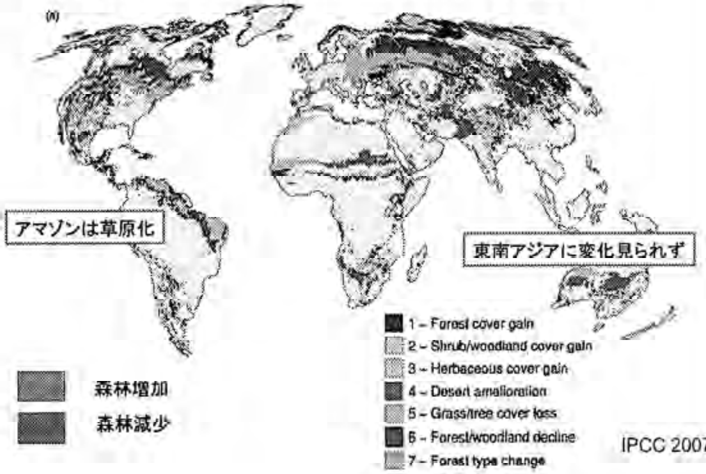


(IPCC, 2007, Fig. SPM-6, adapted)

Projected warming in the 21st century shows scenario-independent patterns... Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean.

6

A2シナリオによる植生変化（2000年と2100年の比較）



IPCC 2007

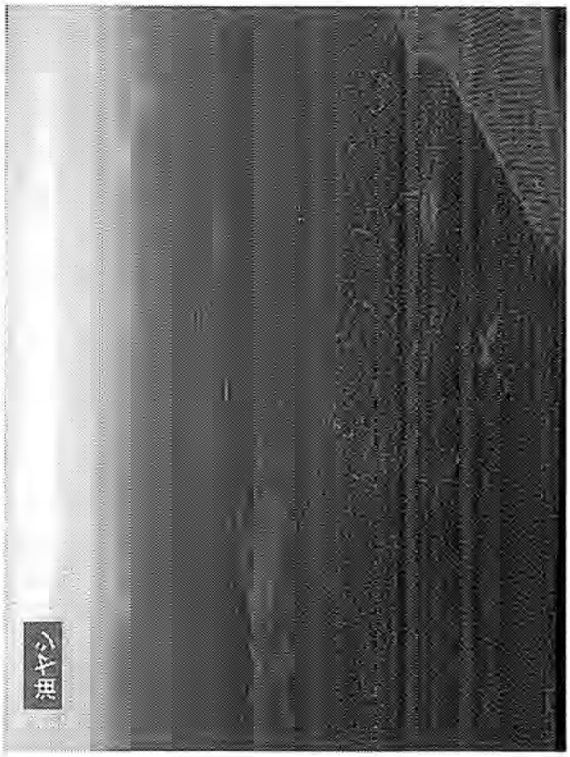
7

東南アジア熱帯の現状

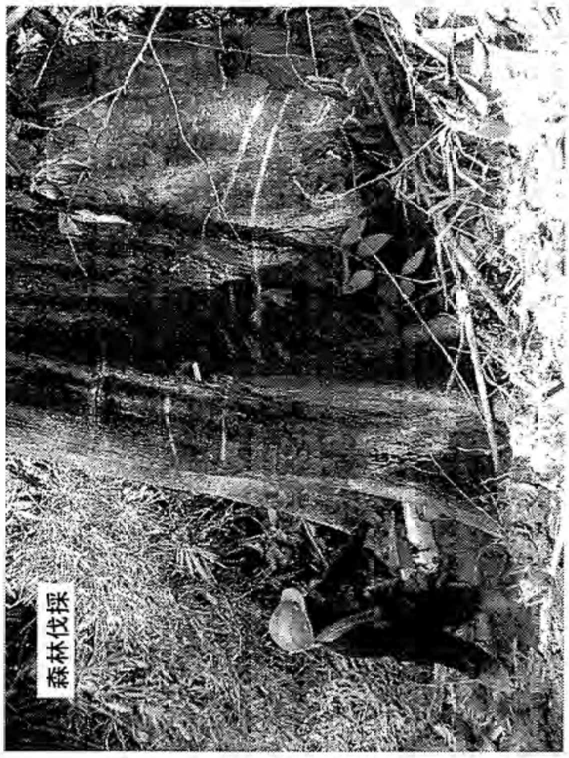
- 土地利用が急激に進行
- 干ばつが半定期的に襲来
- 大規模森林火災が発生

地球温暖化との相乗効果はないのか？

8



9



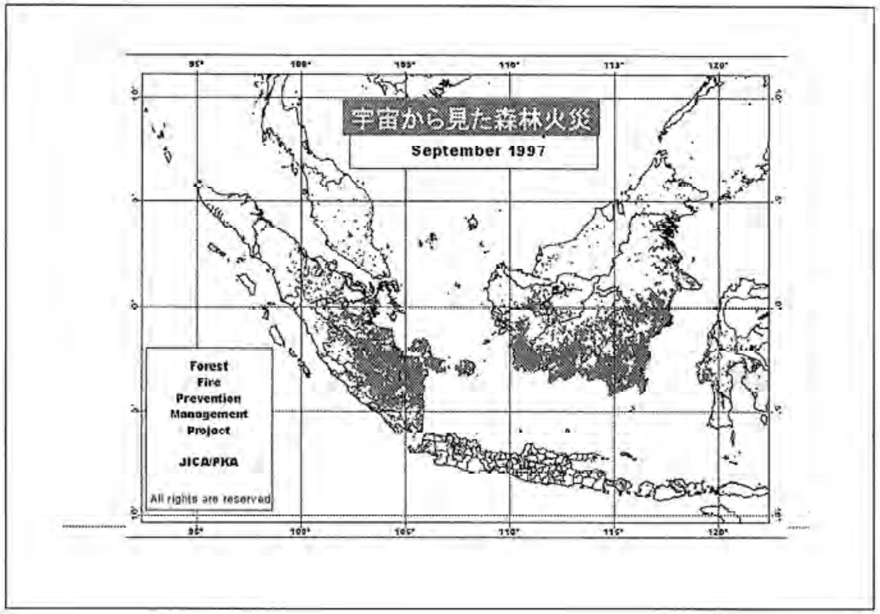
10

11

12


択伐林(抜き切り)：やがて回復すると
仮定されてはいるが？

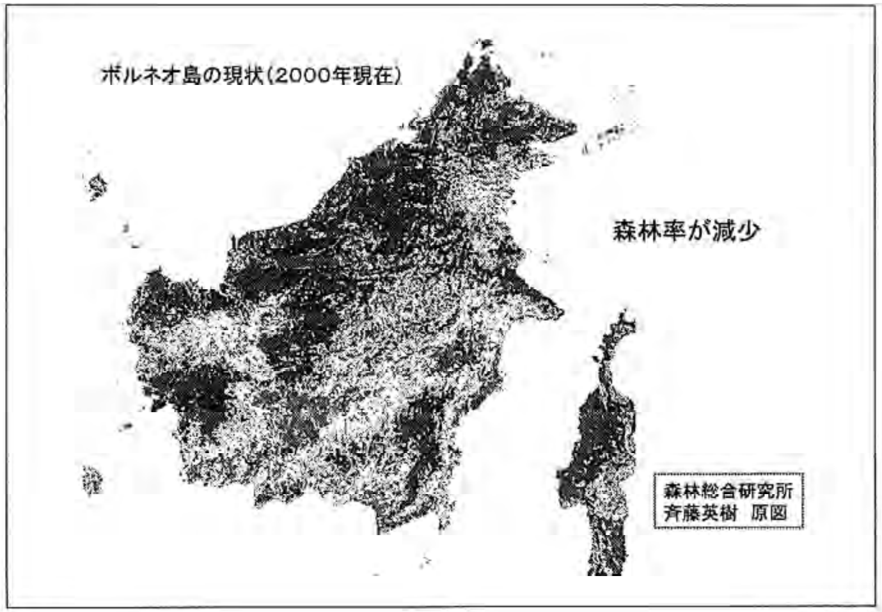
13


宇宙から見た森林火災
September 1997
Forest
Fire
Prevention
Management
Project
JICA/PKA
All rights are reserved

14

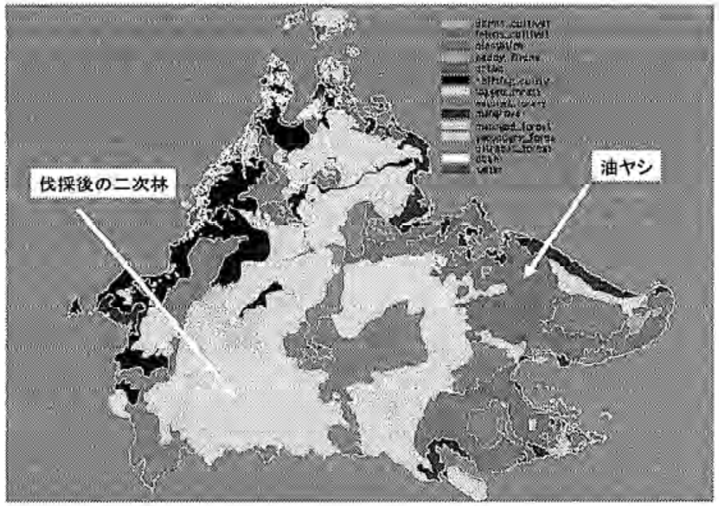

1998エルニーニョ干ばつによる立ち枯れ

15


ボルネオ島の現状(2000年現在)
森林率が減少
森林総合研究所
斉藤英樹 原図

16

北ボルネオの土地利用(1991)



17

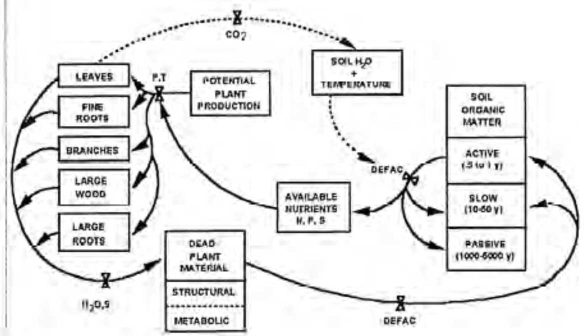
ボルネオの熱帯林は、土地利用と気候変化との相乗効果によって、大きく変わるのではないか？

- 生物相への温暖化予測方法(3つの方法)
  - -生物と気候の相関関係(将来も同じ関係が続くと仮定する)
  - -生理的なメカニズムに基づく
  - -過去の変化とのアナログ推測
- 生態系モデルを使った予測
  (栄養塩やエネルギーなど物質を基盤にした変化の予測)

18

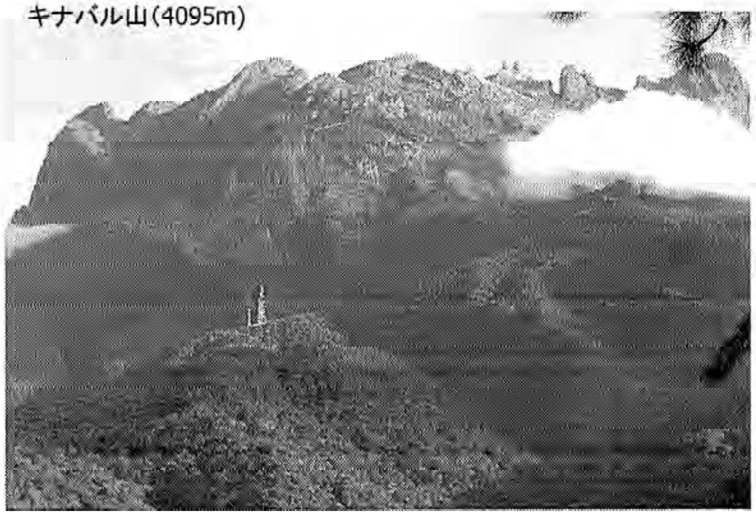
モデルを使った熱帯林生態系の予測

センチュリー・モデル



19

キナバル山(4095m)



20

シナリオ

ベースライン
2000年～2050年に年平均上昇率を0.043℃
CO2・降水量変化なし

干ばつシナリオ
10年毎に1998年規模のｴﾙ･ﾆｰﾆｮ干ばつ が発生
乾燥は1～5月、樹木死亡率は6月に2.6%上昇

択伐シナリオ
地上部バイオマスの49%が減少
枝、葉、樹皮のC,N,P,Sは100%土壌に還元
幹のC,N,P,Sは系外に持ち出し
西暦2000年に伐採、森林は放置

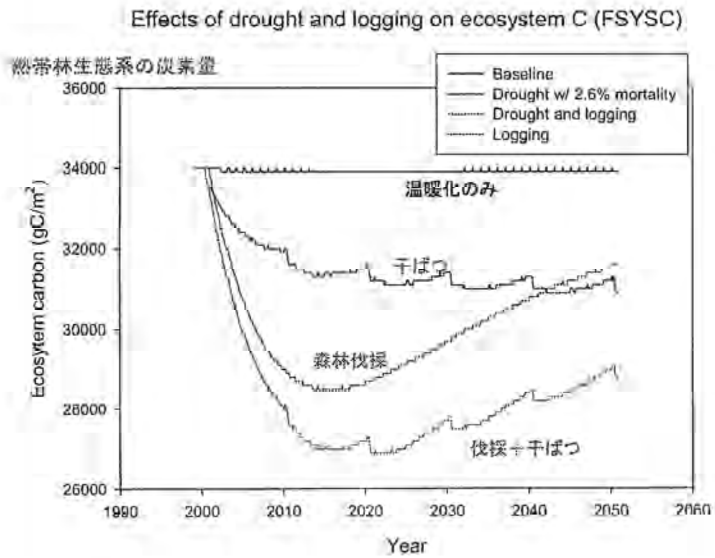
21

森林の炭素量を評価

植物の45-50%が炭素
土壌にも含まれる(腐葉土)

森林生態系での炭素の役割
・森林の骨格を形成し、他の生物の棲みかとなる
・他の生物の食べ物となる

22



23

予測結果
<u>干ばつ無し、平均気温だけが増加する場合</u>

森林生態系に大きな変化は無いかもしれない

・バイオマスは漸次増加、しかし土壌有機物が減少、ネットで炭素の変化量がゼロ。
・バイオマスの増加量は緩やかで、これに伴なう生物群集の変化は、もしあったとしても緩やかなものであろう。

24

1998年規模の干ばつが10年毎に生じる場合

樹木の死亡率上昇に森林回復が追いつかず、バイオマスも生態系炭素貯留量も漸次減少を始め、丘陵フタバガキ林は炭素のソースとなる。

植物季節の変化、乾燥による淘汰を通した植物群落の変化、土壌生物の変化など、生態系の質的な変化が起こる可能性が高い。

25

さらに伐採が加わる場合

干ばつにより、伐採からの森林回復は著しく遅れ、年ごとに干ばつが無いシナリオとの差が大きくなる。

これは既に伐採が行われ、回復途上にある二次林にも適用される。

26

ボルネオに将来"薄い"熱帯林が広がる可能性

"熱帯林"を見たことがない地元の子供たちが増える

保全区域、土地利用の地帯区分、伐採方法、森林計画の改善が必要
(土地利用のストレスを軽減するような枠組みや政府開発援助が必要)

27

森林の動物

28

29

生物多様性への影響は不可避

30

Chuluun Togtohyn, Ph.D.
National University of Mongola
Colorado State University
Global Citizen NGO

VULNERABILITY OF THE MONGOLIAN STEPPE AND NOMADIC CULTURE TO CLIMATE CHANGE: ADAPTATION OR CATASTROPHE?

1

- Brief Introduction of Mongolia
- Climate Change and Its Impact
- Land Use Change
- Vulnerability of Pastoral Community
- Adaptation
- Choice

2

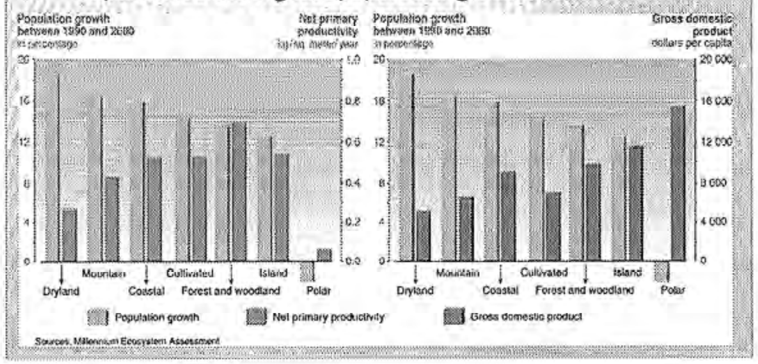
Dryland systems, history, geography, population & economy

MONGOLIA

3

MA: ECOSYSTEM SERVICES AND POVERTY REDUCTION

Critical concern: Dryland systems
- Dryland systems with the lowest NPP and GDP per capita experienced the highest population growth rate in the 1990s

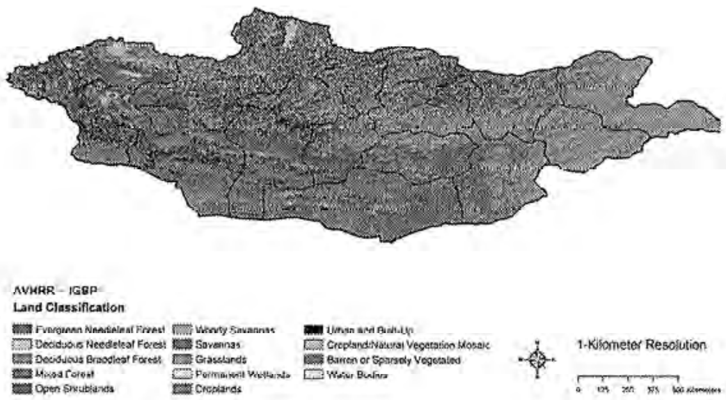


4

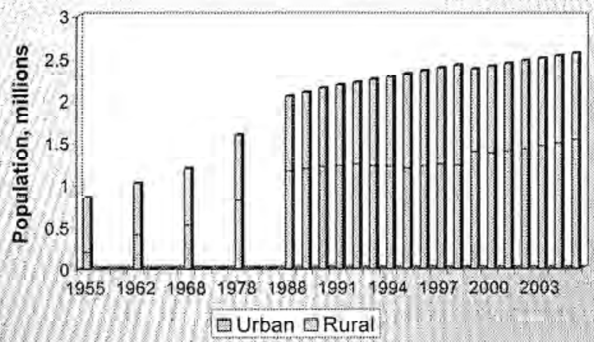
- The Great Wall is a line drawn by nature, which distinguishes lands suitable for agriculture from those that are not. It was a frontier of the nomadic culture.
- 198 BC, agreement between the Han Empire and the Hun nomadic empire.
- 1206 , foundation of Mongolia by Chingis Khaan, a ruler over the largest land Empire and a founder of globalization.

5

International Geosphere Biosphere Programme (IGBP)
Land Cover Classification

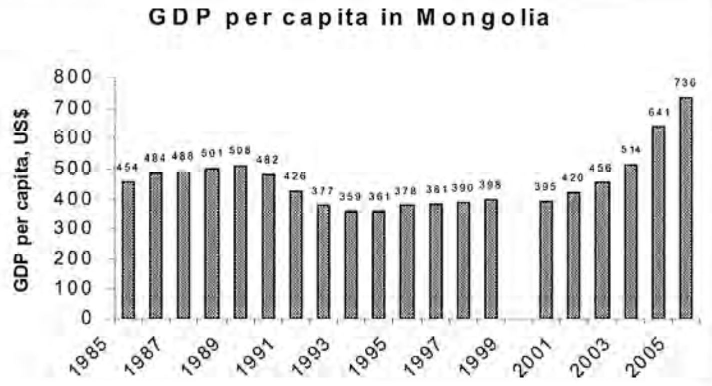


6



- High population growth until early 1990 (2.8%);
- The urban population over-exceeding in mid 1970s;
- The rural population is relatively stable.

7



- Drop of the GDP per capita after 1990 and slow recovery during a decade;
- Recent sharp increase of GDP per capita due to global market price increase of copper and gold.

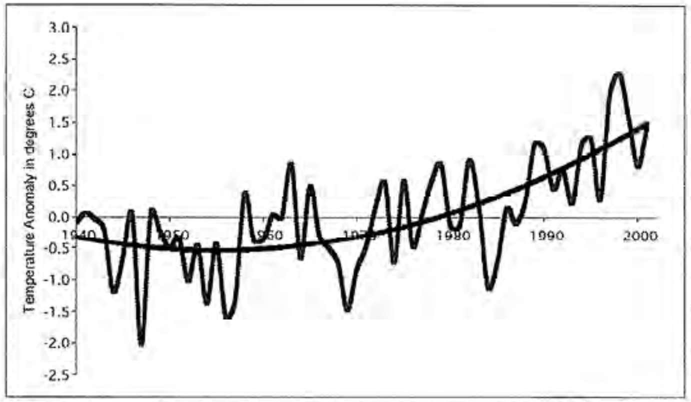
8

Global warming, water resources, NPP trends & plant onset trends

CLIMATE CHANGE AND ITS IMPACTS

9

TEMPERATURE TREND (1940-2001)

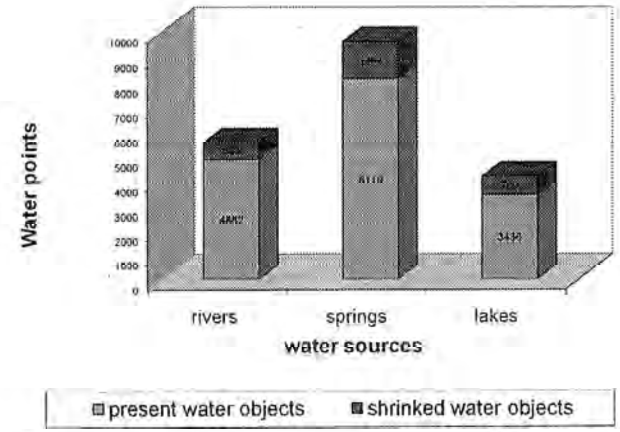


AIACC 2005

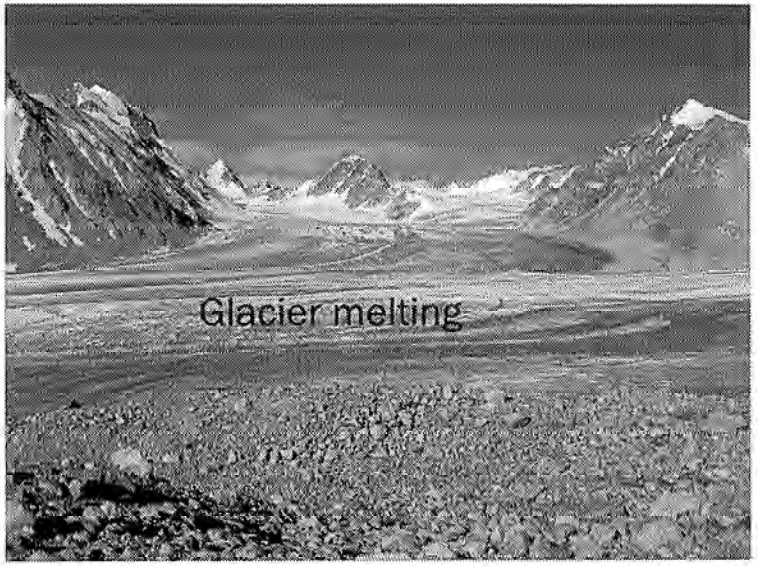
Figure 2.5: Temperature trend for the period 1940-2001

10

WATER SHRINKING IN 1998-2003

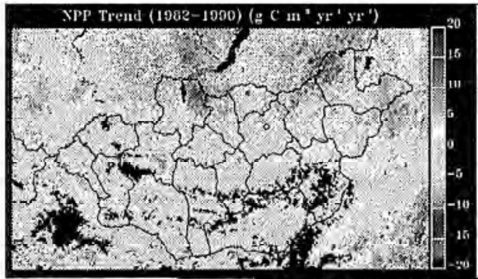


11



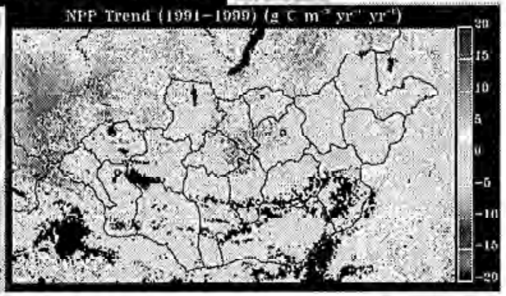
12

NPP TRENDS



1982-1990

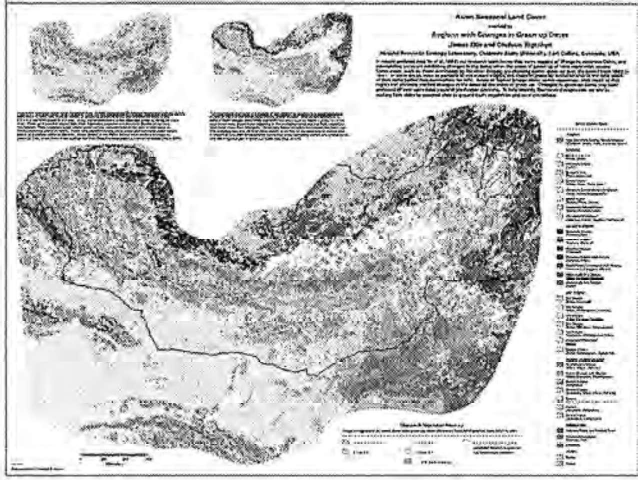
1991-1999



Ojima, Chuluun et al. 2004

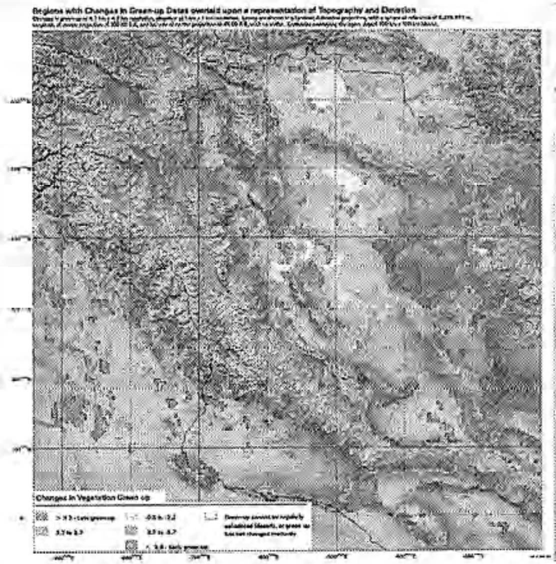
13

PLANT ONSET TRENDS, 1982-1991



Ellis et al. 2002

14



Overlay of the plant green-up trends over topography map

CHULUUN & OJIMA (NSF / AIACC)

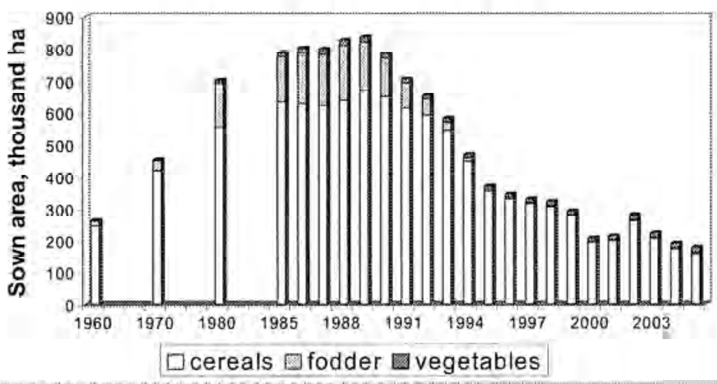
15

Agriculture, livestock dynamics & vulnerability of rangelands

LAND USE CHANGE

16

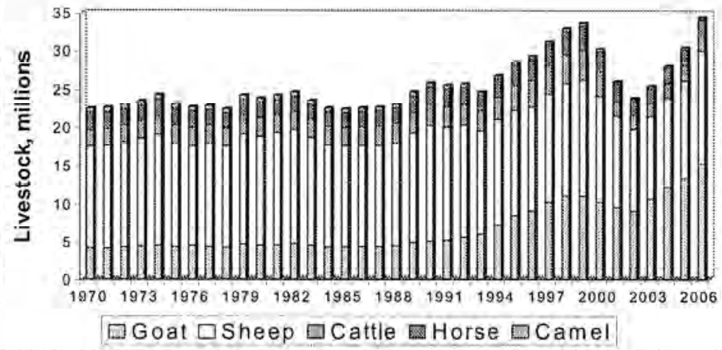
Sown areas in Mongolia



•Self-sufficiency in flour supply before 1990;
•Agriculture's collapse since 1990: 4 times decrease of sown areas and fodder cropping failure.

17

Livestock dynamics in Mongolia



•Relatively stable (20-25 million) livestock numbers before 1990;

•More dynamics since 1990: 33 million by 1999, reducing after the 1999-2002 *zuds* and almost 35 million by 2006.

•The goat number tripled since 1990 due to cashmere value.

18

Rangeland Vulnerability: Climatic extreme events (*zud* & drought) + (livestock density – carrying capacity) **during 1970-1990 and 1990-2003**

$V = \Delta S + \Delta N$

dS – *Zud* index, (L.Natsagdorj & G.Sarantuya, 2004)
dN - relative index of pasture use

Chuluun & Altanbagana, 2005

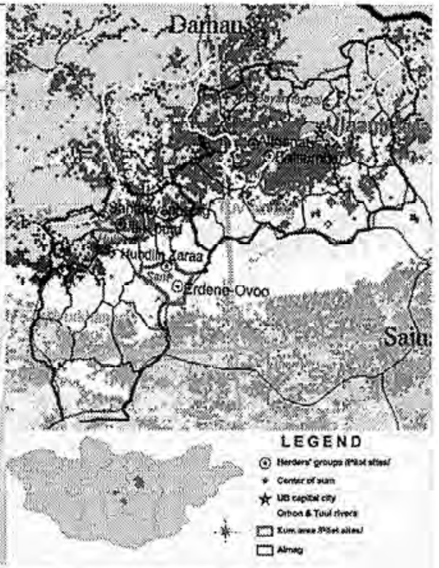
19

Participatory method, cultural landscape, land degradation, water limitation, sacred lands, adaptation options

VULNERABILITY OF PASTORAL COMMUNITY

20

RESEARCH COMMUNITIES:
"POLICY FRAMEWORK FOR ADAPTATION STRATEGIES OF THE MONGOLIAN RANGELANDS TO CLIMATE CHANGE AT MULTIPLE SCALES" (PARCC)



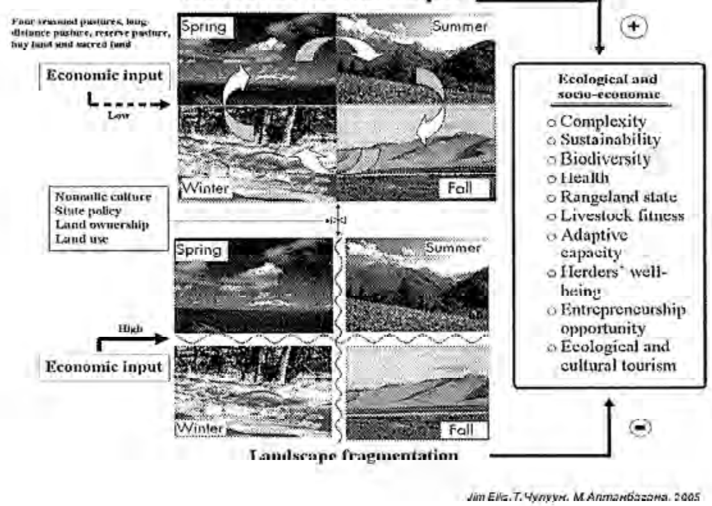
21

Participation of local government

22

23

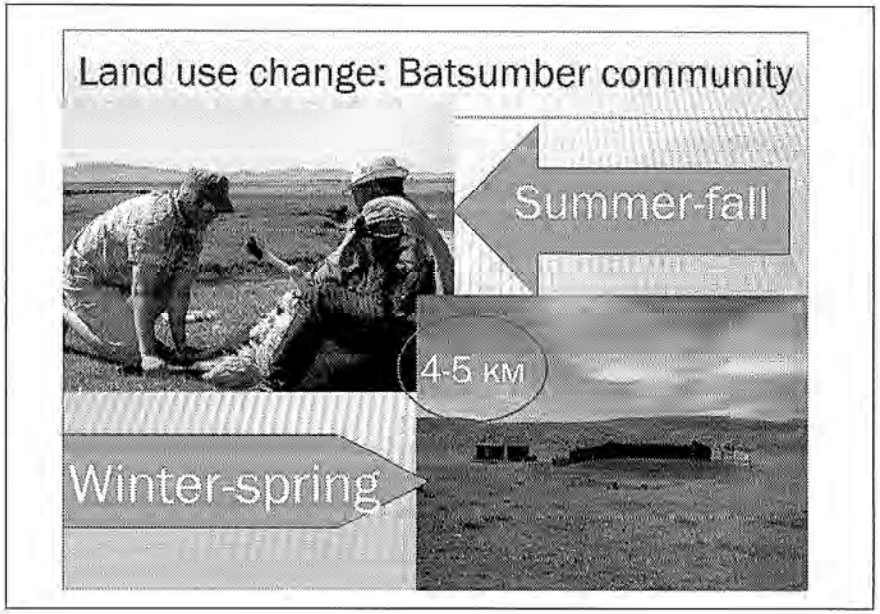
Cultural Landscape



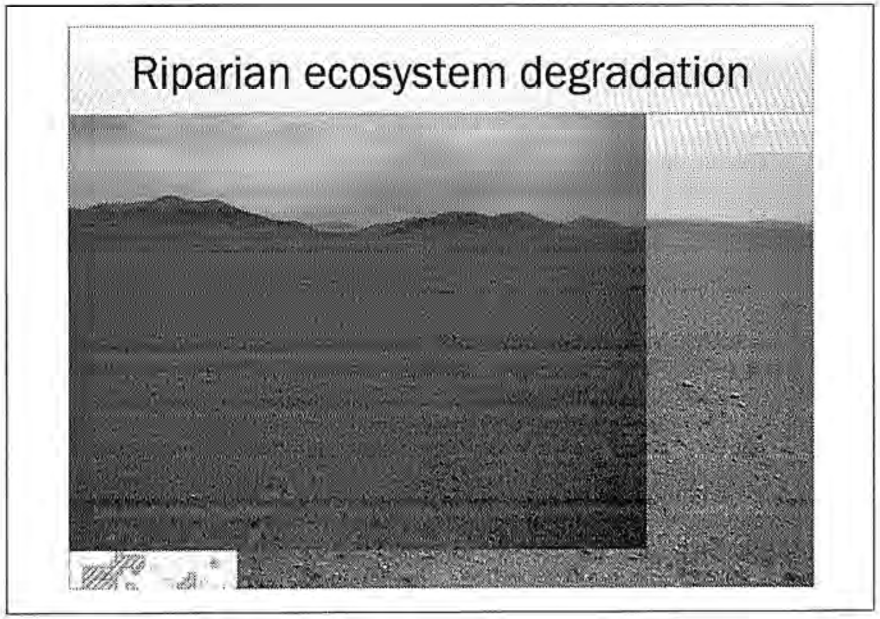
24


Cultural landscape
The whole is more than the sum of its parts!
Summer
Fall
Hayland
Spring
Winter
Otor
Reserve pasture
Sacred land

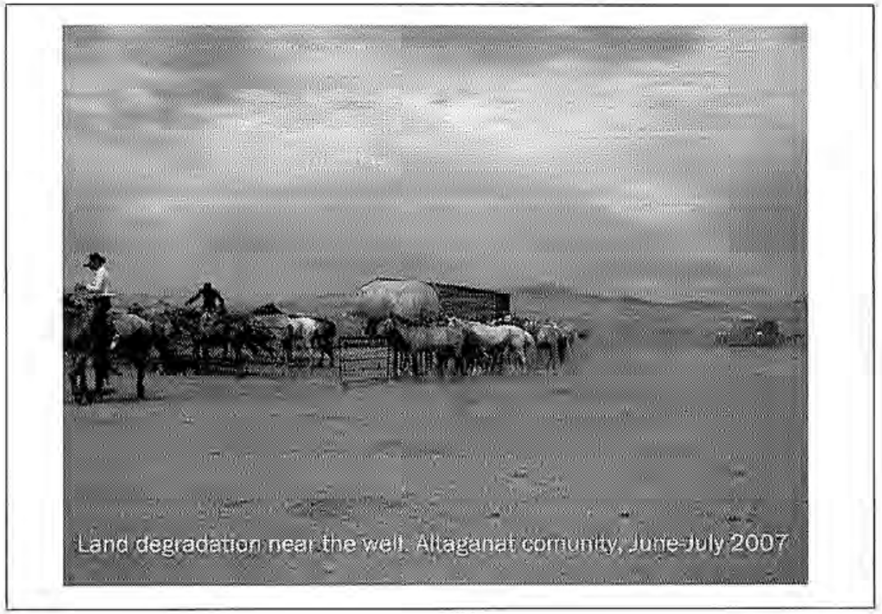
25


Land use change: Batsumber community
Summer-fall
4-5 KM
Winter-spring

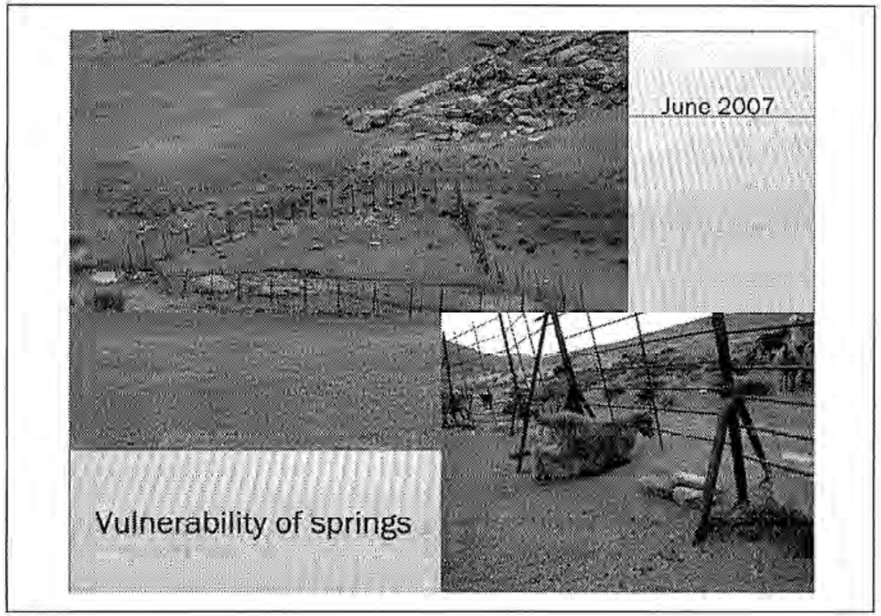
26


Riparian ecosystem degradation

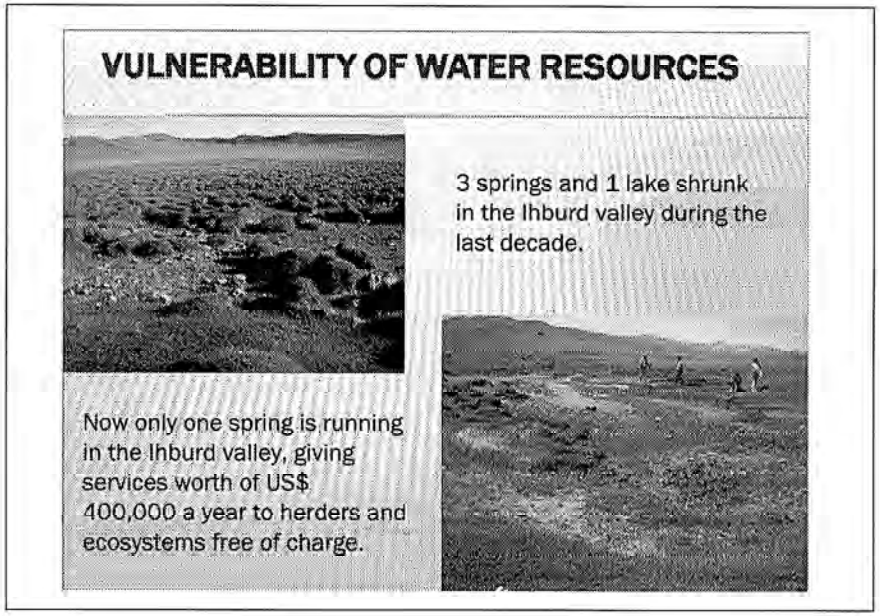
27


Land degradation near the well. Altaganat comunity, June-July 2007

28


June 2007
Vulnerability of springs

29

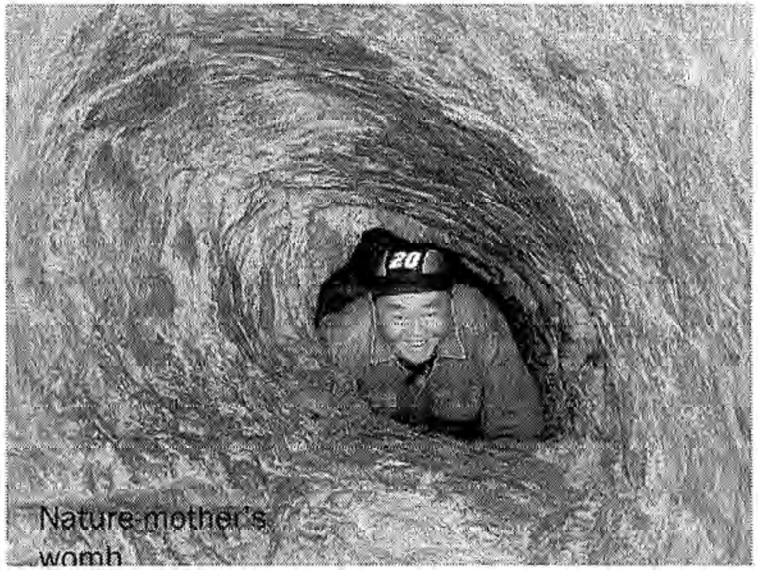

VULNERABILITY OF WATER RESOURCES
3 springs and 1 lake shrunk in the Ihburd valley during the last decade.
Now only one spring is running in the Ihburd valley, giving services worth of US$ 400,000 a year to herders and ecosystems free of charge.

30

31


Tovhon temple

32



33

34

35

Nomadic culture in the Information Era & cultural landscape fragmentation with administrative-territorial division

ADAPTATION:
COMMUNITY AND COUNTRY

36

ADAPTATION OPTIONS FOR COMMUNITIES

- Restoration of traditional cultural landscapes:
  - Seasonal pastures;
  - *Otor* and reserve pastures;
  - Haylands.
- Protection and improvement of water sources;
- Community ownership of pastures with protection of sacred lands and sustainable use of natural resources;
- Economic development:
  - Farming ;
  - Increased meat export;
  - Cultural and ecological tourism;
  - Introduction of productive livestock breeds.

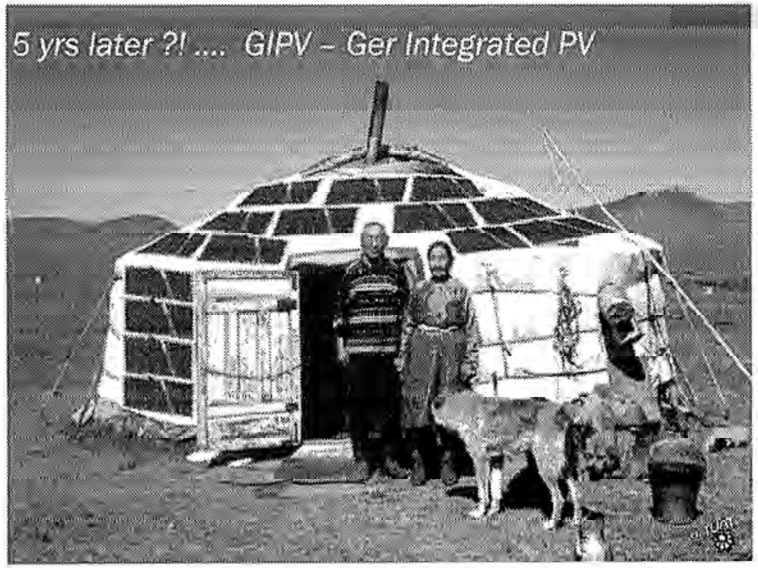
37

EMPOVERMENT OF PASTORAL COMMUNITIES IN THE INFORMATION ERA

- Strengthening of traditional pastoral networks:
  - Renewable energy;
  - Wireless satellite communication;
  - Distance learning;
  - Mobile medical services with distance diagnosis;
- Restoration of cultural landscape and its traditional management
  - Enlargement of administrative-territorial units.

38

39



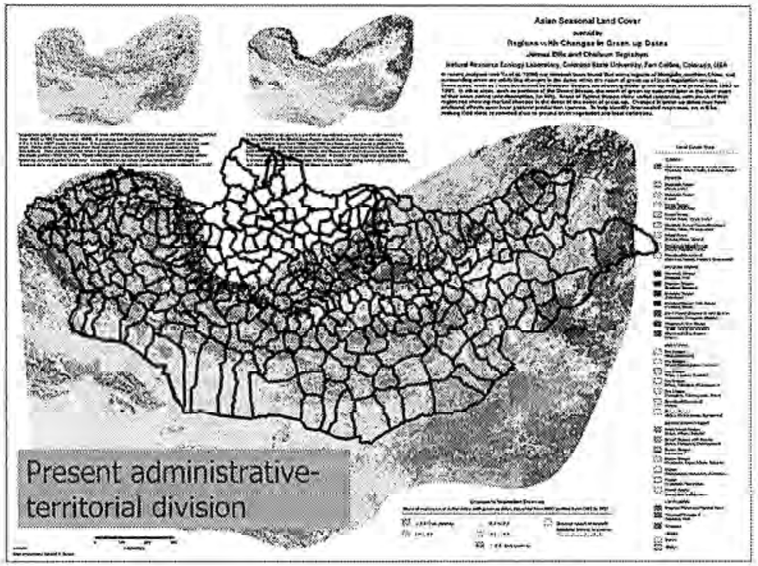
40

CULTURAL LANDSCAPE FRAGMENTATION

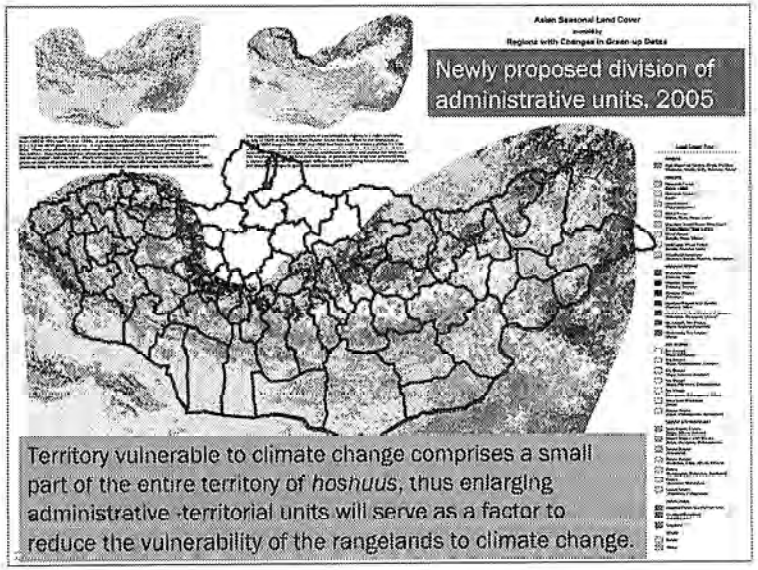
An administrative territorial division of Mongolia was fragmented during the socialist period of last century, often breaking traditional Cultural Landscapes:

159 *sums* out of 330 don't have 1-2 seasonal pastures.

41



42



43

Concluding remarks, sustainable development & brunch point

CHOICE:

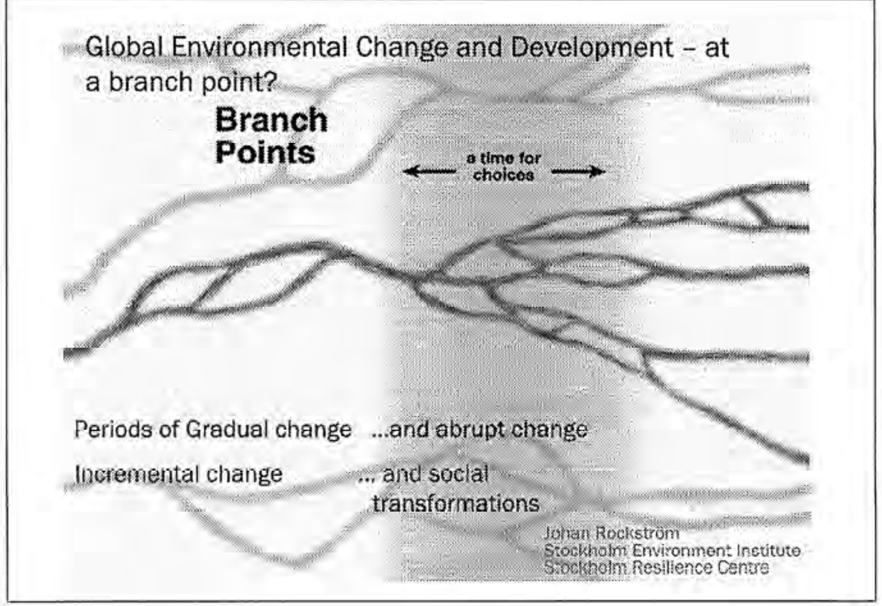
ADAPTATION OR CATASTROPHE

44

CONCLUDING REMARKS

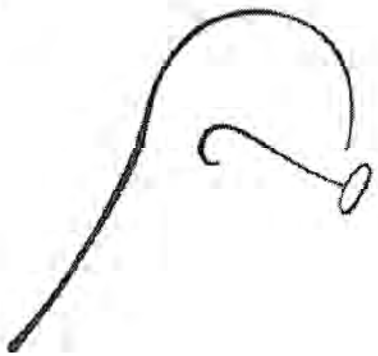
- Abrupt changes in ecosystem function and services already are happening in Mongolia due to interacting climate change and human activities;
- Adaptation strategies at pastoral community, local administrative unit, river basin, sub-regional and country levels should be developed with participation of all stakeholders;
- Adaptation strategies to GEC need to be linked with the SD and MDGs.

45



46

Dr R K Pachauri
Chairman, IPCC

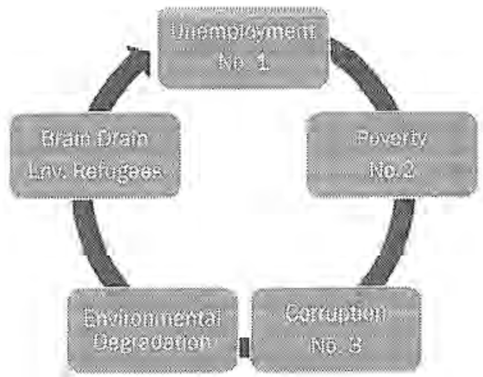


A technological society has two choices. First it can wait until catastrophic failures expose systemic deficiencies, distortion and self-deceptions...

Secondly, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures.

47

CYCLE LEADING TO THE COLLAPSE



48

SUSTAINABLE DEVELOPMENT

- Develop economic, social and political systems in comprehensive way, conserving ecological and cultural capitals;
- Base on uniqueness of ecology, culture and history;
- Adapt to globalization, including climate change;
- Develop global citizen - human capital;
- Cooperation for development.

Chuluun et al., 2004.

49

50

OPTIMISTIC NOTES

- Human capacity (with literacy rate – 99%);
- Rising economy (with GDP per capita - $1,060 in 2006, and $1,500 in October 2007);
- New opportunities in Tavan Tolgoi (coal) and Oyu Tolgoi (copper and gold);
- Emergence of an active civil society;
- Increased awareness about the environment;
- Cultural integrity;
- Positive signs in corruption reduction;
- Finally, friendship of Japan and Mongolia:
  - Japan is number one donor country, assisting my country during its transition to democracy and market economy!

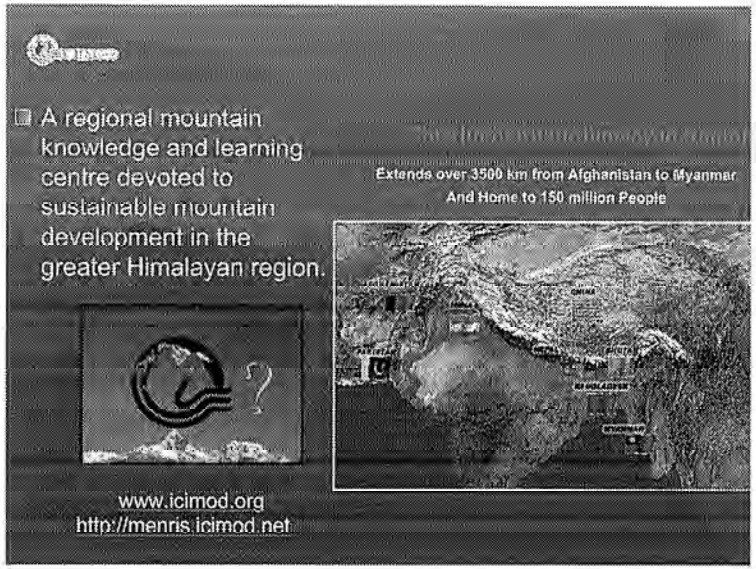
51

BAYARLALAA!

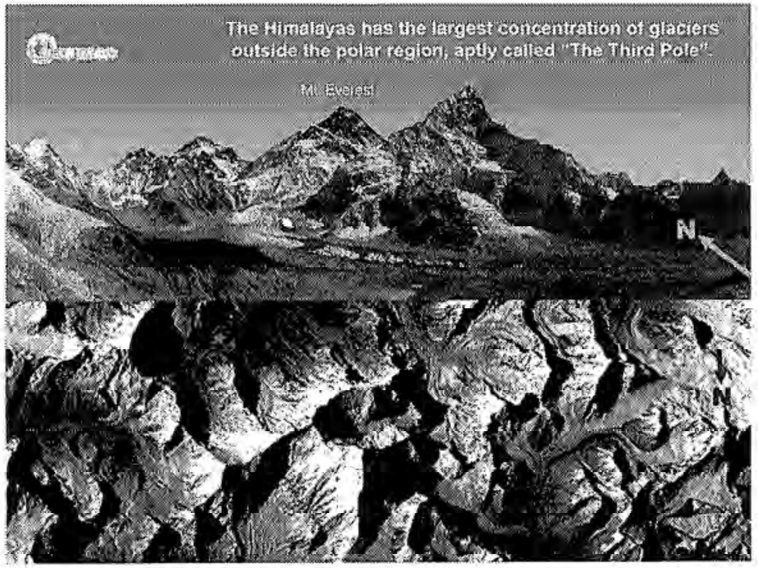
52


Impact of Climate Change on Himalayan Glaciers and Glacial Lakes
APN International Symposium
2 December 2007
Kobe, Japan
Presented By:
Basanta Shrestha, Division Head MENRIS, ICIMOD
(bshrestha@icimod.org)
Other study team members: Samjwal Bajracharya, Pradeep Mool, and members from national partner institutions

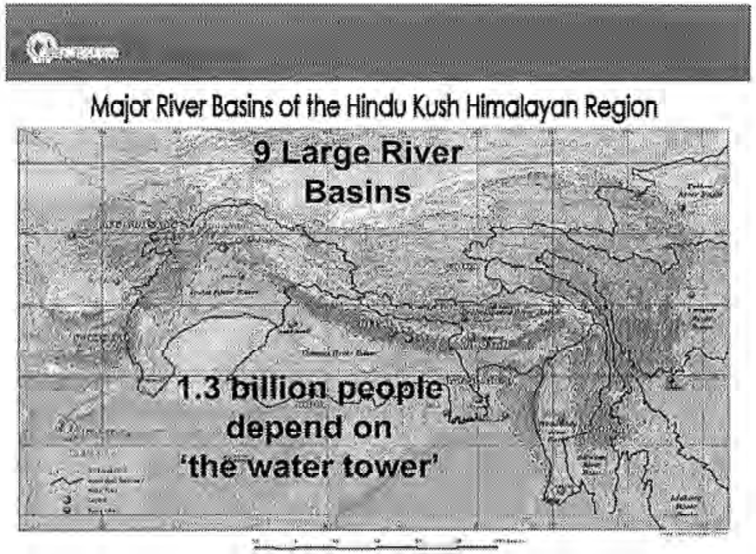
1


A regional mountain knowledge and learning centre devoted to sustainable mountain development in the greater Himalayan region.
Extends over 3500 km from Afghanistan to Myanmar
And Home to 150 million People
www.icimod.org
http://menris.icimod.net

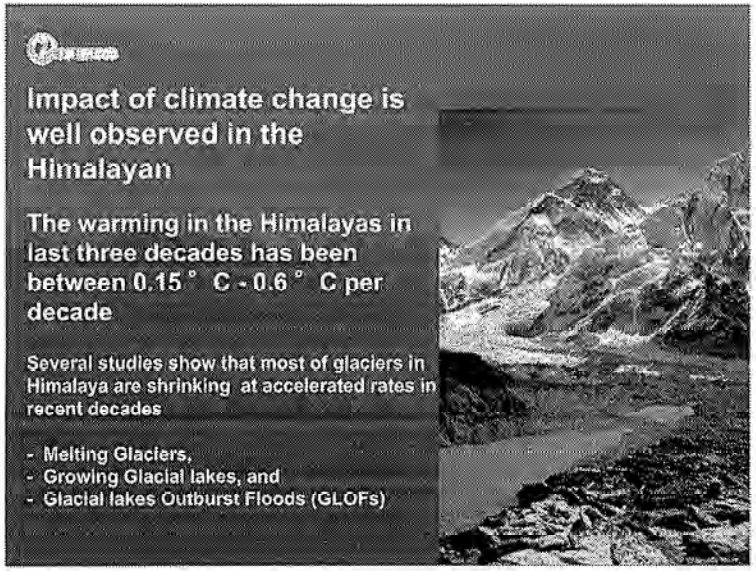
2


The Himalayas has the largest concentration of glaciers outside the polar region, aptly called "The Third Pole".
Mt. Everest
N

3

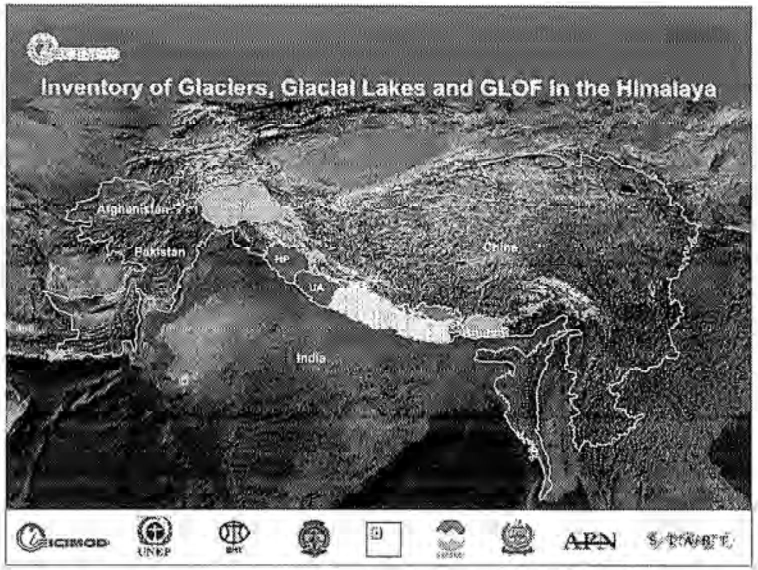

Major River Basins of the Hindu Kush Himalayan Region
9 Large River Basins
1.3 billion people depend on 'the water tower'

4



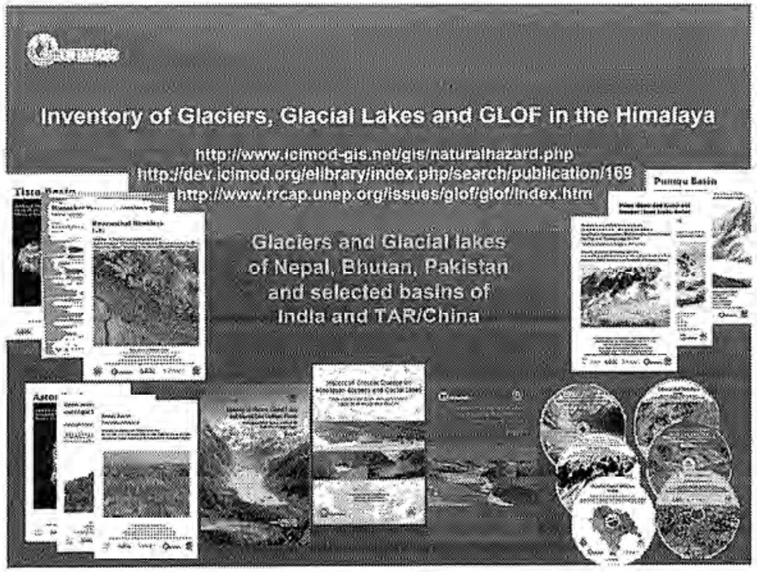
Impact of climate change is well observed in the Himalayan
The warming in the Himalayas in last three decades has been between 0.15° C - 0.6° C per decade
Several studies show that most of glaciers in Himalaya are shrinking at accelerated rates in recent decades
- Melting Glaciers,
- Growing Glacial lakes, and
- Glacial lakes Outburst Floods (GLOFs)

5



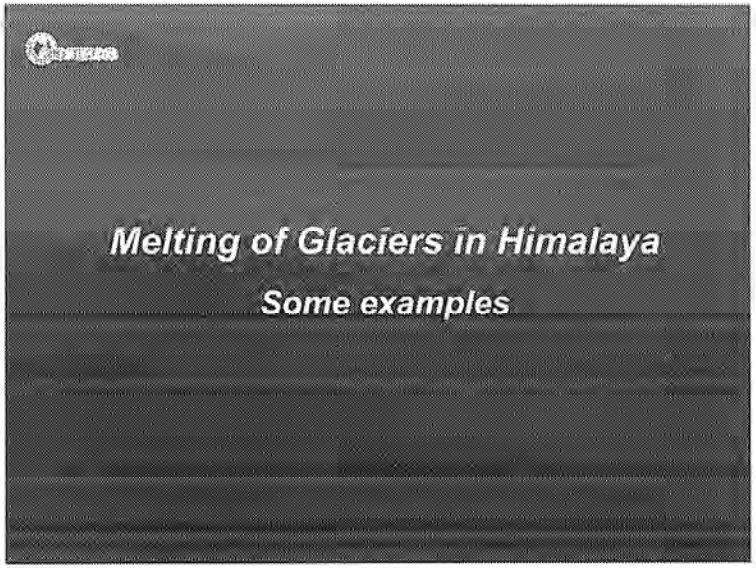
Inventory of Glaciers, Glacial Lakes and GLOF in the Himalaya
Afghanistan
Pakistan
HP
UA
China
India
ICIMOD
UNEP
APN

6



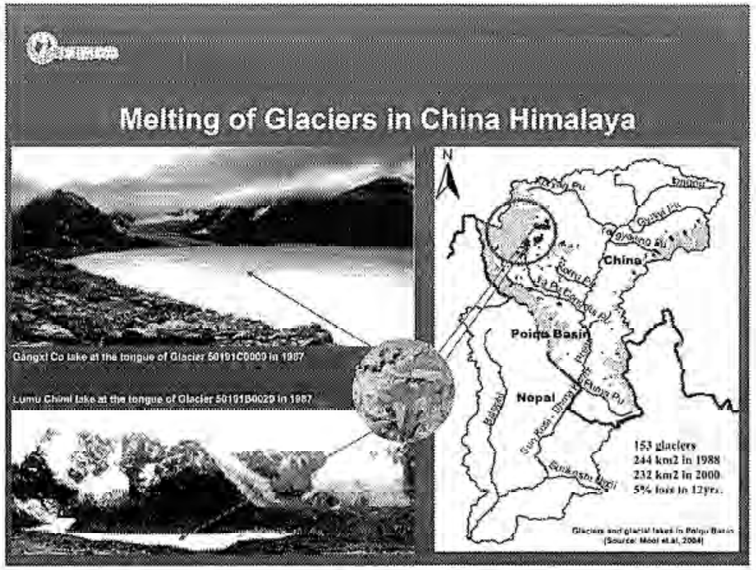
Inventory of Glaciers, Glacial Lakes and GLOF in the Himalaya
http://www.icimod-gis.net/gis/naturalhazard.php
http://dev.icimod.org/elibrary/index.php/search/publication/169
http://www.rrcap.unep.org/issues/glof/glof/index.htm
Glaciers and Glacial lakes of Nepal, Bhutan, Pakistan and selected basins of India and TAR/China

7



Melting of Glaciers in Himalaya
Some examples

8

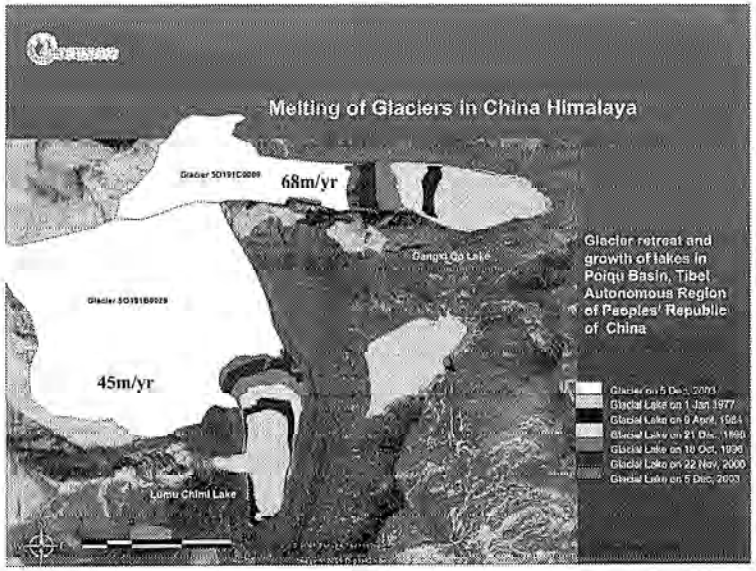


Melting of Glaciers in China Himalaya
Gangxi Co lake at the tongue of Glacier 50191C0009 in 1987
Lumu Chimi lake at the tongue of Glacier 50191B0029 in 1987
China
Poiqu Basin
Nepal
153 glaciers
244 km2 in 1988
232 km2 in 2000
5% loss in 12yrs.
Glaciers and glacial lakes in Poiqu Basin
(Source: Mool et.al, 2004)

9

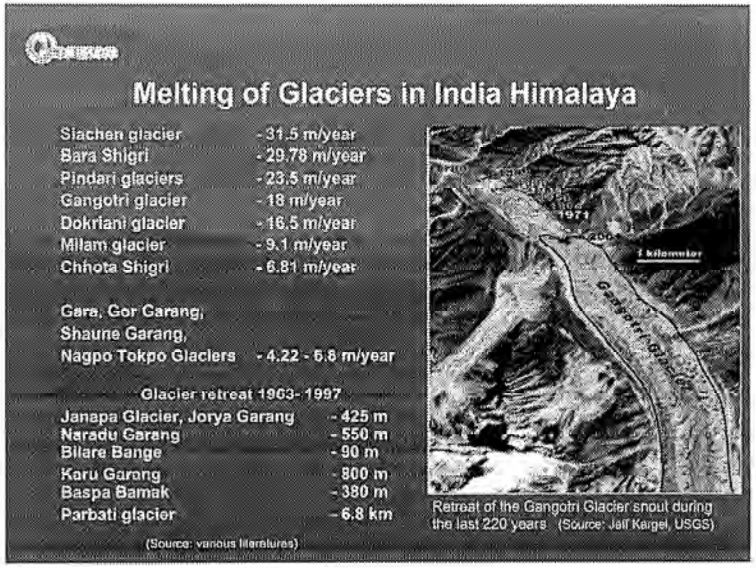
Landsat MSS image on 1 Jan, 1977
Landsat MSS image on 9 April, 1984
EOS ASTER image on 5 Dec, 2003
Landsat ETM+ image on 22 Nov, 2000

10



Melting of Glaciers in China Himalaya
68m/yr
45m/yr
Gangxi Co Lake
Lumu Chimi Lake
Glacier retreat and growth of lakes in Poiqu Basin, Tibet Autonomous Region of Peoples' Republic of China

11

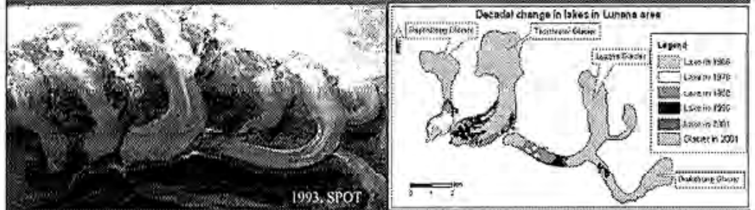


Melting of Glaciers in India Himalaya
Siachen glacier - 31.5 m/year
Bara Shigri - 29.78 m/year
Pindari glaciers - 23.5 m/year
Gangotri glacier - 18 m/year
Dokriani glacier - 16.5 m/year
Milam glacier - 9.1 m/year
Chhota Shigri - 6.81 m/year
Gara, Gor Garang,
Shaune Garang,
Nagpo Tokpo Glaciers - 4.22 - 6.8 m/year
Glacier retreat 1963- 1997
Janapa Glacier, Jorya Garang - 425 m
Naradu Garang - 550 m
Bilare Bange - 90 m
Karu Garang - 800 m
Baspa Bamak - 380 m
Parbati glacier - 6.8 km
(Source: various literatures)
Gangotri Glacier
1 kilometer
Retreat of the Gangotri Glacier snout during the last 220 years (Source: Jeff Kargel, USGS)

12

Melting of Glaciers in Bhutan Himalaya

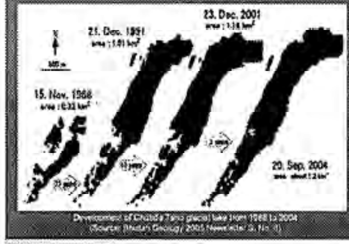
Glaciers shrunk by around 8% between 1963 to 1993.

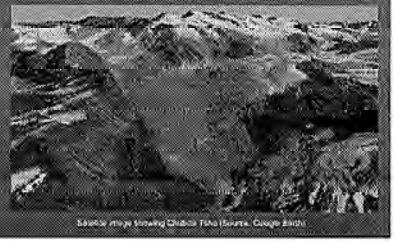


- Raphstreng glacier retreated 42m/yr from 1968 to 2001
- Luggye glacier retreated 57m/yr from 1988 to 1998

13

Lake Chubda Tsho increased by 0.027 km²/yr from 1968 to 2001.





14

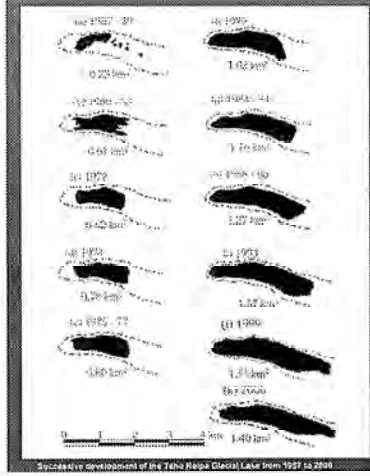
Melting of Glaciers in Nepal Himalaya

- Most glaciers shrunk by around 10 to 60 m/yr
- About 6% area loss in the period 1970 to 2000

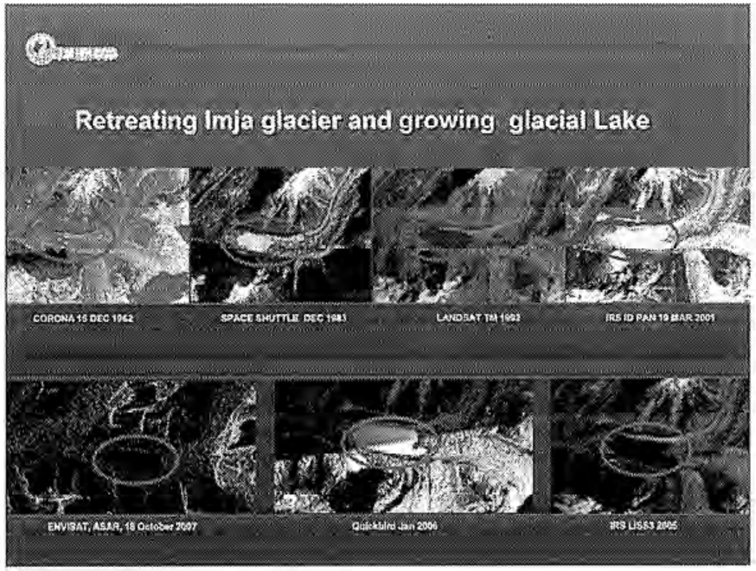
Glacier Name	Retreat rate	Reference
AX010	30 m retreat form 1978-1989	Fujita 2001
Khumbu	10m surface lowering from1970-1995	Kadota et al. 2000
7 unnamed clean type glaciers in Khumbu region	30-60 m retreat from 1970s to 1989	Yamada at al. 1992
(Imja glacial lake associated with) Imja and Lhotse Sar glaciers	Retreat rate about 41m/yr from 1962-2001 and 74m from 2001 to 2006	Bajracharya 2006
(Tso Rolpa glacial lake associated with) Trakarding glacier	66m per year from1957-2000	WECS 1993, Mool 2001, Bajracharya 2005,

15

Development of Tsho Rolpa lake with the retreat of Trakarding glacier



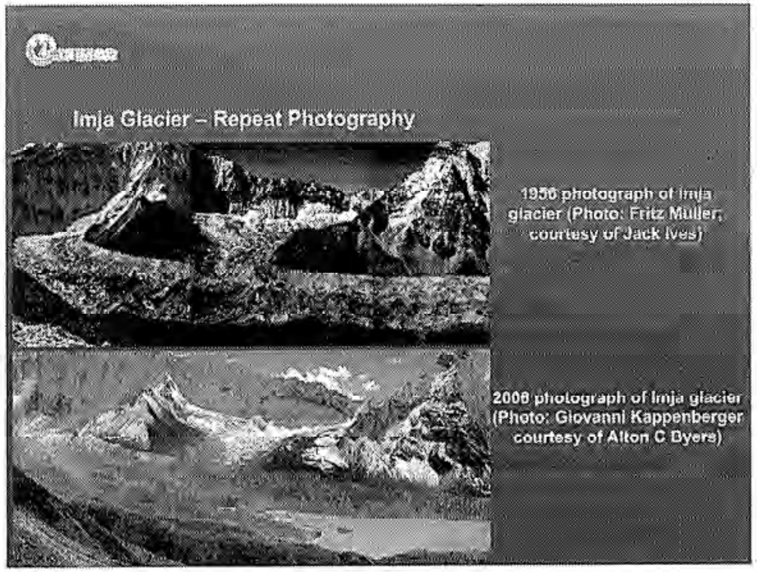
16


Retreating Imja glacier and growing glacial Lake
CORONA 15 DEC 1962
SPACE SHUTTLE DEC 1983
LANDSAT TM 1992
IRS ID PAN 19 MAR 2001
ENVISAT, ASAR, 18 October 2007
Quickbird Jan 2006
IRS LISS3 2005

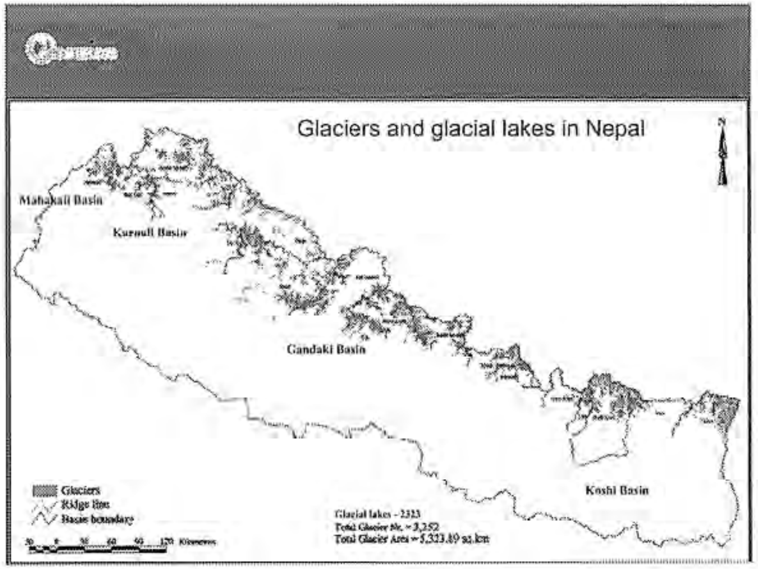
17


Highest retreating glacier in Himalaya
Almost 1 square kilometers in area
26 million cubic meters in 1992
36 million cubic meters in 2002
40 million cubic meters in 2007
Retreat rate – 42m/yr from 1962 to 2001 and 74m/yr from 2001 to 2006
LEGENDS
15 Dec 1962
15 Oct 1975
02 Dec 1983
22 Sep 1992
30 Oct 2000
Jun 2006

18

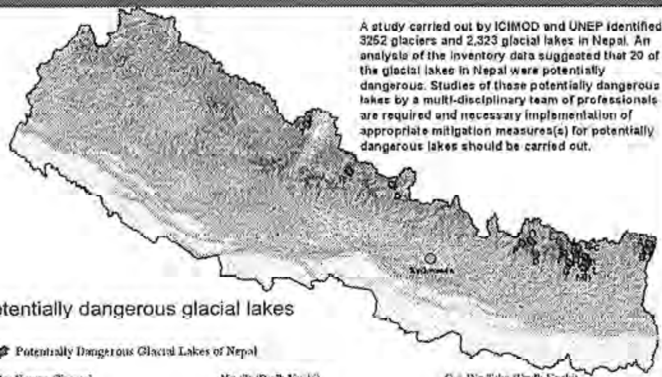

Imja Glacier – Repeat Photography
1956 photograph of Imja glacier (Photo: Fritz Müller, courtesy of Jack Ives)
2006 photograph of Imja glacier (Photo: Giovanni Kappenberger courtesy of Alton C Byers)

19


Glaciers and glacial lakes in Nepal
Mahakali Basin
Karnali Basin
Gandaki Basin
Koshi Basin
Glaciers
Ridge line
Basin boundary

20

A study carried out by ICIMOD and UNEP identified 3252 glaciers and 2,323 glacial lakes in Nepal. An analysis of the inventory data suggested that 20 of the glacial lakes in Nepal were potentially dangerous. Studies of these potentially dangerous lakes by a multi-disciplinary team of professionals are required and necessary implementation of appropriate mitigation measures(s) for potentially dangerous lakes should be carried out.



Potentially dangerous glacial lakes

Potentially Dangerous Glacial Lakes of Nepal

A= Nagma (Tamor)
B= (?) (Tamor)
C= Lower Barun (Arun)
D= Lumding (Dudh Koshi)
E= Imja (Dudh Koshi)
F= Tam Pokhari (Dudh Koshi)
G= Dudh Pokhari (Dudh Koshi)
H= (?) (Dudh Koshi)
I= (?) (Dudh Koshi)
J= Hungu (Dudh Koshi)
K= East Hungu 1 (Dudh Koshi)
L= East Hungu 2 (Dudh Koshi)
M= (?) (Dudh Koshi)
N= West Chamjang (Dudh Koshi)
O = Dig Tsho (Dudh Koshi)
P= Tsho Rolpa (Tama Koshi)
Q= (?) (Budhi Gandaki)
R= Thulagi (Marsyangdi)
S= (?) (Kali Gandaki)
T= (?) (Kali Gandaki)

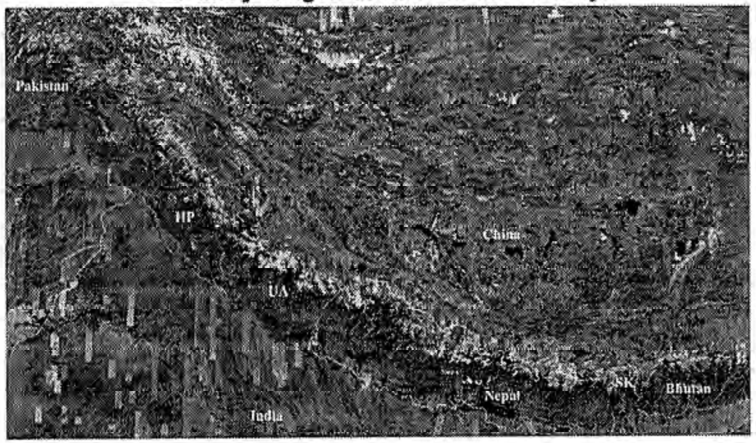
? No name

21

Location of some of the past GLOF events effecting in Nepal, often have Trans-boundary implications

22

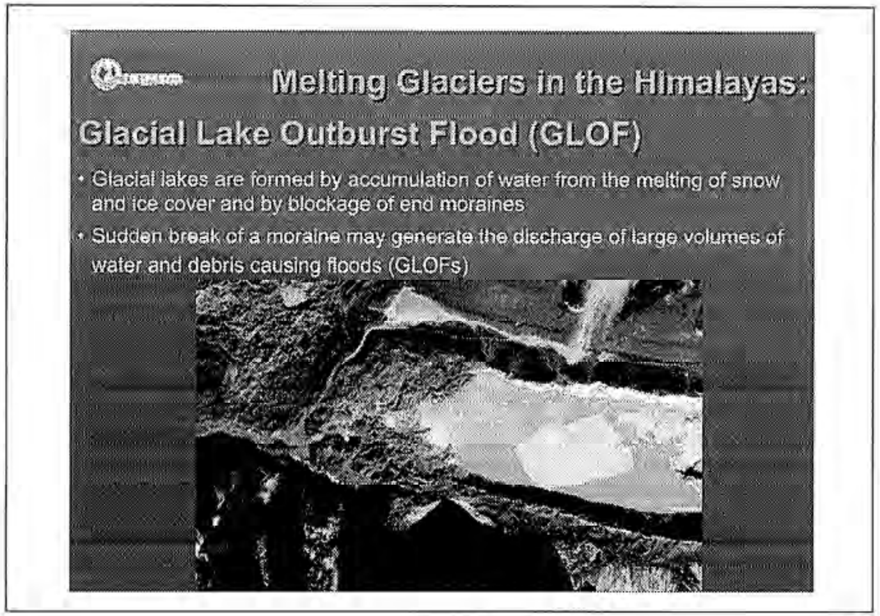
Potentially dangerous lakes in the Himalaya



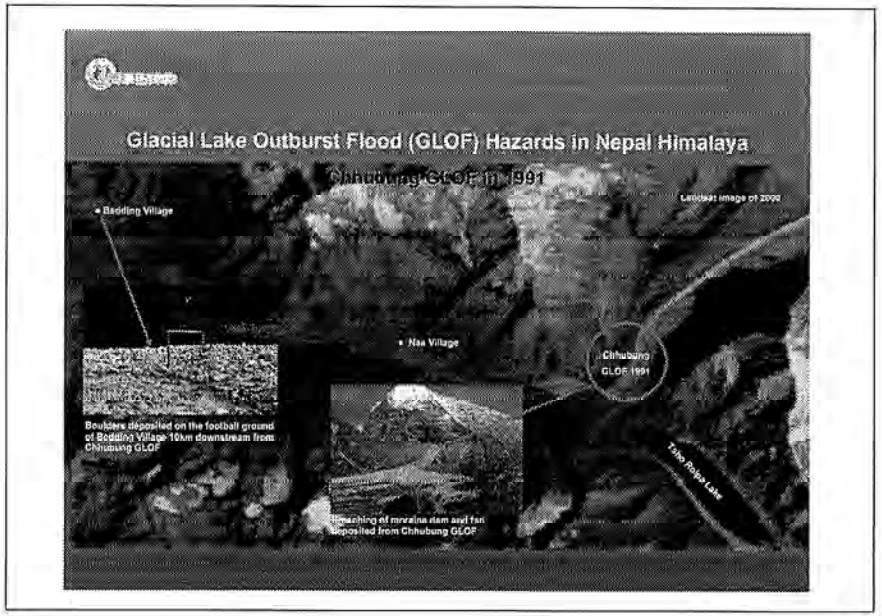
23

Glacial lakes Outburst Floods (GLOFs)

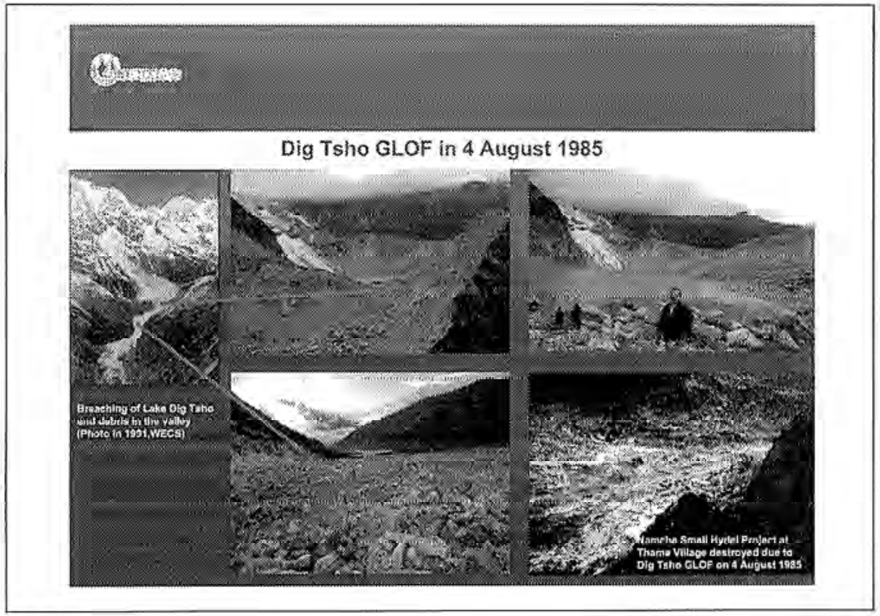
24


Melting Glaciers in the Himalayas:
Glacial Lake Outburst Flood (GLOF)
• Glacial lakes are formed by accumulation of water from the melting of snow and ice cover and by blockage of end moraines
• Sudden break of a moraine may generate the discharge of large volumes of water and debris causing floods (GLOFs)

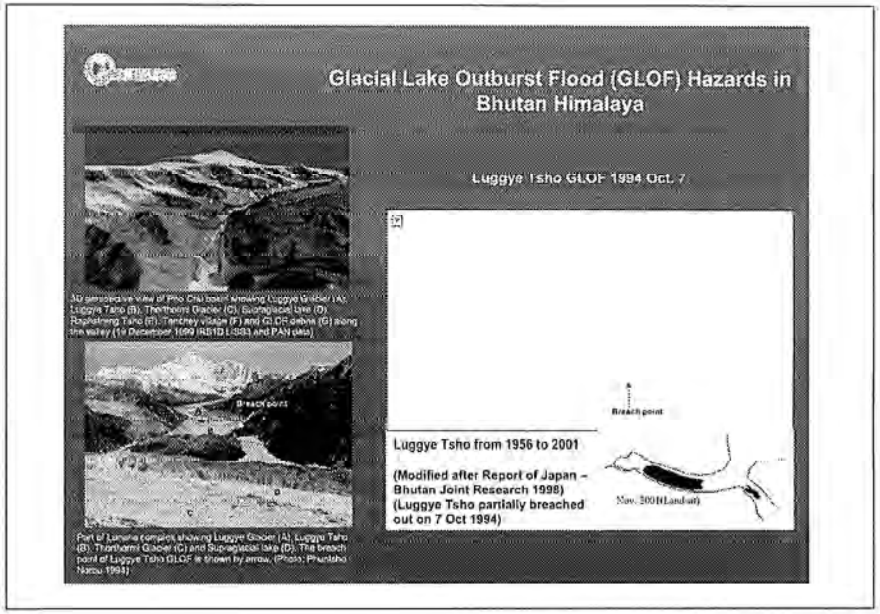
25


Glacial Lake Outburst Flood (GLOF) Hazards in Nepal Himalaya
Chhubung GLOF in 1991
Landsat image of 2000
• Bedding Village
• Naa Village
Chhubung GLOF 1991
Tsho Rolpa Lake
Boulders deposited on the football ground of Bedding Village 10km downstream from Chhubung GLOF
Breaching of moraine dam and fan deposited from Chhubung GLOF

26


Dig Tsho GLOF in 4 August 1985
Breaching of Lake Dig Tsho and debris in the valley (Photo in 1991,WECS)
Namche Small Hydel Project at Thame Village destroyed due to Dig Tsho GLOF on 4 August 1985

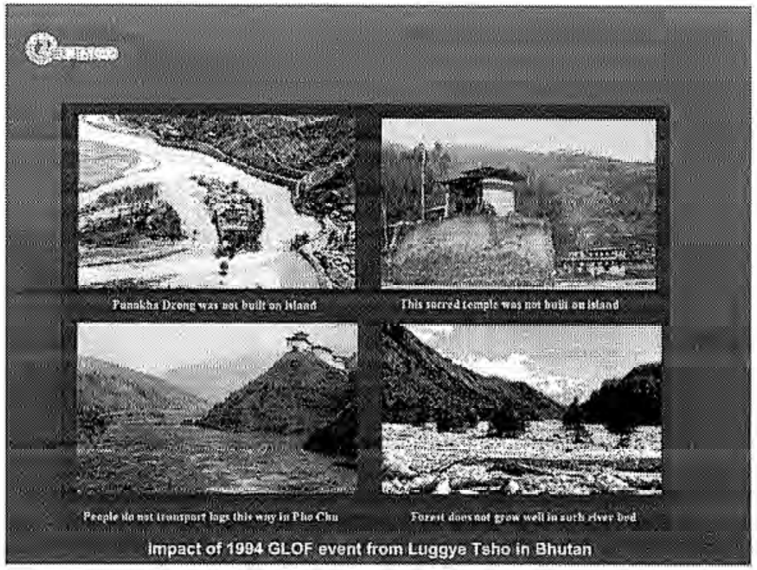
27


Glacial Lake Outburst Flood (GLOF) Hazards in Bhutan Himalaya
Luggye Tsho GLOF 1994 Oct. 7
Breach point
Luggye Tsho from 1956 to 2001
(Modified after Report of Japan – Bhutan Joint Research 1998)
(Luggye Tsho partially breached out on 7 Oct 1994)

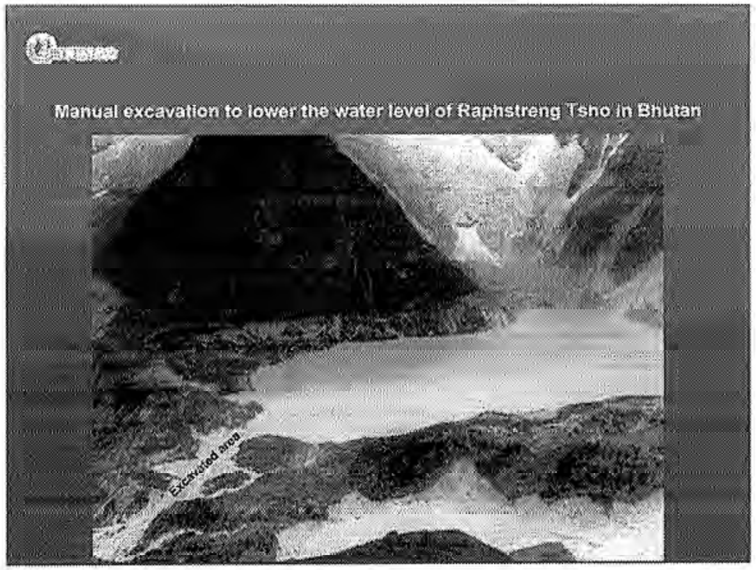
28


Tshoju
G
Dota
Tenchey
F
The U-shaped valley looking downstream showing the sand deposit in the Tshoju Village and erosion near Dota and Tenchey Villages by the GLOF of 1994. (Photo: Yeshi Dorji 1994)

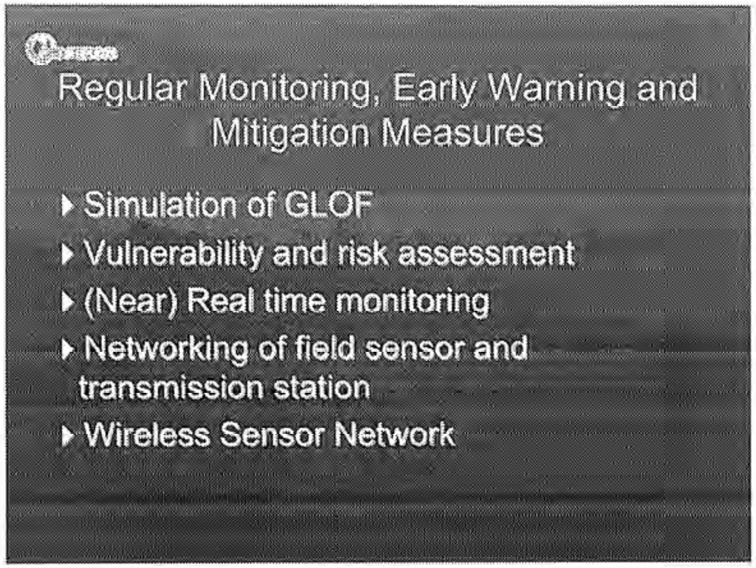
29


Punakha Dzong was not built on island
This sacred temple was not built on island
People do not transport logs this way in Pho Chu
Forest does not grow well in such river bed
Impact of 1994 GLOF event from Luggye Tsho in Bhutan

30


Manual excavation to lower the water level of Raphstreng Tsho in Bhutan
Excavated area

31


Regular Monitoring, Early Warning and Mitigation Measures
Simulation of GLOF
Vulnerability and risk assessment
(Near) Real time monitoring
Networking of field sensor and transmission station
Wireless Sensor Network

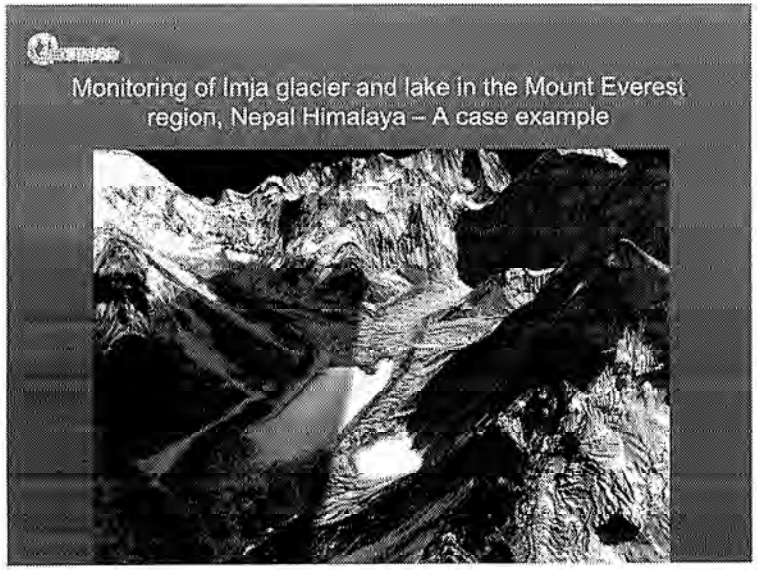
32


Tsho Rolpa glacial lake
Mitigation and Early Warning System at the Tsho Rolpa Glacial Lake in Nepal
Outflow from the outlet canal at end moraine

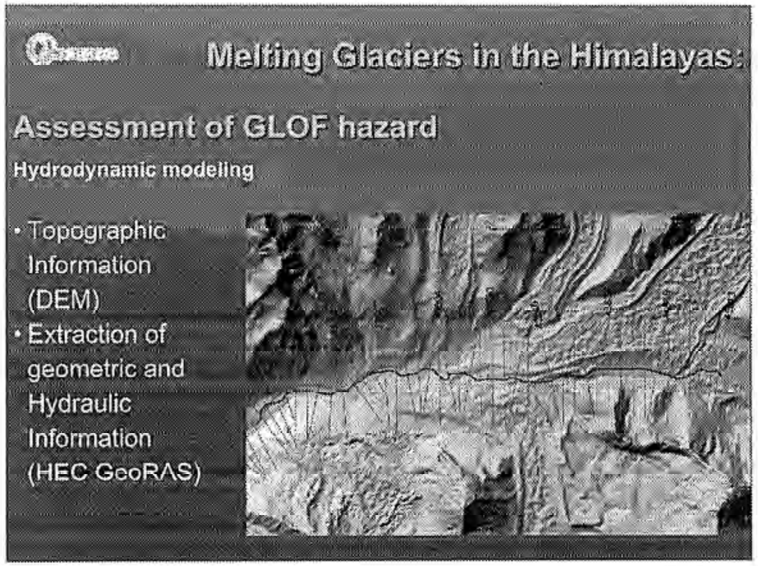
33


Early Warning Systems and Risk Mitigation work
Tsho Rolpa Lake in Nepal Himalaya
Channel Construction
(Arun Shrestha 2000)
ICIMOD Oct 2000

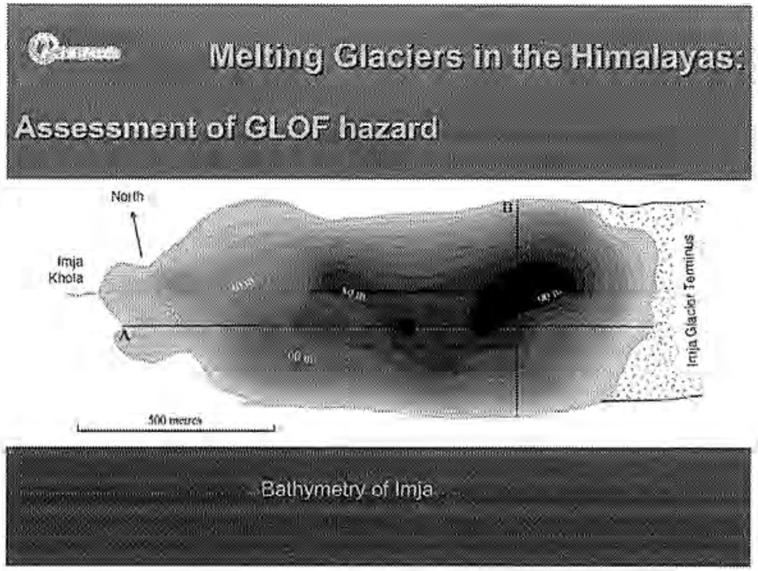
34


Monitoring of Imja glacier and lake in the Mount Everest region, Nepal Himalaya – A case example

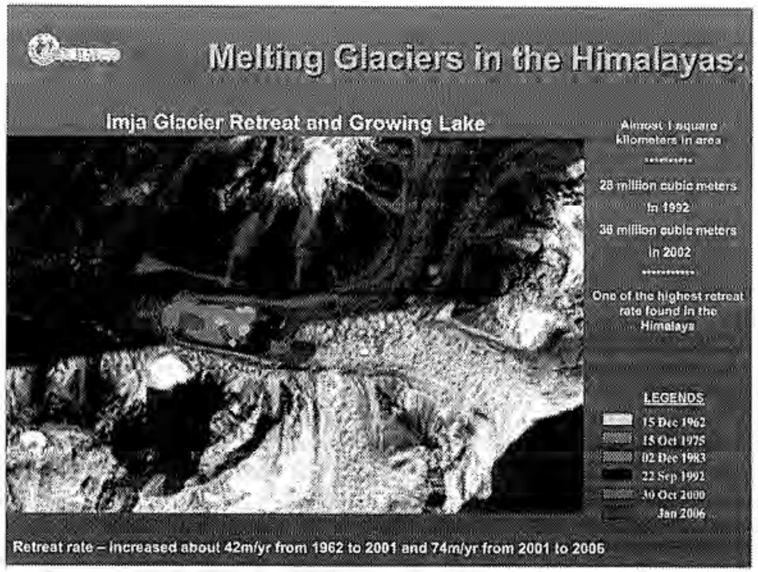
35


Melting Glaciers in the Himalayas:
Assessment of GLOF hazard
Hydrodynamic modeling
• Topographic Information (DEM)
• Extraction of geometric and Hydraulic Information (HEC GeoRAS)

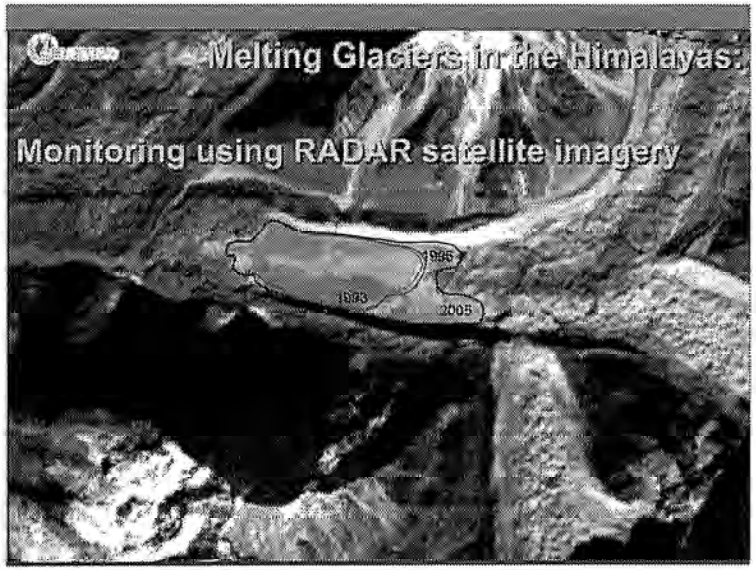
36


Melting Glaciers in the Himalayas:
Assessment of GLOF hazard
North
Imja Khola
Imja Glacier Terminus
500 metres
Bathymetry of Imja

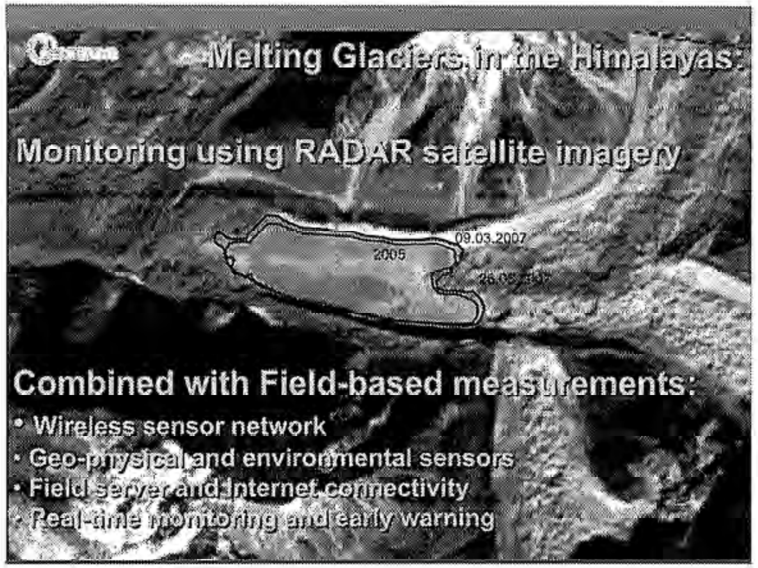
37


Melting Glaciers in the Himalayas:
Imja Glacier Retreat and Growing Lake
Almost 1 square kilometers in area
28 million cubic meters in 1992
38 million cubic meters in 2002
One of the highest retreat rate found in the Himalaya
LEGENDS
15 Dec 1962
15 Oct 1975
02 Dec 1983
22 Sep 1992
30 Oct 2000
Jan 2006
Retreat rate – increased about 42m/yr from 1962 to 2001 and 74m/yr from 2001 to 2006

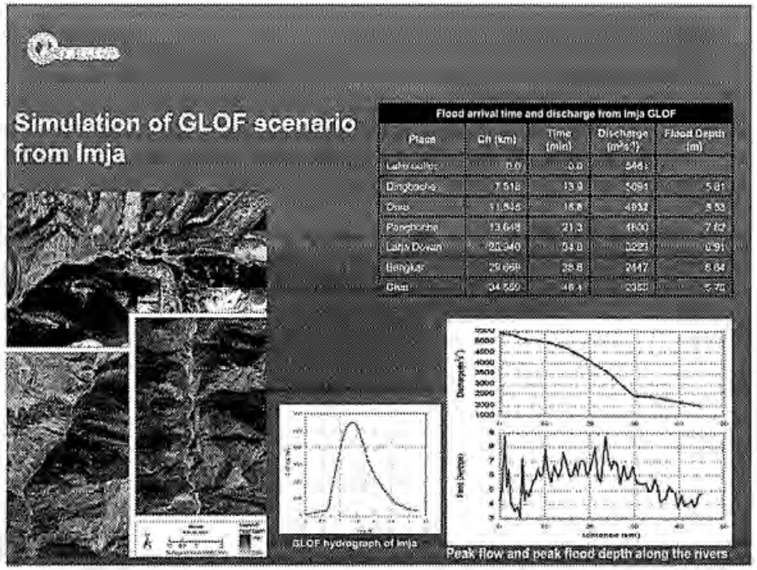
38


Melting Glaciers in the Himalayas:
Monitoring using RADAR satellite imagery
1986
1993
2005

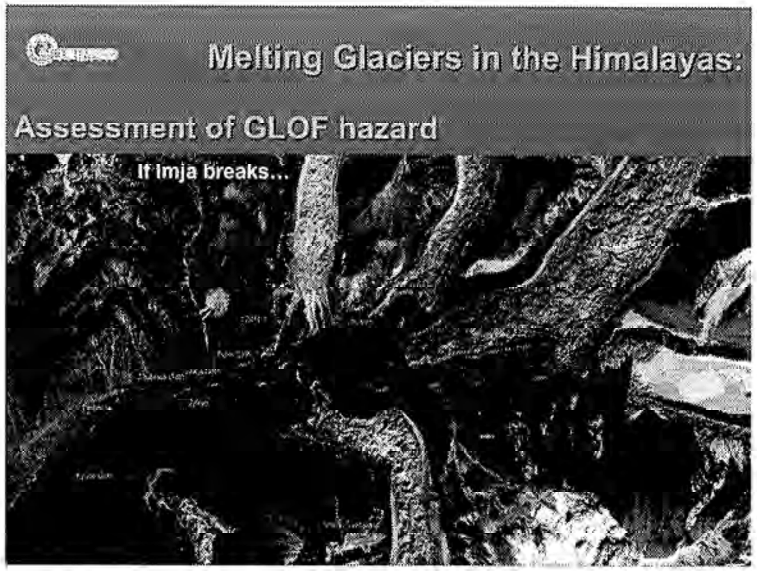
39


Melting Glaciers in the Himalayas:
Monitoring using RADAR satellite imagery
09.03.2007
2005
Combined with Field-based measurements:
• Wireless sensor network
• Geo-physical and environmental sensors
• Field server and internet connectivity
• Real-time monitoring and early warning

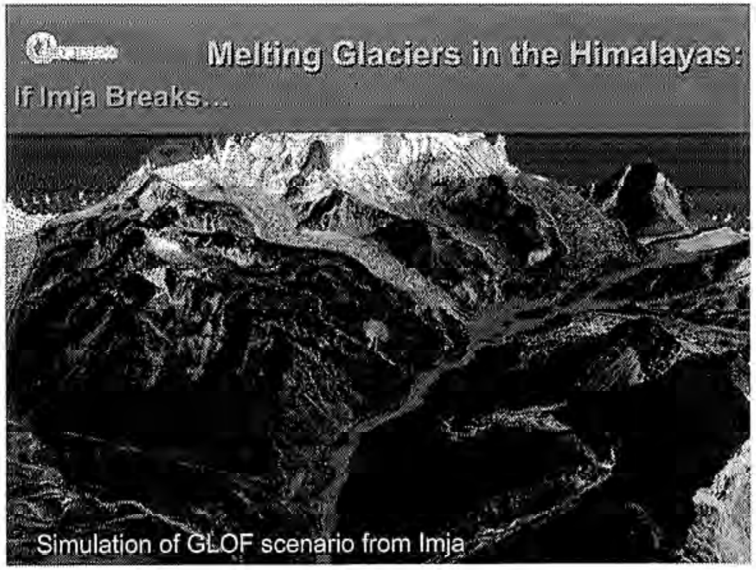
40


Simulation of GLOF scenario from Imja
Flood arrival time and discharge from Imja GLOF
Place | Ch (km) | Time (min) | Discharge (m³s⁻¹) | Flood Depth (m)
Dingboche | 7.518 | 13.9 | 5091 | 5.81
Bengkar | 29.669 | 39.8 | 2447 | 6.04
GLOF hydrograph of Imja
Peak flow and peak flood depth along the rivers

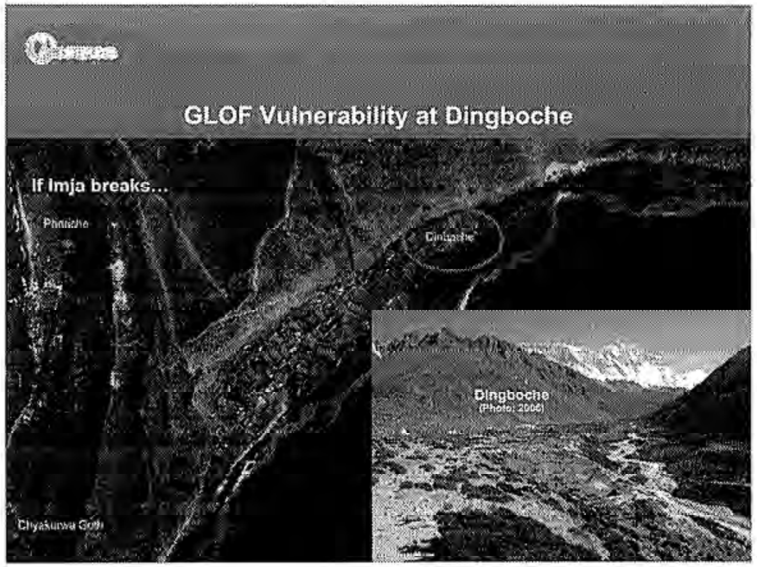
41


Melting Glaciers in the Himalayas:
Assessment of GLOF hazard
If Imja breaks...

42

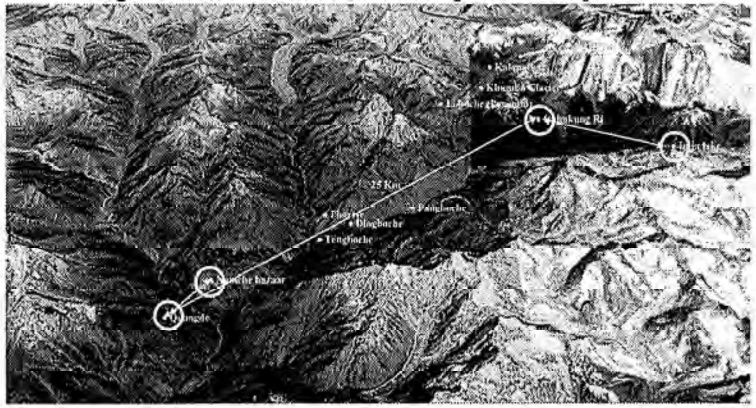

Melting Glaciers in the Himalayas:
If Imja Breaks...
Simulation of GLOF scenario from Imja

43


GLOF Vulnerability at Dingboche
If Imja breaks...
Dingboche

44

Networking of field sensor and transmission station in Mt. Everest region for the real time monitoring of Lake Imja Tsho



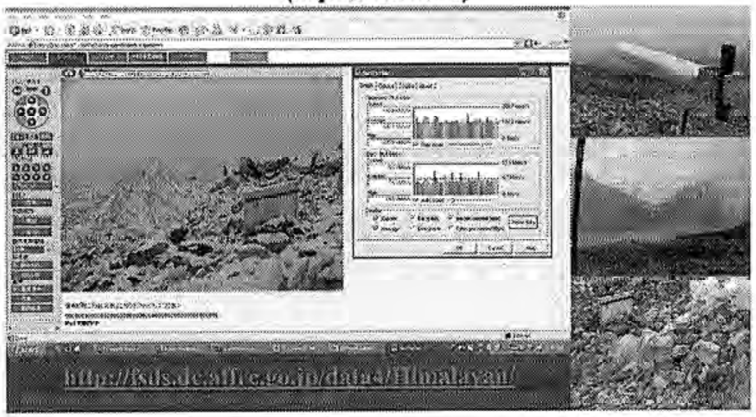
45

Monitoring of Glacier and Lake and GLOF in the Himalaya

- Wi-Fi Mesh-network
- Web Server
  - ✓Measurement
  - ✓Device Control
- Sensors (up to 24ch)
  - ✓ Air temp.
  - ✓ Humidity
  - ✓ Solar Radiation, UV
  - ✓ CO_2 concentration
  - ✓....
  - tolerate the cold weather
- Camera (0.3-8M Pixels)
- Solar-cell
- LED Lighting

46

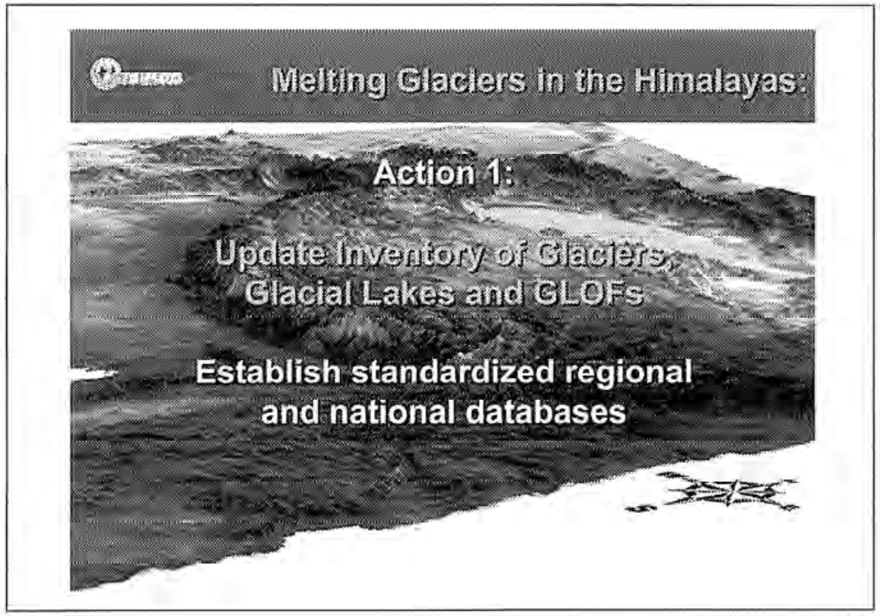
Imja Lake and its network statistics of local bandwidth (Imja to Namche)



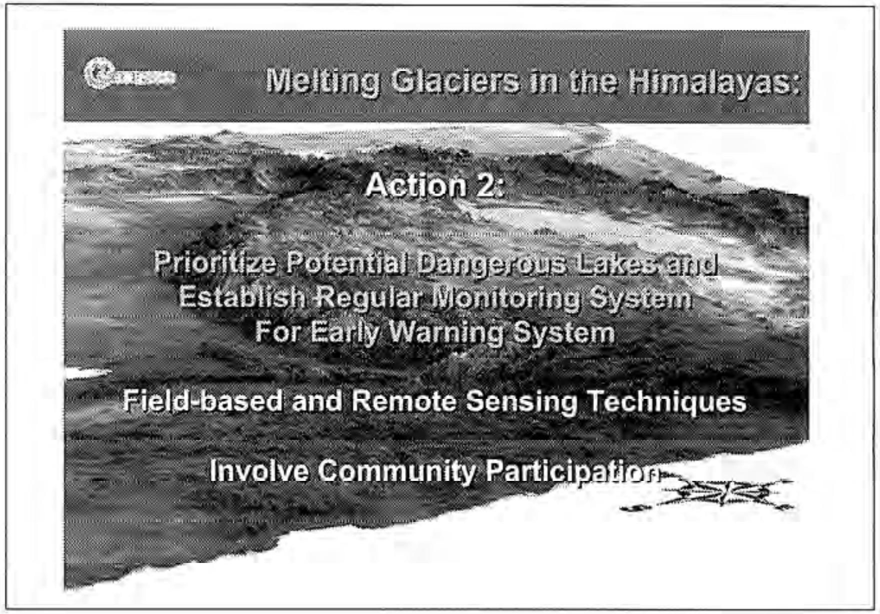
47

Melting Glaciers in the Himalaya

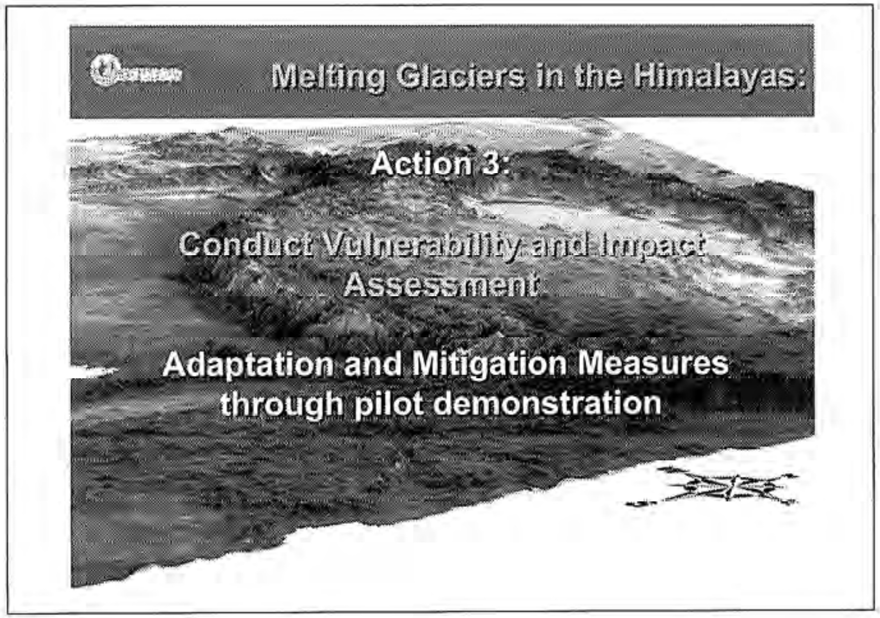
48


Melting Glaciers in the Himalayas:
Action 1:
Update Inventory of Glaciers, Glacial Lakes and GLOFs
Establish standardized regional and national databases

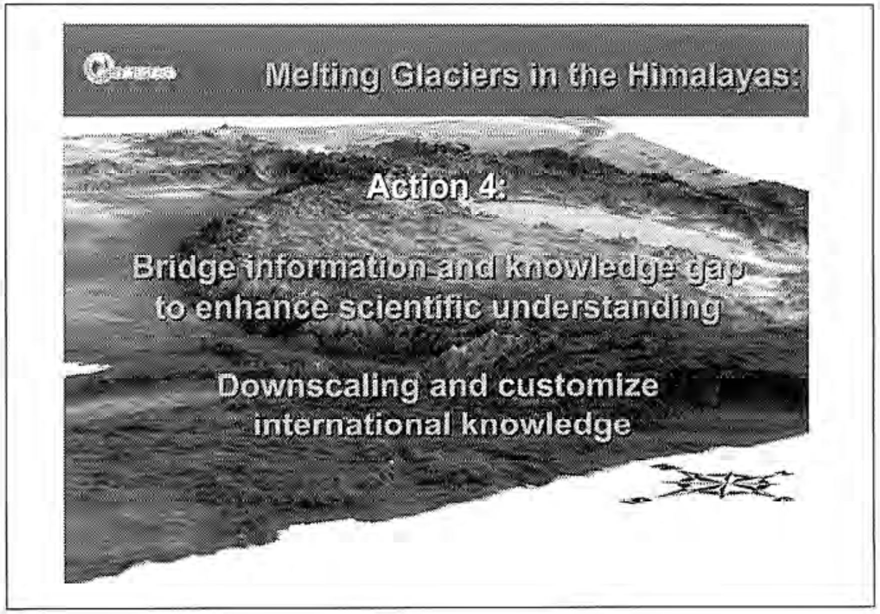
49


Melting Glaciers in the Himalayas:
Action 2:
Prioritize Potential Dangerous Lakes and Establish Regular Monitoring System For Early Warning System
Field-based and Remote Sensing Techniques
Involve Community Participation

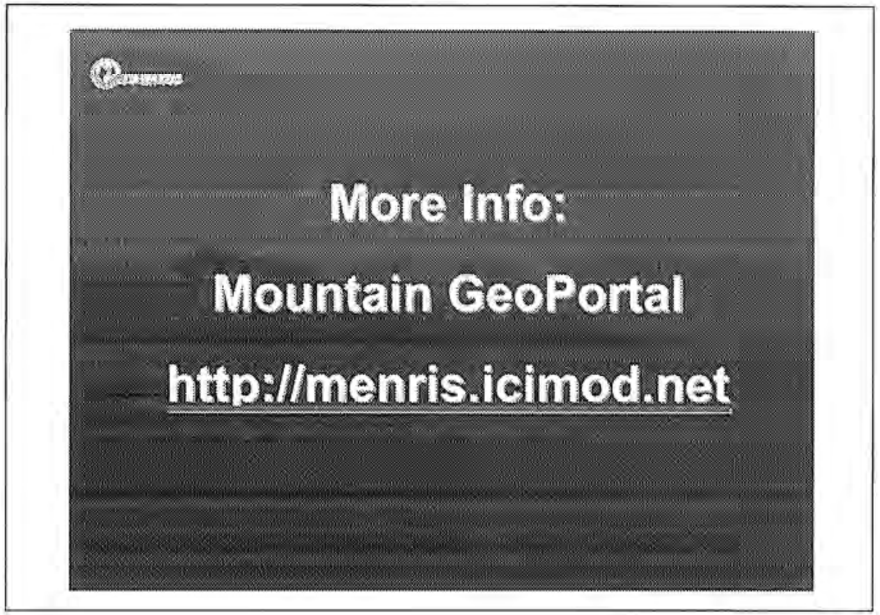
50


Melting Glaciers in the Himalayas:
Action 3:
Conduct Vulnerability and Impact Assessment
Adaptation and Mitigation Measures through pilot demonstration

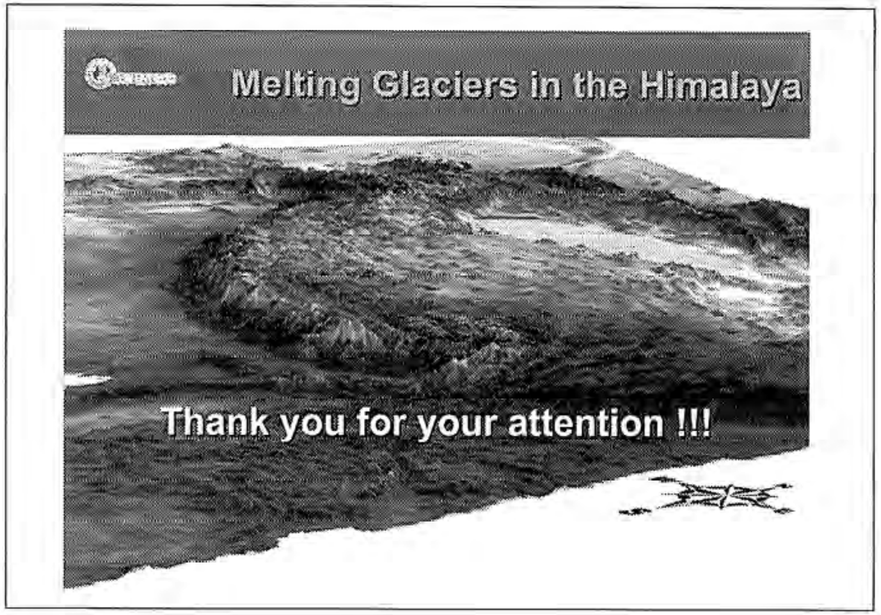
51


Melting Glaciers in the Himalayas:
Action 4:
Bridge information and knowledge gap to enhance scientific understanding
Downscaling and customize international knowledge

52


More Info:
Mountain GeoPortal
http://menris.icimod.net

53


Melting Glaciers in the Himalaya
Thank you for your attention !!!

54

APN 事務局
〒651-0073　兵庫県神戸市中央区脇浜海岸通 1-5-1
国際健康開発センター（IHD）ビル 5F
TEL:078-230-8017　　FAX：078-230-8018
E メール：info@apn-gcr.org
ホームページ：http://www.apn-gcr.org

The APN Secretariat
5th floor, IHD Center Building 5-1 Wakinohama-kaigandori
1-chome, Chuo-ku, Kobe 6510073 Japan
Tel: +81-78-230-8017　Fax: +81-78-230-8018
E-mail: info@apn-gcr.org
Website: http://www.apn-gcr.org