Forest gardening on abandoned terraces links local biomass carbon accumulation to international carbon markets, reverses land degradation, improves food diversity, and increases farmer income

Hans-Peter Schmidt[1*], Bishnu H. Pandit[2], Wolfgang Lucht[3], Dieter Gerten[3], Claudia Kammann[4]
ithaka institute for carbon strategies, Switzerland

ithaka institute

Hochschule Geisenheim University

PIK
Potsdam Institute for Climate Impact Research

Ratanpur, Tanahu
Central Nepal
800 – 1200 m asl

Ratanpur region

many of the ancient terraces lay barren and vulnerable to erosion largely due to rural depopulation

Paddy rice terraces lay barren due to exodus of work forces

The lady farmers maintain kitchen gardens

Main objectives

- erosion control, land slide protection
- water retention
- biodiversity preservation
- soil organic mater increase

- carbon sequestration

- increase of economic productivity
- development of new forest products
- creation of jobs in the village

the link between all objectives are trees creating forest garden

Beside fruit, nut, fodder & food trees, trees for new processed agro-products were selected

Cinnamon

Essential oils

Mulberry

Fruit, fodder, silk

Michelia Champaca

Parfume, fodder, timber

Pawlonia

furniture

How to transform good ideas into self sustaining, multipliable systems?

ithaka institute

Relate local and global climate change

climate change is a **global** problem affecting **local** conditions
climate change needs **local** solutions with **global** impact.

90 kg CO_2 per year

90 kg CO_2 per 700 km

CO_2-Certificates

10 year average of a cinnamon tree in Nepal

at 130 g CO_2 per km

ithaka institute

forest garden
850 mixed trees
11.5 ton CO_2 per year

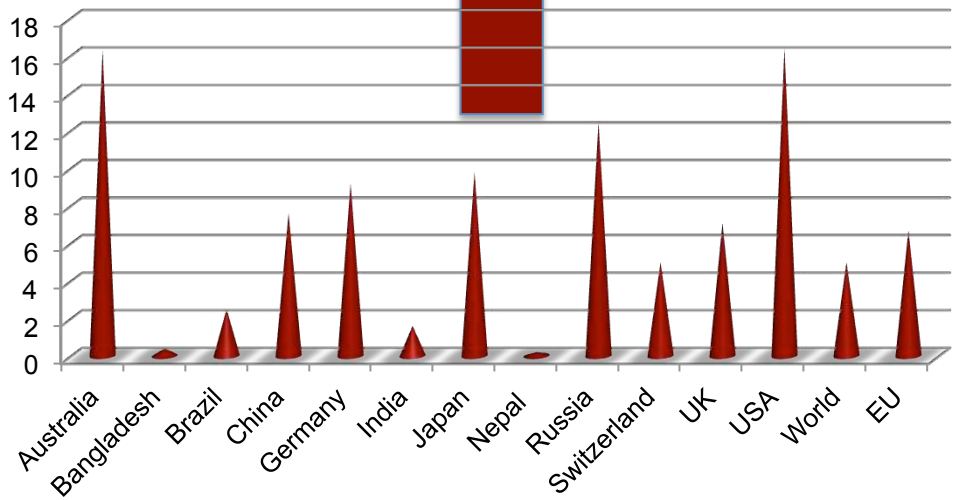
40 people in Nepal
8 people in India
1 person in Germany
= **11.5 t CO_2**

CO_2

400 Euro

CO_2

ca. 500 mixed trees per ha in Nepal



CO2 emissions per capita in tons per year

world bank 2013

ithaka institute

ithaka institute

Make the carbon cycle visible

demonstrate the carbon content of a tree
by transforming biomass into biochar

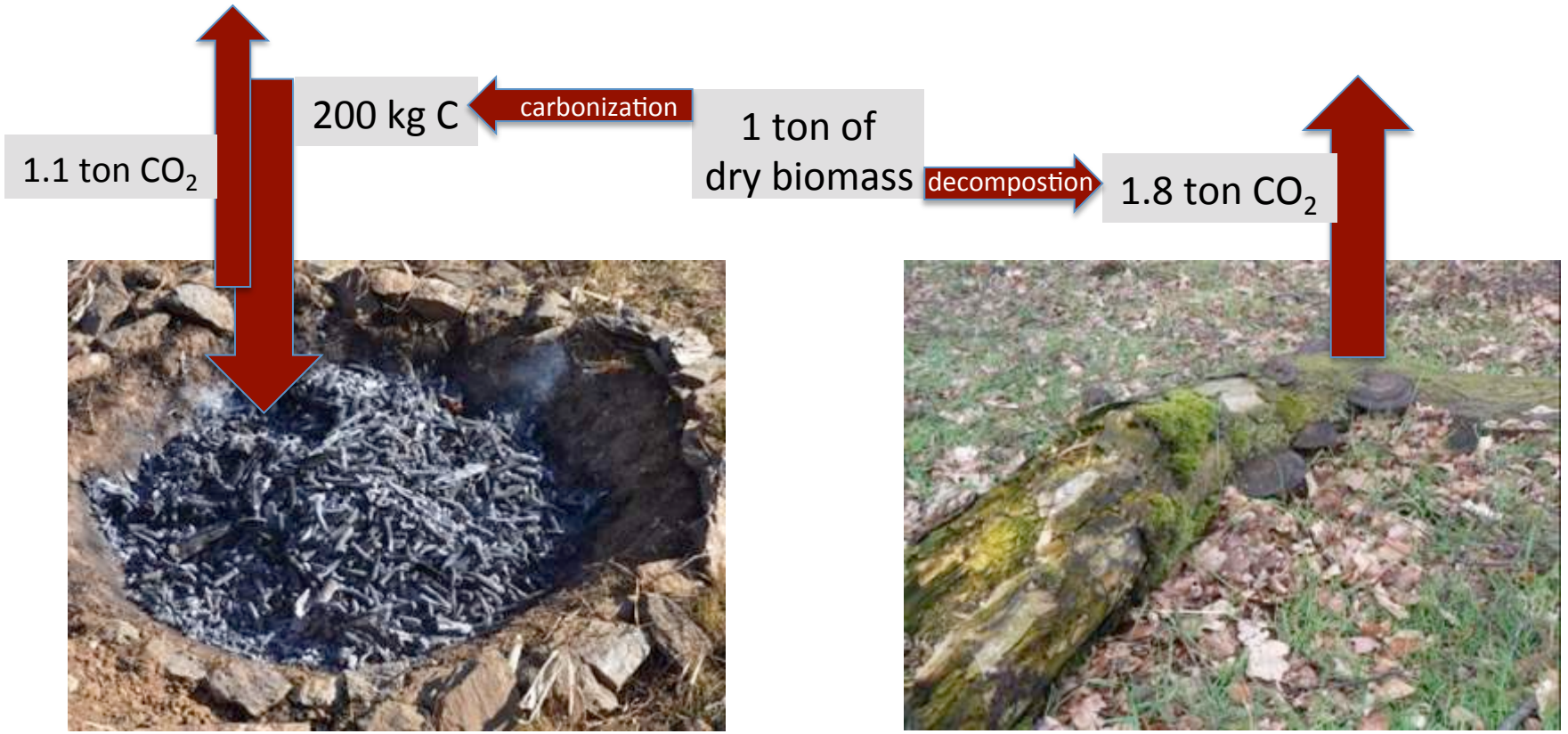
ithaka institute

Eupatorium – main feedstock for biochar production in Ratanpur is an invasive shrub species also called „forest killer“

flame curtain pyrolysis of Eupatorium feedstock

Production of 800 l biochar takes 2 to 3 hours

1 ton of dry biomass becomes 200 kg of stable carbon instead of returning 1.8 ton CO_2 to the atmosphere



ithaka institute

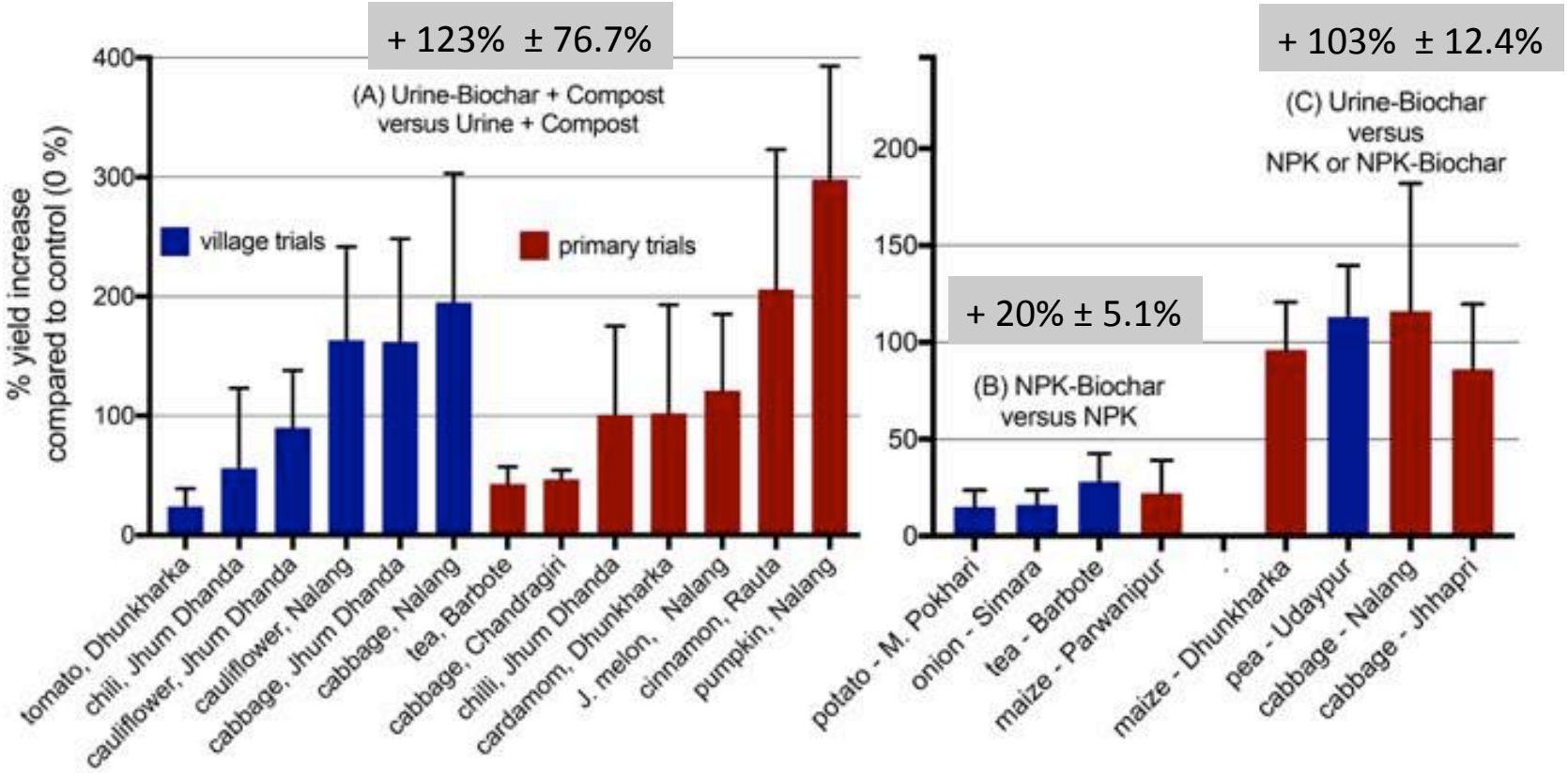
Charging biochar with cow urine makes an organic fertilizer

Turn local waste streams into opportunities

ithaka institute

cow urine quenched biochar

organic biochar based fertilizer
21 field trials – 13 crops

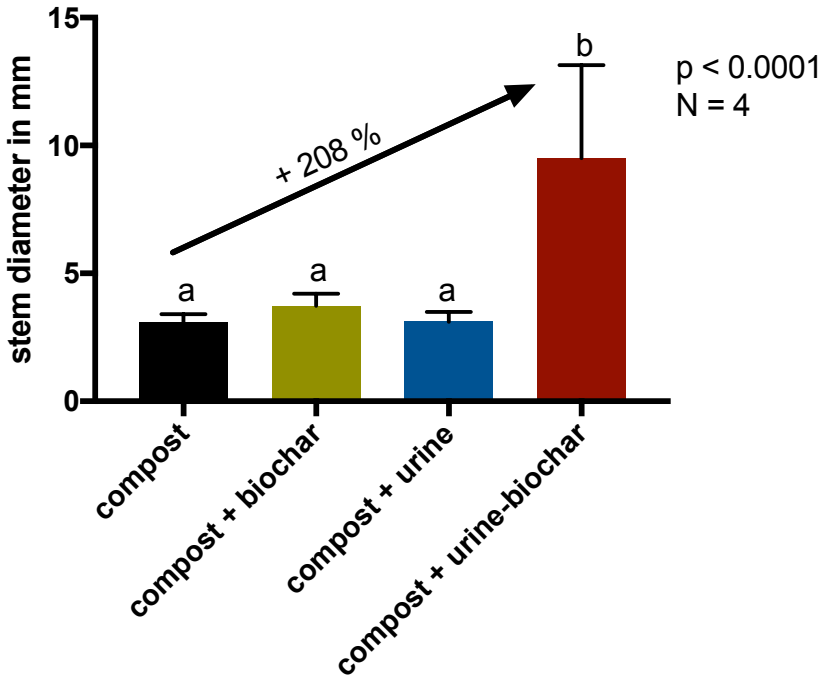


Average yield increases of (A) urine-biochar + compost treatments compared to urine + compost, (B) NPK-biochar compared to NPK only, and (C) urine-biochar compared to NPK only or to NPK-biochar. Yield increases are given as the absolute percentage increase above the control yield value. The bars show means and standard deviation. The red colored columns indicate primary trials, the blue columns village trials.

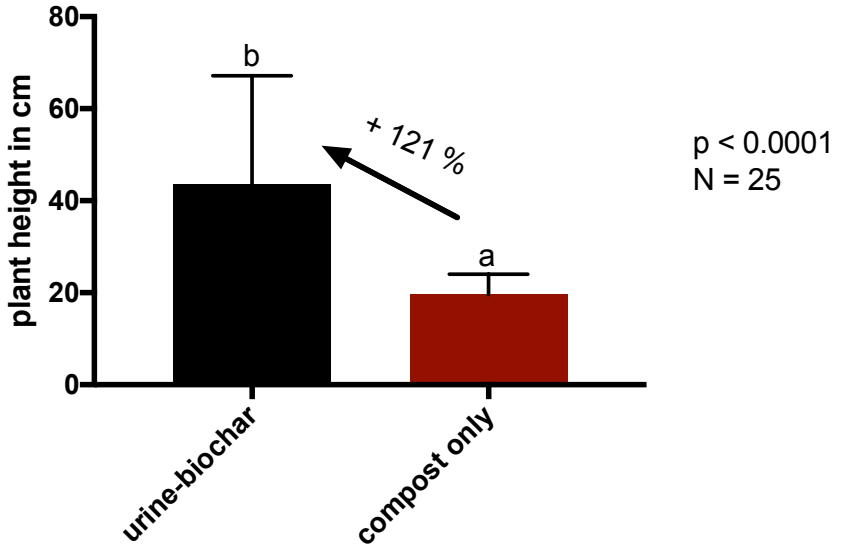
ithaka institute

Organic biochar fertilizers accelerate growth and improve soil fertility

Cinnamon trial, Udaypur, after 10 months



cardamom plant height , 10 weeks after plantation



Schmidt et al. 2017, submitted

Apply the 2 l biochar charged with cow urine and compost to plant new trees or crops

Planting of trees united the village farmers

and links to the global community

10,000 mixed trees planted in the first year

water retention pits for young tree irrigation

Tree nursery

ithaka institute

CO_2-credits linking global and local development

CO2-credits pay for

- tree saplings (max. 200 per family)
- plantation activities (pit digging)
- water retention pit
- irrigation pipe
- partial fencing
- tree nursery
- prime per tree if >80% tree survival for first three years

Ratanpur Agro-forestry 2015-2017

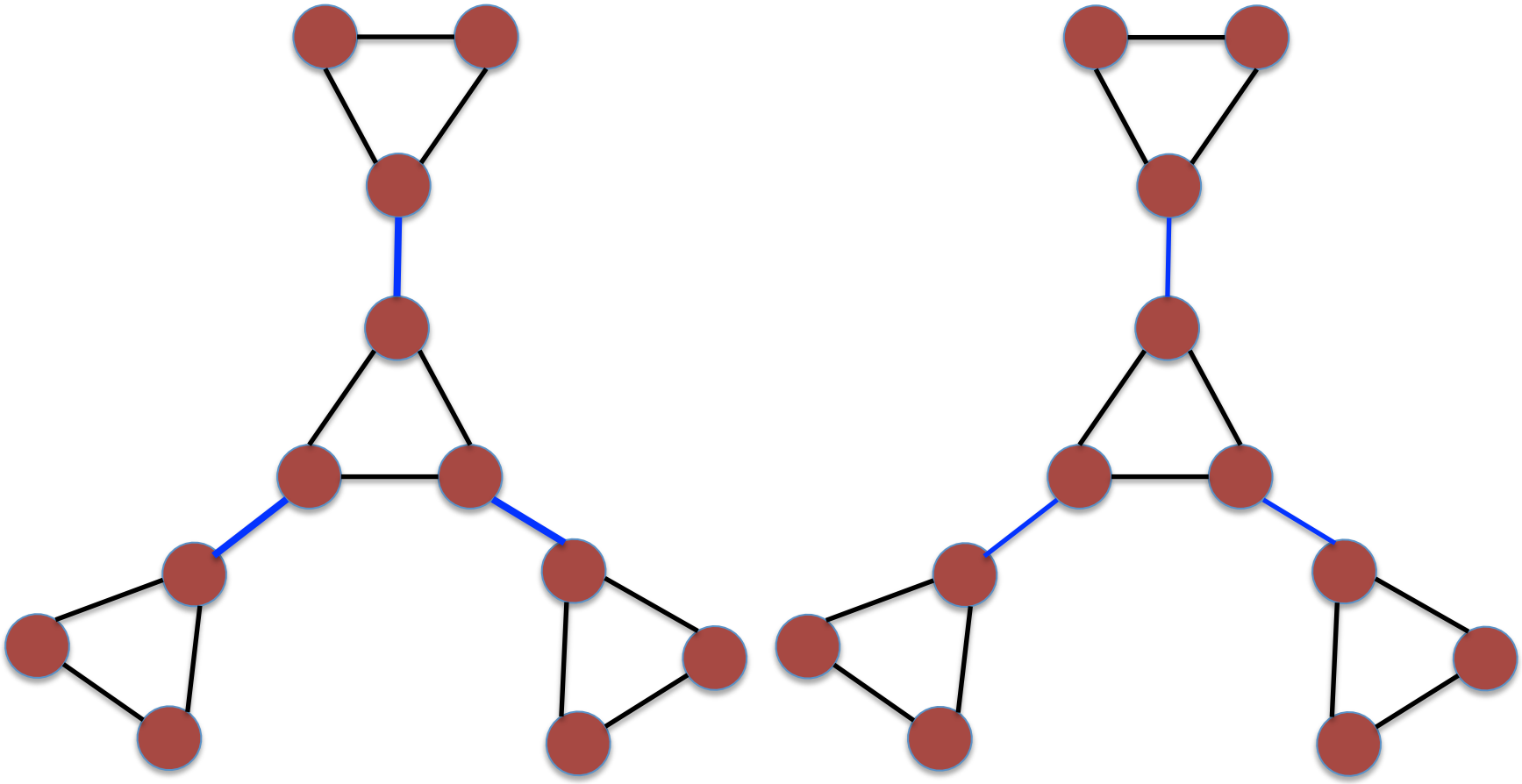
- 89 farmer families planted a total of > 25,000 multi species trees on their private land
- Annual intercropping on 40% of established forest gardens
- Each tree was planted with 2 liters of cow-urine enhanced biochar totaling 50,000 liters of biochar (app. 10 t biochar with an equivalent of 36 t of CO_2)
- 26 water retention pits,
- 6.8 km irrigation pipes

First year survival rate: 57%

ID	Name of farmers	Michelia champaka	Cinnamon	Melia azedirach	Mulberry	Paulownia & others	Total	Dead plants	Net survival	survival rate in %	Replanted	Michelia champaka	Cinnamon	Mulberry	others	total survived 8th may 2016	survival rate from start
1	BabuRam Pandit	35	80	70	15	8	208	6	202	97.1	0	11	8	15	48	82	39%
2	Bam Dev Pandit	100	100	65	47	10	322	10	312	96.9	0	45	15	7	59	126	39%
3	Dev Bahadur Pandit	100	100	15	10	5	230	5	225	97.8	20	78	62	4	25	169	68%
4	Hari Bahadur Pandit	100	50	50	0	5	205	10	195	95.1	0	62	25		9	96	47%
5	Jagat Bahadur Pandit	85	50	50	0	5	190	6	184	96.8	0	38	28		34	100	53%
6	Surya Kala Gharti	30	70	3	0	5	108	2	106	98.1	0	23	55		22	100	93%
7	Ananda Pandit	25	25	3	0	0	53	2	51	96.2	0	17	19		0	36	68%
8	Kalpana	75	75	0	75	5	230	5	225	97.8	0	45	50	53	3	151	66%
9	Harka Bahadur Gharti	100	100	50	0	5	255	4	251	98.4	10	69	43		0	112	42%
10	Man Bahadur Gharti	150	50	0	0	15	215	8	207	96.3	0	102	5		23	130	60%
11	Santi Maya	100	50	0	0	5	155	8	147	94.8	0	40	11		4	55	35%
12	Jamuna Gharti	25	25	0	0	7	57	3	54	94.7	0	20	17		0	37	65%
14	Shiva Pant	75	25	13	0	5	118	6	112	94.9	0	29	11		16	56	47%
15	Uttam Prakash Pandit	100	75	25	87	10	297	15	282	94.9	0	41	49	13	35	138	46%
16	Narayan Prasad Dhakal	300	200	10	24	15	549	11	538	98.0	0	177	95	0	31	303	55%
18	Hari Maya Pandit	200	100	0	0	15	315	10	305	96.8	12	102	81		26	209	64%
20	Bishnu Hari Pandit	500	419	0	970	18	1907	90	1817	95.3	50	114	274	582	41	1011	52%
21	Ithaka		81		30		111	1	110	99.1			73	28		101	91%
25	Gopal Bdr Pandit	75	75	15	35	5	205	6	199	97.1	0	35	41	10	2	88	43%
26	Prem Prakash Dhakal	350	250	100	0	0	700	21	679	97.0	0	141	260		43	444	63%
17	Prakash Pandit	300	150	200	100	20	770	24	746	96.9	24	184	55	96	10	345	43%
27	Jwala Prasad Dhakal	50	30	0	0	0	80	2	78	97.5	4	33	28		2	63	75%
30	Dol Nath Dhakal	15	85	0	0	17	117	4	113	96.6	69	13	30		86	129	69%
31	Resham Pandit Chhetri	100	100	100	0	5	305	9	296	97.0	0	42	80		15	137	45%
34	Krishna Hari Sharma	20	30	0	0	0	50	2	48	96.0	0	0	32			32	64%
	Total	3010	2395	769	1393	185	7752	270	**7482**	**96.5**	189				average survival		57%
															total survival		53%

ithaka institute

Working with psychologists to creat social models that improve success rates: Triade System



2end year survival rate with Triade System: 86%

	Ratanpur	Initial plantation- second year							Survival Nov, 2016								
ID	Name of farmers	Michelia champaka	Cinnamon	Melia azedirach	Others (paulownia, bamboo, mango, litchi, kapur)	Total	Deduction to make 60% of last year	Ithaka responsibility	Michelia champaka	Cinnamon	Melia azedirach	Others (paulownia, bamboo, mango, litchi, kapur)	Total	Deduction to make 60% of last year	Ithaka responsibility	individual survival rate	triade survival rate
	Ratanpur																
Group A																	
1	Hari Maya Pandit	0	50		2	52	0	52	0	47		2	49	0	49	94%	
2	Yadav Pandit	100	190		2	292	NA	100	95	186		2	283	NA	100	97%	
3	Prakash Pandit		132		2	134	132	2		130		2	132	132	0	99%	97%
Group B																	
4	Damodar Pandit	0	153		2	155	NA	100	0	140		2	142	NA	100	92%	
5	Eak Raj Pandit	0	100		0	100	NA	100	0	94		0	94	NA	94	94%	
6	Bishnu Hari Pandit		125		2	127	164	100		121		2	123	164	100	97%	94%
	Ithaka (club house)				63		NA	63				63		NA	63		
Group C																	
7	Prem Prakash Dhakal	400	700		14	1114	0	100	370	681		12	1063	0	100	95%	
8	Narayan Prasad Dhakal	150	225		2	377	27	100	140	192		2	334	27	100	89%	
9	Jwala Prasad Dhakal		15		2	17	0	19		11		2	13	0	19	76%	87%
Group D																	
10	Hari Bahadur Pandit		100		4	104	27	77		80		4	84	27	57	81%	
11	Surya Prasad Pandit	25	100		2	127	NA	100	21	82		2	105	NA	100	83%	
12	Santi Maya	25	100		2	127	38	89	20	80		2	102	38	64	80%	81%
Group E																	
13	Dev Bahadur Pandit		50		2	52	27	25		45		2	47	27	20	90%	
14	Kalpana Pant	0	50		2	52	0	52	0	48		2	50	0	52	96%	
15	Shiva Pant	150	75		6	231	15	100	144	66		6	216	15	100	94%	93%
	Bandipur																
Group F																	
79	Laxmi Rana Magar	50	60	10		120	NA	128	45	50	10		105	NA	128	88%	
80	Maya Thapa	30	65	3		98	NA	100	27	55	3		85	NA	100	87%	
81	Mina R Magar	0	5	4		9	NA	57	0	3	4		7	NA	57	78%	84%
Group G																	
82	Jivan Sapkota		20	3		23	NA	26		15	2		17	NA	26	74%	
83	Ram Maya Rana		150	3		153	NA	100		136	3		139	NA	100	91%	
84	Sushila Bhattaria	2	38	3		43	NA	46	1	35	3		39	NA	46	91%	85%
Group H																	
19	Sarada Bhattarai	20	20	3		43	NA	46	15	15	3		33	NA	46	77%	
20	Devi Maya Bhattarai	10	30	3		43	NA	46	7	26	3		36	NA	46	84%	
	Subtotal	**471**	**919**	**68**		**1458**	NA	**1468**	**414**	**786**	**67**		**1267**	NA	**1468**	87%	
	Total	**3611**	**9897**	**108**	**650**	**14138**		**7969**	**3166**	**8700**	**107**	**644**	**12547**		**7824**	**89%**	**86%**

forest garden after one year
banana, paulownia, cinnamon, michaelia and black lentil

1 year before

Success is the most convincing argument

Forest garden after one year: cinnamon, michaelia and ginger

Carbon inputs per ha and a (10 year average)

500 mixed trees =

3.1 t C from woody biomass → wood + biochar

3.5 t C from leaves → mulch + animal feed→ compost

5.5 t C from understory cropping → food, mulch, animal feed, roots → compost

→ ± 11 t C ha^{-1} a^{-1} input

Assuming that 30% of the total annual C input is maintained via biochar, compost, urine, mulch and exudates as SOM, a theoretical SOM increase of 6 t ha^{-1} a^{-1} or 0.15 % SOM a^{-1} would not be unlikely.

Which we hope to demonstrate within the next decade.

global climate effects of local climate action (e.g. forest gardens)

- The 25,000 garden trees sequester a minimum of **400 t CO_{2eq}** per year (not counting SOM increase)

- Offset the CO2-footprint of 34 Germans on 50 ha.
- Current offset value: **US$ 14,000** (at US$ 35 per t CO_2)

- Main tree products: fruits, nuts, medicine, essential oil, silk, perfume, honey, timber, animal fodder
- Annual crop values (after five years) **> US$ 250,000**

- SOM increase, biodiversity, erosion control, water retention are added values


www.ithaka-institut.org
Hochschule
Geisenheim
University
PIK
Potsdam Institute for
Climate Impact Research
ithaka institute